



United States Military Academy
West Point, New York 10996

**ANALYSIS OF THE BATTLE OF
WATERLOO AND NAPOLEON'S
COURSES OF ACTION WITH THE
JANUS COMBAT MODELING
SIMULATION**

**A TECHNICAL REPORT OF THE
DEPARTMENT OF SYSTEMS
ENGINEERING**

Second Lieutenants Didier Hubert
and Samuel Eric Machac
St. Cyr French Military Academy

Directed by
MAJ Rocky Gay
Department of Systems Engineering
and
Fred Kagan
Department of History

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EXECUTIVE SUMMARY

Napoleon's French Army was successful in its engagements against the Allied forces during the first two days at Waterloo. On the final day, Napoleon had the opportunity to achieve complete victory. With Wellington's forces arrayed to his immediate front and additional Allied forces approaching from the west, the French needed to fight quickly and decisively in order to attain total victory. Marshal Ney led four inspired and courageous cavalry charges at the infantry squares of Wellington. Yet, the French cavalry could not break the British line and Wellington's Army was able to capitalize on the spent French forces and triumph.

2LTs Didier Hubert and Samuel E. Machac from the St. Cyr, French Military Academy, worked with MAJ Rocky Gay and Mr. Paul West in the Janus Combat Simulation Lab of the Department of Systems Engineering at the United States Military Academy to examine the battle. These French junior officers researched and modeled the weapon systems of the era and studied the details of the battle to precisely replicate it within Janus. The simulation, replicating the actual battle, resulted in similar force attrition results on both sides as were attained in the actual fight. These results confirmed after several simulation replications of the actual battle, in which the simulation consistently produced results similar to the aftermath of Marshal Ney's attack.

Courses of action available to Napoleon included the capture of La Haye Sainte, key terrain between the Allied forces and the French, from which the French artillery could engage the Allied forces more effectively. In addition to this artillery, the French could have employed their infantry divisions, who were idle in the reserve. Thus, the four scenarios examined were:

1. The actual battle where the cavalry of Marshal Ney charged into the British infantry squares.
2. The French capture of La Haye Sainte and the subsequent employment of artillery to assist the cavalry attacks of Marshal Ney.
3. The employment of French infantry division reserves with the cavalry of Marshal Ney.
4. The French capture of La Haye Sainte and the subsequent employment of artillery, as well as, the French infantry division reserves to assist the cavalry attacks of Marshal Ney.

The results demonstrated that while the addition of French combat arms produced corresponding increases in the Allied losses, it did not significantly benefit the combat effectiveness of the French forces. The addition of French infantry forces always increased the Allied losses; however, the French also lost a large number and continued to have difficulty penetrating the British squares. Furthermore, the addition of effective artillery on the battlefield from La Haye Sainte did enhance the French assault on the Allies and assisted the cavalry charge, yet, it was not strong enough to significantly degrade the combat power of the British infantry. Finally, the use of all three combat arms

on the battlefield produced the heaviest Allied losses; still, the French were still not able to defeat the British line effectively by this frontal assault.

The simulation results:

Course of Action/Simulation	French Losses	Allied Losses	Loss Exchange Ratio= $\frac{\text{\# Allied Losses}}{\text{\# French Losses}}$
<i>Actual Battle Results In June 1815</i>	6450	1530	.237
<i>Scenario of Actual Battle Tactics (Scenario I)</i>	6562	1806	.275
Scenario with only French Cav and Inf forces in attack (Scenario II)	7264	2310	.318
Scenario with only French Cav and Arty forces in attack (Scenario III)	5962	2094	.351
Scenario with French Cav, Inf and Arty forces in attack (Scenario IV)	7528	2372	.315

Comparison of The Combat Losses of The Four Simulation Courses of Action of Marshal Ney's Attack

Based on these results, the different alternatives drive us to devalue the importance of La Haye Sainte and underline the tactical decision making failures of Napoleon: a frontal attack with lone cavalry or even a combined arms attack would not have brought a more favorable outcome for the French. Instead, possibly a flank attack and the simultaneous synchronized employment of all the French forces could have led to a French victory. Faulty tactics will not prevail, even though, the fighting force is enhanced with numerous combat multipliers. It is far better to have a solid, sound tactical operation from the start and add the combat multipliers to an already favorable situation.

PREFACE

I. FOREIGN EXCHANGE PROGRAM

a. Presentation of the project

Our project is in the framework of the foreign exchange program between Saint-CYR and WEST POINT. It lasted from March the 15th up to May the 10th. In fact, we arrived just before Spring Break, and we worked seven weeks on the project in the Engineering Systems Department.

b. Main events

They were as follows:

1. The meeting with the Superintendent commanding the Academy of West Point.
2. The meeting with the General Raffin
3. The presentation of our subject to the Deputy Undersecretary of the Army (Operations Research)

c. Difficulties encountered

In the framework of the realization of the project, the difficulties were as follows:

1. The status of cadets which brought about duties
2. The language barrier

II. THANKS

We would like to thank the persons who took part to the success of our stage during or before it. The order was established indifferently:

- Major Rocky Gay, director of the project.
- Mr. Paul West, engineer at the Janus department and responsible for the Jets program.
- Professor Kagan, History Professor at West Point.
- The staff of the Janus department.
- LTC Bruno de Villele, French Exchange Officer at West Point.
- The cadets Ryan Honl and Gregory Lafata.
- Major Jean-Louis Riccioli, director of the Historical Department at Saint-CYR.
- The staff of the Crosat (Janus department of the War Academy at PARIS).
- The staff of the SHAT (Historical Service of the French Army).

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I. PRESENTATION OF THE SUBJECT

A. Description

This project is an historical analysis of the battle of Waterloo with combat simulations.

We recreated the decisive phase of the battle: the charge of the French cavalry at 1600 hrs on 18 June 1815. We will model the military actions at the battle of Waterloo with the Janus combat simulation program. We modeled the French and British Army organizational structures and equipment, the employment of all combat forces at Waterloo. Modeling of forces included cavalry infantry and artillery with the correct organizational structures and tactics. Weapon systems modeling included rates of fire, ranges, basic loads, probability of hits and kills and speed. We verified the results of our combat simulation with what actually occurred to validate the simulation. After which, we modeled different assumptions the French commanders could have made and evaluate the possible outcome.

B. Presentation of the Janus System

Named for the two-faced Roman god who was the guardian of portals and the patron of beginnings and endings, Janus exists in several versions and is currently employed for analysis and battalion level tactical training by the US Army, as well as, France. Janus is an interactive, six-sided, closed, stochastic, ground combat simulation featuring precise color graphics. Interactive refers to the interplay between the military personnel who decide what to do in crucial situations during simulated combat and the systems that model that combat. Up to six sides may be simulated on the latest version of Janus, Janus 6.0. Closed means that the disposition of opposing sides is largely unknown to the players in control of a side. Stochastic refers to the way the system determines the results of actions like direct fire engagements, according to the laws of probability and chance. Ground combat means the principal focus is on ground maneuver and artillery units, although Janus also models weather and its effects, day and night visibility, engineer support, minefield employment and breaching, rotary and fixed wing aircraft, resupply, and a chemical environment.

The main features of the Janus system are as follows:

1. Terrain Representation

The simulation uses digitized terrain developed by the Defense Mapping Agency, displaying it in a form familiar to military users with contour lines, roads, rivers, vegetation, and urban areas.

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2. Modeling Realism

Since Janus models weapons systems as a function of each system's capabilities as affected by terrain and weather.

3. After Action Review & Analysis

Janus offers the capability for battle analysis and After Action Review (AAR).

4. Multiple Runs

Janus has the capability to re-fight the battle using different tactics, techniques, or procedures.

5. Database Features

The Janus database describes combat systems and weapons systems extensively and in detail.

6. AUTOJAN Replay

A feature called AUTOJAN permits playback of a previously executed Janus scenario run. During the original scenario run, Janus recorded all manual actions the users made.

C. Purpose of project

1. Segments covered

There are two main segments this project covers:

- .historical :recreate this battle and find out the main failures of the French commanders
- .scientific :validate the Janus system

2. Specific Tasks

- a. Research the battle of Waterloo and the exact movement of forces include force structure, timing of attacks. and artillery fires.
- b. Research the weapon systems characteristics of all weapons within the all forces at Waterloo.
- c. Model the battle of Waterloo on the Janus combat simulation.
- d. Evaluate possible combat actions from French commander's options and conduct statistical analysis to determine what factors were significant to victory.

II. HISTORICAL PRESENTATION

1. DESCRIPTION OF THE ARMIES

A. THE FRENCH ARMY

1. GENERAL DESCRIPTION

- a. Organization**
- b. Strategy**

2. DESCRIPTION OF THE COMBAT ARMS

- a. Infantry**
 - i. Organization**
 - ii. Tactics**
- b. Cavalry**
 - i. Organization**
 - ii. Tactics**
- c. Artillery**
 - i. Organization**
 - ii. Tactics**

B. THE BRITISH ARMY

1. GENERAL DESCRIPTION

- a. Organization**
- b. Strategy**

2. DESCRIPTION OF THE COMBAT ARMS

- a. Infantry**
 - i. Organization**
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- b. Cavalry**
 - i. Organization**
 - ii. Tactics**
- c. Artillery**
 - i. Organization**
 - ii. Tactics**

2. BACKGROUND OF THE BATTLE

Time line of the events from March to June

1. LES CENT JOURS

2. THE CAMPAIGN OF WATERLOO

- a. June the 15th**
- b. Battle of Ligny and Quatre Bras**
- c. June the 17th**

3. WATERLOO

A. ACTUAL EVENTS

- 1. THE TERRAIN**
- 2. THE FORCES COMMITTED**
- 3. TIMELINE OF THE BATTLE**

B. CONTROVERSY

- 1. LA HAYE SAINTE NOT CAPTURED**
- 2. LA HAYE SAINTE CAPTURED**

1. DESCRIPTION OF THE ARMIES

A. THE FRENCH ARMY

1. GENERAL DESCRIPTION

a. Organization

A French corps at full strength contained about 25,000 infantry, cavalry, artillery, and engineers plus some military and civilian support units. A corps frequently consisted of four infantry divisions, a cavalry division, and from five to eight batteries of artillery. Even though French divisions could operate away from their corps, this was not usually considered desirable when large forces were assembled in one area. Napoleon compensated for his own rather sedentary attitude to army direction by giving his corps commanders a great deal of initiative in executing general instructions.

There was one significant exception to the French organization into divisions and corps. The Imperial Guard which contained infantry, cavalry and artillery was not in a corps: organizations in this elite body of troops were different from those found elsewhere. Napoleon's Guard was composed of all the various types of soldiers which he found to be of greatest value. He assembled them together loosely and personally retained battle control of most of this force.

b. Strategy

Throughout his long military career, Napoleon endeavored always to surprise his enemies, particularly at the beginning of a campaign. Strategically, he did the unexpected. He used dispersion, rapid movement and battlefield concentration to keep his opponents off balance. In his great Italian Campaign of 1796, he moved rapidly and began fighting astride enemy communications. By striking at unexpected places, he won with relatively light weapons. He was always a master of strategic surprise. His casualties in his early campaigns were moderate, because he was able to employ some tactical surprise, as well.

As Napoleon's military resources increased, he began to rely more on power than on surprise, once on the field of battle. He was usually able to keep the strategic initiative by out-thinking his opponents and making full use of the remarkable French strategic mobility based upon his corps organization. No opposing commander could ever anticipate where the Emperor would move and from what point he would strike. His actual tactical strokes, however, became more massive. This was particularly true after 1809 and in his northern European campaigns. French Armies under other marshals in Spain continued to try to fight in the old way.

Of what did this tactical massiveness consist? It was more a new emphasis than a new organization. The same cavalry, artillery and infantry were deployed on narrower fronts and fought even more stubbornly for limited objectives. But there were some technical changes too. Napoleon increased the ratio of heavy cavalry. He kept all the

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cavalry in the reserve, usually close to his headquarters, and used it for shock charges at critical times on the field of battle. Normal cavalry functions such as reconnaissance and outpost duties were handled by other units.

Napoleon's artillery was always employed well in many variations and were important in his battle plans. With the passage of time, however, he began to rely even more on concentrations of fire by several batteries on a single point. His new guns were larger in bore and weighed more than his old ones; the percentage of heavier pieces also increased. Napoleon concentrated them even more and used particularly his Imperial Guard's 12-pounders and 6-inch howitzers in preparing the way for his massive cavalry and infantry attacks.

Napoleon's conception of an offensive battle also changed with the years. Early in his career, he defeated inept commanders and poorly organized armies by confusing them utterly and then striking hard at an unexpected place. This system did not work indefinitely: opponents learned through defeat and made their dispositions so that tactical surprise by the French was more difficult to achieve. Napoleon's later victories came only after hard fighting. But he still had the patriotism, increasing population and material resources of France to rely on. The Emperor began to send forward dedicated Frenchmen of all three arms (cavalry, infantry, artillery) not to conquer immediately, but to wear down the enemy in bloody, almost even combat. He weakened his enemies by repeated attacks with line troops; he used no more fresh troops than necessary. When his enemies were approaching the limit of their endurance, if possible after most of their reserves had been committed, Napoleon would suddenly throw the Guard infantry and light artillery forward in a final victorious movement. This hammering type of battle plan became more or less standardized during the last years of the Empire. It was effective, but costly.

Napoleon granted his commanders tactical freedom, but directed their strategic movements, usually through Marshal Berthier, the Imperial Chief of Staff. Even when present with a corps, Napoleon gave only general guidance. He allowed his subordinates to make decisions on formations and other details. This system produced many victories, but it had its weaknesses. A marshal who did not understand an overall concept could jeopardize its success by carrying out his part badly.

2. DESCRIPTION OF THE COMBAT ARMS

a. Infantry

i. Organization

A company of French infantry when formed for battle was three ranks deep and about 30 men broad. This was the basic company formation and seldom varied. But the final appearance of battalions brigades and divisions depended upon the different arrangements of companies. A battalion in column could have a front of one or two companies, that is about 30 or 60 files. This would have given a depth of 18 or 9 ranks. The distance between ranks in the same company was 30-32 inches, but the companies in column were usually about 68, 34, or 17 feet apart - full, half, or quarter distance. All

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companies could also form a 'close' column with 30-32 inches between successive companies, but this was not usually done intentionally.

A brigade could be formed into column either by having the battalion columns one behind the other, or in line parallel to each other. Similarly, a division could have its brigades one behind the other, or side by side. Another column arrangement was used at Waterloo: entire battalions were formed into three rank lines - all companies in a single line - and these battalions placed one behind another.

ii. Tactics

French commanders sent forward against them swarms of skirmishers, or tirailleurs, who maintained no rigid alignment, but took advantage of cover. Even though disorganized, individual courage enabled them to approach close to the enemy line and direct aimed fire at it. The idea of skirmishers did not, of course, originate with French Republican commanders: light infantry tactics had been known for a long time. But the French now placed up to 25 per cent of their total force in these irregular lines which frequently extended across their entire battlefield. The tirailleurs swept away the skirmishers of the enemy, if any, and then attacked their main lines. Numerous casualties were inflicted; confusion often resulted. Mere firing at the tirailleurs by line formations was ineffective, because individual French-men who took full advantage of any available cover presented such small targets.

During the few minutes that the tirailleurs engaged the entire enemy front, French commanders would send forward one or more heavy columns to strike selected points. Infantrymen in these columns needed minimum training. Only the front and outside men on the outside flanks could fire their muskets effectively. Columns advancing with patriotic determination on narrow fronts against sections of enemy lines already disorganized by the tirailleurs were extremely formidable. Shock conflicted with firepower; the bayonets of the columns were arrayed against the muskets of the lines.

In the French Revolutionary battles and later throughout the Empire, French infantry in column often broke enemy lines without taking their muskets from their shoulders. They were not actually exerting shock for no fighting took place. The power applied by columns was psychological, but it was just as effective. If disorganizing fear could be induced into the minds of the enemy immediately in front of the head of a French column, physical shock was unnecessary. If enemy front lines could be penetrated, the French usually won the melees which followed because of their superiority in numbers and personal valor. Where the enemies of France had two battle lines fairly close together, the second was involved in the downfall of the first. If the second line was too far back, it was unable to participate in the initial fight and was defeated in a second similar action.

b. Cavalry

i. Organization

Cavalry was reintroduced into the French Armies in the proportions common earlier in the eighteenth century. By stages, an extremely efficient cavalry composed of three distinct types was developed light cavalry was for reconnaissance and screening.

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Heavy cavalry was for use on the battlefield, to deliver shock attacks. Dragoons functioned at first as mounted infantry, but soon became true cavalry. They were intermediate between the light and heavy types and could act as either.

Napoleon used his cuirassiers and other similar heavy mounted troops for shock in battle. These horsemen had pistols and carbines for guard duty and harrying their opponents at close range, but their really effective weapon was the saber.

French squadrons usually numbered about 120 horsemen and occupied in the normal two-rank order a front of between 180 and 200 feet, if they were closed up properly on the center. Any irregularity would have increased the width. A squadron was the base unit for cavalry for battlefield action. Larger units were composed of squadrons arranged either in rough line with intervals, or in a series of these lines in echelon; columns were tactically undesirable.

ii. Tactics

In 1815, the way to use cavalry effectively was to take advantage of both forms of shock, from moving men and horses and from the saber blows of the troopers. For maximum efficiency, the speed of the charge was well under a gallop, not only to preserve a solid formation and have the horses reasonably fresh at the time of the impact, but also to allow the men to use their arms precisely. A canter or fast trot was considered best.

What happened when a French squadron of 120 men hit a British square of about 500? Only about eighteen men in the first cavalry rank could actually engage the square. If the front rank was defeated, subsequent ranks could do nothing. Some historians and even Allied eyewitnesses had the idea that the French charged in columns of several squadrons with no intervals between the ranks. This view appears to be in error; if a 'close' column of French cavalry had attacked, a single casualty in the front rank would have caused many more farther back.

c. Artillery

i. Organization

French artillery was organized into brigades, but this word is misleading. A brigade meant a battery in the modern sense. In the French horse artillery, the guns, caissons and other equipment were all horse-drawn; all gunners were mounted. These units were generally assigned to cavalry. In the foot artillery, horses were still used to draw all materiel, but the gunners marched or occasionally rode limbers and carriages for short distances. Brigades of foot artillery were composed of six guns and two howitzers. Similar horse-artillery units had four guns and two howitzers.

ii. Tactics

Napoleon used them not only to reinforce his tirailleurs in disorganizing the entire enemy front, but also to concentrate fire on the points to be attacked by his infantry columns. The French light artillery was also improved; it still dashed forward beside the columns and went into action at even shorter range, often at below 100 yards. Multiple

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ball charges were extremely effective in enfilade from the flank against an enemy line at close range.

B. THE BRITISH ARMY

1. GENERAL DESCRIPTION

a. Organization

Wellington's army organization was simple compared to Napoleon's. The Duke set up autonomous divisions in 1809 and kept them until Toulouse, but he did not have formal, permanent corps. Several divisions were sometimes placed under the command of Sir Rowland Hill, and less frequently under Sir Thomas Graham and Sir William Beresford. But these arrangements were used principally when Wellington could not command all his divisions in person because of the distances involved. When possible, he preferred to give orders himself directly to his division or even lower-echelon commanders, or to write them short, definite instructions for simple movements.

b. Strategy

In strategy, Wellington was far more straightforward and less of a gambler than Napoleon but he probably possessed an intellect fully equal to Napoleon's on military matters. These two have had few equals in military history in seeing clearly all aspects of large military problems. The Duke could not risk defeat, nor even a victory if losses would be unacceptably high; the Emperor could afford enormous casualties, but often had to win quickly, so he could get back to Paris. These considerations led to what appeared to be slow, methodical defensive procedures for Wellington as opposed to rapid strokes of offensive genius, sometimes unrewarding, for the Emperor. But the Duke could also attack with speed, power and coordination, and did so on several occasions.

Wellington saw no fundamental difference between offensive and defensive war. If he was more powerful than his enemy, he normally took the offensive. If he was not, he made up for it by using terrain, the transportation difficulties of his enemies and the many and various troubles that French Armies always had in supplying themselves. He considered every practical move the enemy could make and distributed his forces accordingly. He was most feared because of his defensive ability, but he was far from a 'one-way' player.

Wellington understood the growing dependence of the Emperor on tactical mass. The Duke must have evolved procedures to neutralize and ultimately defeat a numerous and powerful French field-artillery, Napoleon's heavy shock cavalry and full corps-size French infantry columns. He probably also pondered about the pounding attacks in series which Napoleon delivered at critical points to weaken his opposition, sometimes for hours on end, before finally sending forward the Imperial Guard to win the victory.

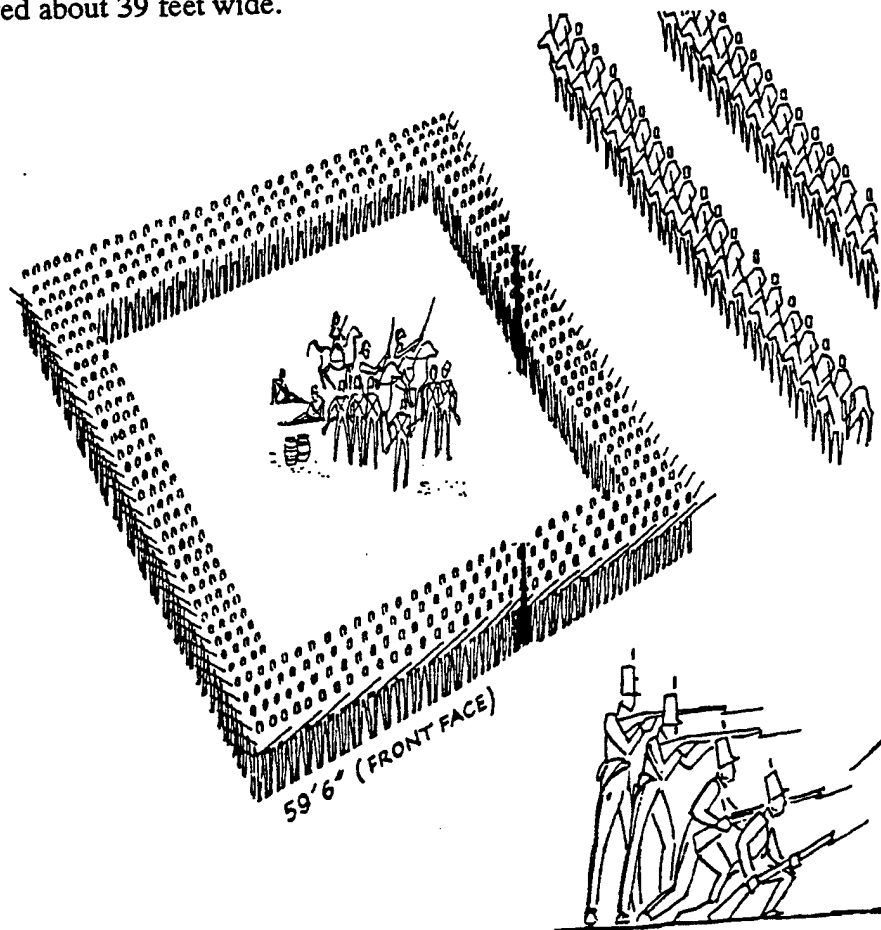
2. DESCRIPTION OF THE COMBAT ARMS

a. Infantry

i. Organization

The basic infantry unit of the British Army was the battalion; regiments, even then, were not used as field organization units. A battalion was divided into ten companies, two of which were the 'flank' companies. These two, the Grenadier and the Light (skirmishing) company, had slightly different uniforms and training, but all infantry men carried the same weapons. The eight line companies were identical and were periodically made uniform in strength.

The average British, KGL (King's German Legion) and Hanoverian battalion had a strength of about 500 men and formed a square about 60 feet on a side. In close order, a man occupied 21 inches of front; squares were formed four ranks deep. The front and rear faces of a square might have been composed of 136 men or 34 files; $34 * 21/12 = 59.5$ feet. The open space inside, exclusive of file soldiers and mounted officers, would have measured about 39 feet wide.



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ii. tactics

The basic formation of a battalion of British infantry was a line two ranks deep; the Grenadier company was on the right, the eight line companies in the center, and the light company on the left. The battalion could be formed into column by ordering all companies to swing 90 degrees pivoting on either their right or left flank, but not moving other-wise. A column so formed was known as an 'open' column. There were wide intervals between each company; the larger the battalion the more open the column. For a battalion of 500 men, this interval was about thirty-eight feet. Columns could also be formed at 'half' or 'quarter' distance which had respectively half and a quarter of the 'open' distance between companies. A 'dosed' column was formed when the companies were separated by no more than the distance between front and rear ranks of one company, a single pace of about thirty-two inches.

Columns formed on full company fronts were for drill and maneuver in fairly open terrain. Large battalions, like those of the Guards and the 52nd, probably drilled mostly as wings with columns made up of half-companies (platoons). A full company, or a half-company for large battalions, appears to have been the standard 'drill section' of that time. Marches along narrow roads, however, had to be made in narrow columns of quarter companies or even less.

British infantry by the time of Waterloo always deployed against other infantry in lines two ranks deep. When cavalry appeared, a battalion formed a square; each face was four ranks deep. When a battalion was in ranks, but not menaced by the enemy, it was normally in column of companies at quarter distance. It could form in line or into a square where it was in about thirty seconds, or move a short distance in any direction and then form. The square could be formed in several ways; if isolated from all other friendly infantry, it was probably as nearly perfect as it could be; it had equal sides and rounded corners. But where other battalion squares were present and a checkerboard alignment desirable, fronts and rears were more important than the sides. Many squares appear to have been composed of three companies in front and in the rear, with two for each side.

b. Cavalry

i. Organization

Wellington was disappointed throughout his European military career in his cavalry. The main cause was the cavalry itself: British horsemen were fine physically, brave and superbly mounted, but they lacked field training, active service experience and officers of professional competence. Wellington hesitated to mass great bodies of horse, because he doubted the tactical skill of his officers, and the power of the regiments to maneuver. 'I considered our cavalry', he wrote ten years after the war was over, 'so inferior to the French from want of order, that although one squadron was a match for two French, I did not like to see four British opposed to four French. As numbers increase, order becomes more necessary. Our men could gallop, but could not preserve their order.'

All authorities seem to agree that British cavalry units could not be controlled once they were launched in a charge.

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ii. Tactics

Cavalry and artillery were usually subordinate to infantry.

c. Artillery

i. Organization

Wellington's influence on British artillery was not as great as his influence on infantry. He made no effort to increase the size and number of his field-pieces after the French fashion. The French artillery was always superior in weight of metal and number of pieces.

ii. Tactics

Further, Wellington seldom concentrated his artillery fire. His guns were not for counterbattery work, but to support his individual infantry units, particularly against the French columns.

2. BACKGROUND OF THE BATTLE

Time line of the events from March to June

1. LES CENT JOURS

The campaign of 1814 and the First Empire just ended. It appeared that a new area in her history, "la periode des cent jours", lay before FRANCE. There was, however, one last dramatic act to be played before EUROPE saw the last of NAPOLEON BONAPARTE.

On June 18, 1815, at the farm of Le Caillou, Napoleon met his generals to draw up plans for the coming battle of Waterloo. the Emperor appeared confident, he was clearly convinced that victory awaited his forces. The well-known events of the 18th form only the climax of the short but intense military phase of the Hundred Days. The so called battle of Waterloo was in fact composite action made up of no less than four contributory actions: two on June 16, Quatre Bras and Ligny; and two on the 18th Waterloo and Wavre. Each of three smaller actions had a most decided influence on what took place between La belle alliance and the ridge of Mont-St-Jean.

The first events which drove to the battle of Waterloo are as follows

March the 25th:

A formal treaty of alliance was signed between England, Austria, Prussia and Russia to pledge over a half a million men for the destruction of "the Ogre".

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Napoleon decided an immediate offensive against the allied forces in the Netherlands. The basic plan was to defeat Prussian and British army in turn with local superiority of numbers, using the famed mobility of the French army.

June:

The moves of the French troops towards Brussels remained unknown by the Duke Wellington until 15th of June.

	Battalions	Squadrons	Batteries
French	175	180	50
English	133	109	34
Prussian	136	137	41

Table 1. French and Allied Formations Strength

The Emperor had appointed Marshal Soult as chief of staff and he gave command of the right wing to Marshall Grouchy and the left wing to Marshall Ney.

2. THE CAMPAIGN OF WATERLOO

a. June the 15th

On the afternoon, Wellington issued ordered movements away from the critical area which would actually increase the distance between the British and the Prussian armies and, thus, play straight into Napoleon's hands.

In mid-afternoon, Napoleon issued orders to both Ney and Grouchy; the former was to take the first and second corps and press forward up the Brussels road while the latter with third and fourth corps moved up the Fleurus road to meanwhile to close up on Charleroi, once the columns of Grouchy's wing had cleared the town.

As Ney's troops approached Les Quatre-Bras, they came under heavy fire from a battery of eight guns and unspecified number of infantry stationed along both sides of the main road. The late hour made it impossible to estimate even the approximate strength of their opponents, Prince's Bernard's advanced battalion and a single battery of horse artillery and the whole brigade of Nassauers (4000 infantry and eight guns) on the main position along the edge of the Bossu Woods, a little over a mile south of Quatre Bras which was reinforced despite Wellington's orders.

At night, most initial objectives had been attained (save only the town of Le Fleurus and the crossroads at Quatre Bras and the Sambre bridges had been secured intact.

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b. Battle of Ligny and Quatre Bras

At 0600 AM, the Emperor dictated two important dispatches to his subordinates. The first, addressed to Grouchy, outlined the impending operations as they would affect the French right wing, engaging any Prussians he might find there. Grouchy was to advance boldly on Sombrefe and Gembloux. A second dispatch went on to order Ney to be prepared for an immediate advance toward Brussels.

Grouchy reported that his cavalry screen had spotted strong columns of Prussian troops advancing toward Sombrefe from Namur. Napoleon decided to attack as soon as possible. Therefore, the big event would, therefore take place on the French right instead of on the left, as hitherto assumed.

	Infantry	Cavalry	Pieces Of Artillery
French	68000	12500	210
Prussian	78000	8000	224

Table 2. Forces at the Battle of Ligny

Napoleon's plan was typical in its concepts. While cavalry forces operated in such a way as to neutralize the 24,000 Prussians on Blucher's left wing, Vandamme's and Gerard's corps were to conduct a frontal attack the center and right of the Prussian position all along the line. Napoleon assumed that meanwhile Ney would have long ago taken position of the vital junction Les Quatre Bras

At 1430 hrs, the Battle of Ligny at last began. The struggle for control of the line of the Ligny brook and the small villages overlooking it swept to and fro with the utmost ferocity. Despite casualties, the IVth French corps charged four times into Ligny only to be driven back on each occasion. Meanwhile, Ney was already in action against approximately 20,000 opponents. It was thus clearly out of question to expect Ney to bring all his forces at Ligny. Napoleon ordered the VIth French corps to march on Fleurus from the outskirts of Charleroi.

By 1700 hrs, Blucher had been compelled to commit almost all its reserves into battle, while Napoleon still had almost 10,000 of his men in fresh condition; that is to say that 58,000 French troops were successfully holding down 84,000 Prussians. An undefined 20,000 men column, it was a part of d'Erlon's corps deterred Napoleon from sending up the Guard.

By 1830 hrs, Napoleon's gravest apprehensions had been relieved. Yet, the Emperor who wanted to commit the Guard in the battle, while the bulk of d'Erlon's corps was already on its way back to Quatre Bras. Blucher chose this very moment to launch a desperate counterattack and this onslaught caught the French somewhat by surprise. However, the Prussian success was short-lived.

By 1930 hrs, the order for the grand assault was given. By eight o'clock, the Battle of Ligny was almost won.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

Napoleon had achieved a great victory, but it was not complete and a great opportunity was thrown away. Although the Prussian center had been shattered, both wings remained relatively intact.

Indeed, at the junction les Quatre Bras, Ney's mistakes are largely to blame. First he had wasted the whole morning of the 16th in inactivity without having appreciated the real importance of capturing the crossroads ahead of him straight away, when sure victory was within his grasp. At 1615 hrs, the numerical advantage had at last swung in the "Iron Duke's" favor. Against all the odds, at 1700 hrs, the French attack was almost successful. Secondly, until 1830 hrs, he never fully realized that his sector had been relegated to secondary importance and was responsible for the movements of d'Erlon's troops.

c. June the 17th

Three possible courses were now open to the French. They might continue to press after Blucher with their main strength (right wing and reserve) and force a second engagement to complete the work of the previous day. Or, secondly, they could fall on Wellington with massively superior numbers with Grouchy's troops. Finally, Napoleon chose the third: to detach Grouchy with his full complement of 33,000 men to harry Blucher, and mass 69,000 troops against Wellington.

Inexplicably, there was no sign of activity from Ney's legions. It was as if the entire French Army, from the Emperor down, was under a spell. Had Ney attacked, even at midday, he could have made Wellington's withdrawal all but impossible, but he attempted nothing.

At 1400 hrs, the troops were ready to advance after Napoleon had burst in fury. However, a colossal thunderstorm burst overhead and within minutes the ground was turned into a quagmire. This ruled out any moves across country, and the French pursuit was consequently confined to the roads.

The pursuit straggled on after Wellington, but by 1830 hrs, "Iron Duke" had effected his escape to a position just beyond the ridge of Mont-Saint-Jean.

3. WATERLOO

A. ACTUAL EVENTS

1. THE TERRAIN

At first light on the 18th, at long last it had stopped raining, although the ground remained sodden.

The battlefield of Waterloo is extremely small in area. The opposing armies occupied two low ridges, separated by a gentle valley extending over a distance of some 1,500 yards. In width, the battle zone barely extended over 5,000 yards stretching from

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

the chateau of Hougoumont in the West to the town of Papelotte in the East. From the center of the French position around the small Hamlet of La Belle Alliance the Brussels-Charleroi highway traversed the area of ground separating the two armies. This road entered Wellington's forward positions at La Haye Sainte before cresting the ridge and running down the reverse slope toward Mont St Jean beyond. This road, in fact, neatly bisected the battlefield and provided the French with their main axis of advance.

2. THE FORCES COMMITTED

The assessment of the strength of the troops committed in the area we are interested in for the simulation is as follows:

	FRENCH TROOPS	ALLIED TROOPS
INFANTRY	9409	11755
CAVALRY	10020	6470
ARTILLERY (GUNS)	118	86

Table 3. Troops committed in the Battle of Waterloo

3. TIMELINE OF THE BATTLE

a. The events

1230 hrs First fires of the French field artillery
1330 hrs French infantry charge of d'Erlon's 1st corps
The English Infantry was committed: it was an hand to hand battle
The English Cavalry was launched in the battle as well
End of this onslaught
Heavy French losses: 3,000 men
A tactical mistake had brought about this slaughter
d'Erlon's troops were unable to resume the fight straight away
1500 hrs Barrage French field artillery
Set fire to the warehouses defended by the English troops
New French attempts in taking positions at La Haye Sainte and new failures
1600 hrs Attacks of the French cavalry against the center of the British Army
1800 hrs French captured La Haye Sainte was due to combined attacks of infantry, cavalry, artillery

b. The French Cavalry Attack (1600 hours)

Napoleon's first attacks had thus been repulsed. Without orders from the Emperor, Ney carried away by an excess of ardor at once ordered up a brigade of Milhaud's cuirassiers hoping to convert the allied retreat into a full scale rout without further delay.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

In the excitement the scale of the cavalry escalated out of all proportion compared to the infantry and artillery.

1. First Attack

i. First Phase

.Cav Based between the road to Charleroi and the corner SE of Goumont'wood, the entire cuirassier corps of Milhaud was launched.

.Inf The British front transformed itself into a series of 20 squares.

.Arty There were 13 British batteries. The gunners manned their pieces until the very last moment and, then, ran for cover within the neighboring squares. The artillery men were then to emerge as the French recoiled and reopen fire against their retreating backs. Although all batteries of abandoned cannons were in French hands for minutes, they never destroyed them.

ii. Second Phase

Cav Lefebvre-Denouettes (lancers and chasseurs de la garde) was launched in order to support Milhaud. They tried to maneuver and attack the left wing.

Arty The British artillery fired at the French Cavalry during the retreat.

2. Second Attack

i. First Phase

Cav Lord Uxbridge launched three brigades of cavalry against the tiring French horsemen.

ii. Second Phase

Cav However, no sooner were they at the foot of the slope when the French officers reformed their squadrons and walked them forward again in a renewed attack. The British cavalry brigades sustained heavy losses,

Inf The massed fire of the allied forces broke up a new attack before it even reached the corpse strewn crest. In the meantime, Prussian troops threatened the right wing of the French army and stormed the village of Planchenoit.

3. Third Attack

Cav Napoleon had no alternative but to order forward Kellerman's (four brigades) and Flahaut's (the Guard attacked the second time on the right wing) cavalry. At 1700 hrs, Napoleon had no formed cavalry reserve left, and between nine and ten thousand horsemen were pounding once more toward the British line.

Arty The French artillery fired until the cavalry reached the crest; however, the British kept on firing during the attack. The single battery of horse artillery which accompanied this new attack was incapable of beating the British.

Inf Wellington's squares barely survived this second crisis. The Reille's corps were conveniently placed to join in the struggle at that very moment were only committed at 1800 hrs.

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4. Fourth Attack

Cav Ney commanded this last attack at the head of the Blancard's brigade. The French remained longer at the bottom but retreated once again.

Inf The squares were protected by the corpses strewn the crest. The bodies of the dead soldiers and horses slowed down the French cavalry.

B. CONTROVERSY

Napoleon could either call off the battle or fling everything against Wellington in the hope of destroying him before Prussian assistance became effective. At 1530 hrs, Ney received a categorical order to take La Haye Sainte.

Napoleon realized how vital this position was and ordered Ney to renew the attack upon it. After the failures of the four cavalry attacks, shortly after 1800 hrs, the "bravest of the brave" again advanced to the attack with part of Donzelot's division, some cavalry and a handful of guns. At last, Ney had resorted to the correct tactical formula, a coordinated attack with all arms and his new effort was completely successful. Without delay, the French Marshal positioned a battery only 300 yards from the English center and loosed upon it a devastating fire.

Thus, the analysis of the battle and its assessment drives us to study the benefit of seizing the La Haye Sainte earlier by the French troops and the advantage of a combined arms fight with a synchronized employment.

All the assumptions will take account of the courses of action available to Napoleon as much as possible.

1. LA HAYE SAINTE NOT CAPTURED

a. Attack of the English with the only cavalry

This alternative is the exact conditions of the battle of Waterloo. This plan brought about the French disaster.

b. Combined arms attack

- a. The d'Erlon's troops sustains heavy losses and does not succeed in taking positions at La Haye Sainte and the battle continues
- b. Foy and Bachelu's troops support the cavalry during the attack of the English center.

2. LA HAYE SAINTE CAPTURED

a. Attack on the English with the only cavalry

This alternative sets up this different events as follows:

- a. d'Erlon's troops sustains heavy losses but succeeds in taking positions at La Haye Sainte yet can not support the cavalry during the attack of the English center.
- b. The field artillery batteries are positioned and can provide efficient fires before the onslaught.

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c. No infantry (Foy or Bachelu) support during the battle

b. Combined arms attack

This alternative sets up this different events as follows:

- a. Ney had resorted to the correct tactical formula, a coordinated attack with all combat arms. The French troops sustain lighter losses and succeed in taking positions at La Haye Sainte.
- b. Infantry troops (Lobau, Foy or Bachelu) can support the cavalry during the attack of the English center.
- c. The field artillery batteries are repositioned and can provide efficient fires before the onslaught.
- d. The assumption of different moves could be studied as well.

II. MODELING THE BATTLE

This chapter covers the portion of the entrance of the data : the weapons, the troops and the map in the Janus System. It required a thorough comprehension of the Janus system and detailed research about the Battle of Waterloo and the transformation of historical data into scientific.

1. MODELING THE WEAPONS

A. DESCRIPTION OF THE DATA BASE

1. CHARACTERISTICS

2. PROBABILITY OF HIT (PH) AND OF KILL (PK)

B. FRENCH WEAPONS

1. INFANTRY

2. ARTILLERY

3. CAVALRY

C. BRITISH WEAPONS

1. INFANTRY

2. ARTILLERY

3. CAVALRY

D. DATA SETS OF THE MODELING

1. TABLE OF THE WEAPONS

2. TABLE OF THE TROOPS

1. MODELING THE WEAPONS

A. DESCRIPTION OF THE DATA BASE

The Janus database describes weapons systems in detail. Individual fighting systems have distinct properties: dimensions, weight, carrying capacity, speed, weapons, and weapons capabilities like range, type of ordnance, and ammunition basic load. Multiple databases may be created for different uses, day and night, for instance, or classified and unclassified.

SYSTEM CHARACTERISTICS - PART 1

Sys Num	Sys Name	Road Spd	Sen Hgt	Max Vis	Wpn Rng	Ele Spa	Gph Sym	Det Sym	Sensor 1 2 3	Lsr Dsg	Eng Typ	Fir Typ	Fly Typ	Mov Typ	Crw Siz	Hos Cap	Pop Cap
201	fr/cui	24	3	2.0	.1	1	20		1 1 1	.	6	1	.	2	1		1
199	fr/drg	24	3	2.0	.2	1	17		1 1 1	.	6	1	.	2	1		1
202	fr/lan	24	3	2.0	.1	1	16		1 1 1	.	6	1	.	2	1		1
200	fr/inf	14	2	2.0	.5	1	7		1 1 1	.	6	1	.	2	1		1
203	12lbsg	20	3	3.0	1.8	10	2		1 1 1	.	5	1	.	1	15		1
206	6 in h	18	3	3.0	1.6	10	2		1 1 1	.	5	1	.	1	13		1
204	8-lbsg	18	3	3.0	1.6	10	2		1 1 1	.	5	1	.	1	13		1
205	6-lbsg	18	3	3.0	1.4	10	2		1 1 1	.	5	1	.	1	10		1
208	br/inf	14	2	2.0	.4	1	8		1 1 1	.	6	1	.	2	1		1
210	9-lbsg	20	3	2.0	1.5	10	1		1 1 1	.	5	1	.	1	14		1
211	6-lbsg	18	3	2.0	1.4	10	1		1 1 1	.	5	1	.	1	10		1
207	br hca	24	3	2.0	.1	1	19		1 1 1	.	6	1	.	2	1		1
209	br lca	24	3	2.0	.2	1	17		1 1 1	.	6	1	.	2	1		1

The database establishes the performance characteristics of all weapons used In Janus (e.g., range, ammunition, PH/PK, etc.). A weapon in Janus can deliver direct or indirect fire against enemy targets.

The components of the Weapons Data hierarchy are:

1. Characteristics
2. Round guidance
 - a. Probability of hit
 - b. Probability of kill
3. MOPP Effects

The modeling of the weapons in the framework of the Battle of Waterloo mainly required the data on the characteristics, the probability of hit (PH) and the probability of kill (PK).

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

1. CHARACTERISTICS

Characteristics Of Weapons In Janus Data Editor

Wpn Factors	Wpn Min Name	Rnds/ Tgr Pul	Tgr Pul til Relod	Round Vel	Inter Fir Tim	Reload Time	Time Lay	Move Fir on	Mopp Time	PH
SSKP										
1	62 cuirsaber	1	1	.0	1.0	4.0	1.0		1.20	.80
30	61 fr pistol	1	1	.3	5.0	20.0	2.0		1.20	.80
1	65 cav saber	1	1	.0	1.0	3.0	1.0		1.20	.80
50	63 cavmusket	1	1	.3	4.0	20.0	2.0		1.20	.80
1	64 fr lancer	1	1	.0	1.0	10.0	1.0		1.20	.80
50	60 frMle1777	1	1	.3	2.0	18.0	2.0		1.20	.80
1	86 bayonets	1	1	.0	1.0	5.0	1.0		1.20	.80
1	66 12p ball	1	1	.4	10.0	40.0	10.0	1	1.20	.80
1	67 12p bgrap	1	1	.4	5.0	15.0	5.0	1	1.20	.80
1	68 12p sgrap	1	1	.4	5.0	15.0	5.0	1	1.20	.80
1	87 fr how b	1	1	.2	10.0	30.0	10.0	1	1.20	.80
1	88 fr how g	1	1	.2	5.0	15.0	5.0	1	1.20	.80
1	69 8p ball	1	1	.4	10.0	40.0	10.0	1	1.20	.80
1	70 8p bgrape	1	1	.4	5.0	15.0	5.0	1	1.20	.80
1	71 8p sgrape	1	1	.4	5.0	15.0	5.0	1	1.20	.80
1	72 6p ball	1	1	.4	10.0	30.0	10.0	1	1.20	.80
1	73 6p bgrape	1	1	.4	5.0	15.0	5.0	1	1.20	.80
1	74 6p sgrape	1	1	.4	5.0	15.0	5.0	1	1.20	.80
50	75 BrownBess	1	1	.3	2.0	18.0	2.0		1.20	.80
30	78 9p shrap	1	1	.4	10.0	30.0	10.0	1	1.20	.80
30	79 9p ball	1	1	.4	10.0	30.0	10.0	1	1.20	.80
10	80 9p bgrape	1	1	.4	5.0	15.0	5.0	1	1.20	.80
30	82 6p shrap	1	1	.4	10.0	30.0	10.0	1	1.20	.80
30	83 6p ball	1	1	.4	10.0	30.0	10.0	1	1.20	.80
10	84 6p bgrape	1	1	.4	5.0	15.0	5.0	1	1.20	.80
1	77 cav saber	1	1	.0	1.0	3.0	1.0		1.20	.80
50	76 cavmusket	1	1	.3	4.0	20.0	2.0		1.20	.80

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

1. Weapon Number and Name

The weapons numbers from 1 to 400 and the weapon name (a 9-character designation for the weapon) transfer and display on all other applicable tables/screens.

2. Lay Time (Sec)

It is the average time in seconds to lay the weapon for direction of target. "Lay Time" is only used when there is more than one target detected and the firer is shifting from one target to another. Without the lay time input, the system would try to engage all targets simultaneously.

3. Aim Time (Sec)

This feature accounts for the fact that a weapon, even if pointed at a target as a function of detection and identification, must be adjusted to get its cross hairs on the target before firing.

4. Reload Time (Sec)

The average time to reload the weapon (magazine/chamber/breach/belt/clip) after all ammunition contained in that magazine/chamber/breach/belt/clip has been expended.

5. Rounds and Trigger Pull

The number of shots fired each time the trigger is depressed. If the weapon is a burst type (cannon or machine gun), the average number of rounds per trigger pull/burst is entered here.

6. Trigger Pulls and Reload

The number of shots that can be fired before the magazine/chamber/belt/clip needs to be reloaded.

7. Round Speed (km per Sec)

The average velocity of the round.

8. Minimum SSKP

The minimum single-shot kill probability. It is the lowest probability threshold at which the weapon will fire.

2. PROBABILITY OF HIT (PH) AND OF KILL (PK)

This assigns Probability of Hit (PH) and Probability of Kill (PK) data sets for each weapon against specific targets.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

-PH Data Sets (Option PH)

Probability of Hit (PH) data is expressed as the probability that a single round fired by a given weapon at a given range will result in a hit.

-PK Data Sets (Option PK)

Probability of Kill (PK) data is expressed as the probability that, given a hit by a particular weapon on a particular target, the target will be killed.

The table displays the probability of hits or kill as a percentage to five decimal places vs. five range intervals for 16 target postures.

The PH and PK are defined under four factors:

1. the motion of the firer, stationary or moving.
2. the motion of the target, stationary or moving.
3. the target's exposure, fully exposed or hull defilade
4. the aspect of the target with respect to the firer, flank or head-on .

B. FRENCH WEAPONS

1. INFANTRY

The French Infantryman was equipped with two main weapons:

1. The Mle 1802 Rifle
2. The bayonet

i) The Mle 1802 Rifle

It is an upgraded version of the French Mle 1777 Rifle.

Its main characteristics are:

- Length: 5ft.
- Weight: 10.7 pounds.
- Caliber: 0.68
- Rate of fire: 3 rounds per minute.
- 1 misfiring every 7 shots.

SYSTEM FILE PH DATA SET: 60 against infantry

RANGE (Meter)	SSDF	SSDH	SSEF	SSEH	SMDF	SMDH	SMEF	SMEH
25	.75	.75	.95	.95	.75	.75	.95	.95
50	.60	.60	.80	.80	.60	.60	.78	.80
80	.50	.50	.67	.67	.50	.50	.60	.67
160	.20	.20	.38	.38	.20	.20	.35	.38
235	.05	.05	.16	.16	.05	.05	.15	.16

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SYSTEM FILE PH DATA SET: 61 against cavalry

RANGE (Meter)	SSDF	SSDH	SSEF	SSEH	SMDF	SMDH	SMEF	SMEH
25	.75	.75	.95	.95	.75	.75	.90	.95
50	.55	.55	.80	.75	.55	.55	.70	.75
90	.40	.40	.55	.53	.40	.40	.45	.53
180	.20	.20	.35	.30	.20	.20	.25	.30
270	.10	.10	.25	.23	.10	.10	.15	.23

SYSTEM FILE PK DATA SET: 460 against inf

RANGE (Meter)	M/DF	M/DH	M/EF	M/EH
25	.90	.90	.90	.90
50	.90	.90	.90	.90
80	.80	.80	.80	.80
160	.70	.70	.70	.70

SYSTEM FILE PK DATA SET: 461 against cav

RANGE (Meter)	M/DF	M/DH	M/EF	M/EH
25	.70	.60	.70	.60
50	.65	.55	.65	.55
90	.60	.50	.60	.50
180	.50	.40	.50	.40
270	.40	.30	.40	.30

The tactics consisted of firing first with the cannons at the enemy units during their advance and shooting them with rifles as soon as they were 90 meters far from the infantry. These tactics were based on the fact that rifles were not effective enough nor accurate for distances exceeding 100 meters.

ii) Bayonets

Even if guns and rifles caused many losses against enemy lines, the decision for victory was the result of the shock of both troops. The men who were on the square flanks were unable to fire at enemies. During the contact, the only defense was the using of bayonets for the first two ranks and the use of muskets for the two last ranks.

SYSTEM FILE PH DATA SET: 586

RANGE	SSDF	SSDH	SSEF	SSEH	SMDF	SMDH	SMEF	SMEH	MSDF	MSDH	MSEF	MSEH	MMDF	MMDH
1	.70	.70	.70	.70	.70	.70	.70	.70	.60	.60	.60	.60	.60	.60
2	.40	.40	.40	.40	.40	.40	.40	.40	.30	.30	.30	.30	.30	.30
3	.20	.20	.20	.20	.20	.20	.20	.20	.10	.10	.10	.10	.10	.10

SYSTEM FILE PK DATA SET: 486

RANGE (Meter)	M/DF	M/DH	M/EF	M/EH
1	.30	.40	.30	.40
2	.40	.50	.40	.50
3	.30	.40	.30	.40

2. ARTILLERY

The place we are focused on is a triangle which circumscribes are MONT SAINT JEAN, CHATEAU DE HOUGOMONT and LA BELLE ALLIANCE. Its base is exactly the area where NAPOLEON put his artillery. The Grand Battery was on both sides of the road to Waterloo near LA BELLE ALLIANCE and the Reille's artillery reinforced by some of the Guards' 12-pounders was located there. These batteries were composed of 12-pounder guns, 8-pounder guns, 6-pounder guns and 6 inch howitzers because they were approximately 1500 meters far from Allied troops.

Different ammunitions of the gun

French artillery was using two different types of projectiles:

- ball remained the main projectile. It represented about 70% of the stock for smooth bore guns. In order to increase its effectiveness it was made of forged iron.
- grape-shot consisted in a thin metal envelope containing balls and iron pieces. It was especially used for short distances against troops.

i) The French 12-pounder gun

The main characteristics are:

- | | |
|-------------------------------|--|
| - Caliber: 121.3 mm | - Crew: 15 men |
| - Length: 2m29 | - Horses: 6 |
| - Weight: 1936 lbs. | - Caissons: 3 |
| - Ball's weight: 12 lbs. | - Ordinary balls: 153 |
| - Muzzle velocity: 415 m/s | - Big grape-shots: 36 |
| - Full weight: 4620 lbs. | - Small grape-shots: 24 |
| - Caisson's weight: 3960 lbs. | - Rate of Fire: 1 ball per minute
2 to 3 grape-shot |

Use of balls according to the distance from the target

Distance	Type of projectile
0 to 500m	small grape-shot
500 to 700m	big grape-shot
over 700m	ordinary ball

ii) The French 8-pounder gun

The main characteristics are:

- | | |
|-----------------------------|---|
| - Caliber: 106.1mm | - Crew: 13 |
| - Length: 2m | - Horses: 4 |
| - Weight: 580kg | - Caissons: 2 |
| - Ball's weight: 4 kg | - Ordinary balls: 137 |
| - Muzzle velocity: 419 m/s | - Big grape-shots: 20 |
| - Full weight: 1650 kg | - Small grape-shots: 40 |
| - Caisson's weight: 1700 kg | - Rate of Fire: 1 ball per minute
2 or 3 grape-shots |

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Use of balls according to the distance from the target

Distance	Type of projectile
0 to 400m	small grape-shot
400 to 600m	big grape-shot
over 600m	ordinary ball

iii) The French 6-pounder gun

The main characteristics are:

- | | |
|-----------------------------|---|
| - Caliber: 96mm | - Crew: 10 |
| - Length: 1.80m | - Horses: 4 |
| - Weight: 400 kg | - Caissons: 2 |
| - Ball's weight: 3 kg | - Ordinary balls: 127 |
| - Muzzle velocity: 418 | - Big grape-shots: 24 |
| - Full weight: 1300 kg | - Small grape-shots: 0 |
| - Caisson's weight: 1600 kg | - Rate of Fire: 1 ball per minute
2 to 5 grape-shots |

Use of balls according to the distance from the target

Distance	Type of projectile
0 to 400m	small grape-shot
400 to 600m	big grape-shot
over 600m	ordinary ball

iv) The French 6-inch howitzer

The main characteristics are:

- | | |
|-----------------------------|-----------------------------------|
| - Caliber: 165.7mm | - Crew: 13 |
| - Length: 76 cm | - Horses: 4 |
| - Weight: 330 kg | - Caissons: 3 |
| - Ball's weight: 11 kg | - Ordinary balls: 147 |
| - Muzzle velocity: 170 m/s | - Big grape-shots: 13 |
| - Full weight: 1450 kg | - Small grape-shots: 0 |
| - Caisson's weight: 1600 kg | - Rate of Fire: 1 ball per minute |

Use of balls according to the distance from the target

Distance	Type of projectile
0 to 400m	small grape-shot
400 to 600m	big grape-shot
over 600m	ordinary ball

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

Modeling on the Janus system

We have defined the four types of artillery guns:

The 12-pound gun	Janus System Number 203
The 12-pound ball	Janus Weapon Number 66
The 12-pound big grape-shot	Janus Weapon Number 67
The 12-pound small grape-shot	Janus Weapon Number 68
The 8-pound gun	Janus System Number 204
The 8-pound ball	Janus Weapon Number 69
The 8-pound big grape-shot	Janus Weapon Number 70
The 8-pound small grape-shot	Janus Weapon Number 71
The 6-pound gun	Janus System Number 205
The 6-pound ball	Janus Weapon Number 72
The 6-pound big grape-shot	Janus Weapon Number 73
The 6-pound small grape-shot	Janus Weapon Number 74
The 6-inch howitzer	Janus System Number 206
The 6-inch ball	Janus Weapon Number 87
The 6-inch grape-shot	Janus Weapon Number 88

3. CAVALRY

The French cavalry was composed of different units and regiments equipped with weapons according to their missions.

a. Description of the French equipment

The Cuirassiers were equipped with:

- a pistol
- a heavy saber

The Dragoons were equipped with:

- a cavalry musket
- a light saber

The Lancers were equipped with:

- a spear
- a light saber

i) Pistols and cavalry muskets

These two weapons were used during the approach to the enemy but fired close to be effective. Cuirassiers and Dragoons fired between 20 and 50 meters far from infantry lines at fast trot in order to have enough time to take their saber. They were unable to reload these weapons during attack.

The characteristics of the cavalry musket were closed to Mle 1802 Rifle's.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

ii) Sabers

They are the main weapons of horsemen close to the enemy. The blade was about one-meter long. The heavier was the saber, the more effective it was. Techniques in saber combat consisted of attacking with the horse at high speed and striking enemy. However, at Waterloo, French horsemen did not enough speed and their momentum was broken by British squares.

iii) Spears

Made of iron or wood, the spear was used for early attacks to disorganize enemy forces. With a length of 3 meters it was very effective against troops equipped with bayonets. Lancers often used surprise and speed when attacking enemy.

b. Modeling with the Janus system

We have defined the two types of artillery guns:

The French Cuirassiers:	Janus Number 201
The French Dragoons:	Janus Number 199
The French Lancers:	Janus Number 202

C. BRITISH WEAPONS

1. INFANTRY

a. Description of the British equipment

The British Infantryman was equipped with two main weapons:

- i. The British Brown Bess musket
- ii. The bayonet

i) The British Brown Bess musket

Its main characteristics are:

- Length: 5ft
- Weight: 10 pounds
- Caliber: 0.42
- Rate of fire: 3 rounds per minute.
- 1 misfiring every 7 shots.

The tactics consisted of firing first with the cannons at the enemy units during their advance and shooting them with rifles as soon as they were 90 meters far from the infantry. These tactics were based on the fact that rifles were not effective enough nor accurate for distances exceeding 100 meters.

The British musket was less accurate and effective than the French one.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

ii) Bayonets

Guns and rifles caused many losses against enemy lines; yet, the decision for victory was the result of the shock of both troops. The men who were on the square sides were unable to fire at the enemy.

During the contact, the only defense was the use of bayonets for the first two ranks and the use of muskets for the two last ranks.

b. Modeling on the Janus system

We have defined the	British Infantryman	Janus System Number 208
	Brown Bess Musket	Janus Weapon Number 75
	Bayonets	Janus Weapon Number 86

2. ARTILLERY

Duke Wellington placed his artillery batteries on the crest forward his brigades and his squares.

They were two types of guns equipping the 13 batteries of the British Artillery

- i. 9-pounder guns
- ii. 6-pounder guns.

These guns used different types of balls according to the distance from the target

Distance (m)	Type of projectile
000-250	small grape-shot
250-350	big grape-shot
350-600	ordinary ball
600-1300	shrapnel

i) The British 9-pounder gun

The main basic load characteristics are:

- Ordinary balls: 88
- Big grape-shots: 8
- Small grape-shots: 8
- Shrapnel: 12
- Rate of Fire: 1 to 2 balls per min.
2 to 3 grape-shot per min.

Distance	Type of ball	Number
0 to 90m	small grape-shot	2
90 to 310m	small and big grape-shot	4 small and 4 big
310 to 570m	ordinary ball	7
570 to 1350m	shrapnel	19

Use Of Balls According To The Distance From The Target And The Time To Fire

Distance	Type of ball	Number
0 to 310m	small and big grape-shot	2
310 to 570m	ordinary ball	2
570 to 1350m	shrapnel	7

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

Use Of Balls Against Cavalry According To The Distance From The Target And The Time Of Fire

ii) The British 6-pounder gun

The main basic load characteristics are:

- Caissons: 4
- Ordinary balls: 132
- Big grape-shots: 14
- Small grape-shots: 14
- Shrapnel: 20
- Rate of Fire: 1 to 2 balls per min.
2 to 3 grape-shot p min.

Distance	Type of ball	Number
0 to 90m	small grape-shot	2
90 to 310m	small and big grape-shot	4 small and 4 big
310 to 570m	ordinary ball	7
570 to 1350m	shrapnel	19

Use of balls against infantry according to the distance from the target and the time of fire

Distance	Type of ball	Number
0 to 310m	small and big grape-shot	2
310 to 570m	ordinary ball	2
570 to 1350m	shrapnel	7

Use of balls against cavalry according to the distance from the target and the time of fire

Modeling on the Janus system

We have defined the two types of artillery guns:

- The 9-pound gun: Janus Number 210
- The 6-pound gun: Janus Number 211

3. CAVALRY

Description of the British equipment

British cavalry, as well as French horsemen, were equipped with short muskets and sabers.

Modeling with the Janus system

We have defined the two types of the British Cavalry

- 1. Light cavalry: Dragoons, Hussars, Carabiniers Janus number: 209
- 2. Heavy cavalry: Uhlans Janus number: 207

D. DATA SETS OF THE MODELS

A. TABLE OF THE WEAPONS

Nu	Code	Weapon	PH vs inf	PH vs cav	PK vs inf	PK vs cav
60	Mle1777	French Musket	60	61	460	461
61	Pistol	French Pistol of Cuirassiers	62		362	
62	CuirSabe	Saber of Cuirassiers	63		463	
63	Carbine	French Carbine of Dragoons	464		460	
64	Lancer	French spear	465		465	
65	Saber	Saber of Dragoons	63		464	
66	12p ball	Ordinary ball of 12lbs gun	466	566	466	
67	12p bgrape	Big grape-shot	567	667	468	
68	12p sgrape	Small grape-shot	568	668	469	
69	8p ball	Ordinary ball of 8lbs gun	569	769	470	
70	8p bgrape	Big grape-shot	570	670	471	
71	8p sgrape	Small grape-shot	568	668	469	
72	6p ball	Ordinary ball of 6lbs gun	572	672	470	
73	6p bgrape	Big grape-shot	570	670	471	
74	6p sgrape	Small grape-shot	568	668	469	
75	BrownBess	British Musket	575	675	475	
76	Carbine	British Carbine of Light Cav.	575		475	
77	Saber	British Saber	63		464	
78	9p shrap	Schrapnels of 9lbs gun	578	678	477	
79	9p ball	Ordinary ball	579	679	481	
80	9p bgrape	Grape-shot	580	780	482	
82	6p shrap	Schrapnels of 6lbs gun	582	782	477	
83	6p ball	Ordinary ball	583	783	481	
84	6p bgrape	Grape-shot	584	784	482	
86	Bayonets	Bayonets	586	786	486	
87	how ball	French 6in howitzer ball	569	769	470	
88	how grape	Grape-shot	568	668	469	

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

B. TABLE OF THE TROOPS

System Number	System Symbol	System
199	fr drag	French Dragoons, Huzards
200	fr inf	French Infantry
201	fr cuir	French Cuirassiers
202	fr lancer	French Lancers
203	12lbs gun	French 12 lbs gun
204	8lbs gun	French 8 lbs gun
205	6lbs gun	French 6 lbs gun
206	6in hwt	French 6 inch howitzer
207	br hcav	British Heavy Cavalry
208	br inf	British Infantry
209	br lcav	British Light Cavalry
210	9lbs gun	British 9 lbs gun
211	6lbs gun	British 6 lbs gun

2. MODELING THE TROOPS

A. FORCE DEFINITION

- 1. UNIT DEFINITIONS**
- 2. BASIC UNIT**

B. FRENCH TROOPS

SIDE 1-BLUE FORCES

1. CAVALRY TROOPS (Task-Forces 1-2)

- a. Organization**
- b. French Structures: the Squadron**
- c. Modeling on the Janus System**
- d. Troops committed**
 - i. First and second attacks
 - ii. Third and fourth attacks

2. INFANTRY TROOPS (Task-Force 3)

- a. Organization**
- b. French Structures**
 - i. The Company
 - ii. The Battalion
- c. Modeling with the Janus System**
- d. Troops committed**

3. ARTILLERY TROOPS (Task-Force 4)

- a. Organization**
- b. French Structures: The Brigade**
- c. Modeling in the Janus System**
- d. Troops committed**

C. BRITISH TROOPS

SIDE 2-RED FORCES

1. INFANTRY TROOPS (Task Force 1)

- a. Organization**
- b. British Structures**
 - i. The Company
 - ii. The Battalion
- c. Modeling in the Janus System**
- d. Troops committed**

2. ARTILLERY TROOPS

- a. Organization**
- b. British Structures: The Brigade**
- c. Modeling in the Janus System**
- d. Troops committed**

3. CAVALRY TROOPS (Task-Force 3)

- a. Organization**
- b. British Structures**
- c. Modeling on the Janus System**
- d. Troops committed**

2. MODELING OF THE TROOPS

A. FORCE DEFINITION

The Force Definition is an option of the main menu. It permits us to build a new scenario. This selection builds the scenario's force file (the list of weapon systems) and the system file (the database characteristics for the systems assigned in the force file). It permits us to change forces in an existing scenario and to update the scenario's system characteristics from the database.

1. UNIT DEFINITIONS

The option Unit Definitions permits us to enter the systems for the scenario, to task organize them, and to give them certain attributes. They permit not only to build a Force File for a new scenario, but also to modify the Force File of an existing scenario, usually by adding or deleting units.

Example of the French forces

SIDE 1 UNIT DEFINITIONS

Unit	System	Sys	Num	Task
ID	Name	Typ	Ele	Force
001	Fr/inf	200	90	3
002	Fr/Drag	199	60	2
003	12-lbs	203	06	4

The maximum aggregation of most systems is 99. The maximum aggregation for artillery systems is 40. In this case, the French infantry icon belongs to Task Force 3 and has 90 soldiers represented by 1 icon.

Each workstation on a side may have as many as five task forces. The workstation with Group 1 will have task forces 1-5; Group 2 will have 6-10; Group 3, 11 - 15,

2. BASIC UNIT

For each kind of troop organization, we modeled a basic unit. This basic unit has the same number of basic elements (French cuirassier or British Light horseman) which have just been defined in the last chapter.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

The choice of this number must take into account the facts as follows:

- a. the limited number (under 100) accepted by Janus
- b. the own organization of the troops

We approximated the number of units created with the real number of soldiers who took part to the battle and not according the number of squadrons whose strength always varies due to previous losses.

This method has the following advantages:

1. It allows us to know the number of losses each time a basic unit disappears.
2. Each large unit is composed of a specific number of a well-defined basic units and permits us to understand how it changes in size during the battle.

B. FRENCH TROOPS

SIDE 1-BLUE FORCES

1. CAVALRY TROOPS (Task-Forces 1-2)

a. Organization

The French cavalry was composed of three distinct types:

1. Light cavalry was for reconnaissance and screening.
2. Heavy cavalry was for use on the battlefield, to deliver shock attacks.

Napoleon used his cuirassiers and other similar heavy mounted troops for shock in battle.

3. Dragoons functioned as mounted infantry.

They were intermediate between the light and heavy types and could act as either.

b. French Structures: the Squadron

The squadron was the basis of cavalry battlefield action. Larger units were composed of squadrons arranged either in rough line with intervals, or in a series of these lines in echelon.

Strength	120 horsemen
Speed	A canter or fast trot
Equipment	Pistols and carbines, but their really effective arm was the saber
Tactical disposition	Two-rank order a front of between 180 and 200 feet
Attack of a square	Only eighteen men in the first cavalry rank could actually engage the square .

c. Modeling in the Janus System

basic unit : a half squadron of 60 horsemen

d. Troops committed

i. First and second attacks

* The entire IV Reserve Cavalry Corps charged behind Marshal NEY. Its commander-in-chief was General de Division Milhaud and it was composed of the 13th and 14th Cavalry Divisions.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

Task Force 1

Regiment	Division	Brigade	Commander	Strength	Num unit	Unit ID
1st Cuirassiers	13th	1st	Colonel Ordener	466	8	1-8
4th Cuirassiers	13th	1st	Colonel Habert	314	5	9-13
7th Cuirassiers	13th	2nd	Colonel Richardot	180	3	14-16
12th Cuirassiers	13th	2nd	Colonel Thurot	258	5	17-21
5th Cuirassiers	14th	1st	Colonel Gobert	518	9	22-30
10th Cuirassiers	14th	1st	Colonel Lahuberdie	359	6	31-36
6th Cuirassiers	14th	2nd	Colonel Martin	285	5	37-41
9th Cuirassiers	14th	2nd	Colonel Bigarne	412	7	42-48
Total				2792	48	1-48

**** The Imperial Guard Light Cavalry Division** commanded by General Lefebvre-Desnouettes also took part in this battle.

Task Force 1

Regiment	Brigade	Commander	strength	Num-unit	Unit ID
Old Guard Chasseurs	1st	General Lallemant	1197	20	49-68
Guard Lancers	2nd	General Colbert-Chabanaïs	880	15	69-83
Total			2077	35	49-83

ii. Third and fourth attacks

* For these attacks, NEY's troops were reinforced by **Imperial Guard Heavy Cavalry Division** commanded by General Guyot and **III Reserve Cavalry Corps** commanded by General Kellermann.

**** III Reserve Cavalry Corps**

Task Force 2

Regiment	Division	Brigade	Commander	Strength	Squadrons	Unit.ID
2nd Dragoons	11th	1st	Colonel Planzeau	593	10	84-93
7th Dragoons	11th	1st	Colonel Leopold	517	9	94-102
8th Cuirassiers	11th	2nd	Colonel Garavaque	459	8	103-110
11th Cuirassiers	11th	2nd	Colonel Courtier	332	5	111-115
1st Carabiniers	12th	1st	Colonel Roge	434	7	116-122
2nd Carabiniers	12th	1st	Colonel Beugnat	413	7	123-129
2nd Cuirassiers	12th	2nd	Colonel Grandjean	311	5	130-134
3rd Cuirassiers	12th	2nd	Colonel Lacroix	480	8	135-142
Total				3539	59	84-142

***** Imperial Guard Heavy Cavalry Division**

Task Force 2

Regiment	Brigade	Commander	Strength	Squadrons	Unit.ID
Old Guard Grenadiers	1st	General Jamin	796	13	143-155
Guard Dragoons	2nd	General Letort	816	14	156-169
Total			1612	27	143-169

2. INFANTRY TROOPS (Task-Force 3)

a. Organization

The French Infantry was composed of

1. The tirailleurs :25 per cent of their total force

They maintained no rigid alignment, but took advantage of cover and swept away the skirmishers of the enemy.

2. Heavy columns

They attacked selected points. French shock forces faced the firepower of British Infantry.

b. French Structures

i. The Company

Strength 90 men
 Equipment French infantry in column often broke enemy lines without taking their muskets from their shoulders.
 Trump Card Their superiority in numbers and personal valor.
 Tactical disposition Three ranks deep and about 30 men broad.
 The distance between ranks was 30-32 inches
 Attack of the enemy Only the front and outside men on the flanks could fire their muskets effectively against enemy lines already disorganized by the tirailleurs.

ii. The Battalion

Strength 580 men or 6 companies.
 Tactical disposition front: one or two companies (30 or 60 files)
 depth: 18 or 9 ranks
 or 68, 34, or 17 feet apart - full, half, or quarter distance.
 or a 'close' column with 30-32 inches between successive companies

At Waterloo, entire battalions were formed into three rank lines and these battalions placed one behind another.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

c. Modeling in the Janus System

basic unit : a company of 90 men

d. Troops committed

* Infantry didn't intervene during the cavalry attacks but the following forces will be used to re-fight the battle (scenario 2,4).

*** The 5th Infantry Division commanded by Bachelu and the 9th Infantry Division commanded by Foy could have supported the cavalry attacks.

Task-Force 3

Regiment	Div	Brig	Commander	Bns	Strength	Num-comp	Unit.ID
3rd Reg of Line	5th	1st	Col Vautrin	2	1143	13	170-182
61 Reg of Line	5th	1st	Colonel Bouge	2	858	10	183-192
72nd Reg of Line	5th	2nd	Col Thibault	2	995	11	193-203
108th Reg of Line	5th	2nd	Col Higonet	3	1107	12	204-215
92nd Reg of Line	9th	1st	Colonel Tissot	2	1068	12	216-227
93rd Reg of Line	9th	1st	Colonel Massot	3	1486	17	228-244
100th Reg of Line	9th	2nd	Colonel Braun	3	1118	12	245-256
4th Light Inf Reg	9th	2nd	Colonel Peyris	3	1614	18	257-274
Total	2	4		20	9409	105	170-274

3. ARTILLERY TROOPS (Task-Force 4)

a. Organization

The French artillery was composed of :

The horse artillery: assigned to cavalry, all the materiel and gunners were mounted.

The foot artillery : movements slower

b. French Structures: The Brigade (equivalent to a present day "battery")

Strength between 10 and 15 men

Equipment

Foot artillery: six guns and two howitzers

Horse-artillery : four guns and two howitzers

Tactical disposition

French light artillery

1. Position beside the columns

Shorter range 100 yards.

Concentration of fires

2. In enfilade, from the flank against an enemy line

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

c. Modeling in the Janus System

* Basic units: We have created units under the type of the guns and their number.

d. Troops committed

* Napoleon decided to form several artillery organizations on the battlefield. One of them was the **Great Battery** composed of about 80 guns.

** Great Battery

Regiment	Corps/Div	Brig	Commander	12p gun	8p gun	6p gun	6in hwt
Old Foot Arty Reg	Guard/Res	1st	General Lallemand	6			2
Old Foot Arty Reg	Guard/Res	2nd	General Lallemand	6			2
Old Foot Arty Reg	Guard/Res	3rd	General Lallemand	6			2
Old Foot Arty Reg	Guard/Res	4th	General Lallemand	6			2
6th Foot Arty Reg	I/Reserve	11th	Captain Charlet	6			2
6th Foot Arty Reg	I/1st Inf	20th	Captain Hamelin		2	6	
6th Foot Arty Reg	I/2nd Inf	10th	Captain Cantin		2	6	
6th Foot Arty Reg	I/3rd Inf	19th	Captain Emon		2	6	
6th Foot Arty Reg	I/4th Inf	9th	Captain Bourgeois		2	6	
1st Horse Arty Reg	I/1st Cav	2nd	Captain Bourgeois		2	4	
Total		10		30	10	28	10

Regiment	Brig	Unit-ID	Unit-ID	Unit-ID	Unit-ID	Task-Force
		12p-gun	8p-gun	6p-gun	6in-hwt	
Old Foot Arty Reg	1st	275			276	4
Old Foot Arty Reg	2nd	277			278	4
Old Foot Arty Reg	3rd	279			280	4
Old Foot Arty Reg	4th	281			282	4
6th Foot Arty Reg	11th	283			284	4
6th Foot Arty Reg	20th		285	286		4
6th Foot Arty Reg	10th		287	288		4
6th Foot Arty Reg	19th		289	290		4
6th Foot Arty Reg	9th		291	292		4
1st Horse Arty Reg	2nd		293	294		4
Total	10	5	5	5	5	

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

**Reille's Artillery

Regiment	Corps/Div	Comp	Commander	12 lbs gun	8 lbs gun	6 lbs gun	6in hwt
2nd Foot Arty Reg	II/Reserve	7th	Captain Valnet	6			2
6th Foot Arty Reg	II/5th Inf	18th	Captain Dehaulles		2	6	
2nd Foot Arty Reg	II/6th Inf	2nd	Captain Meunier		2	6	
6th Foot Arty Reg	II/9th Inf	1st	Captain Tacon		2	6	
4th Horse Arty Reg	II/2nd Cav	2nd	Captain Gronnier		2	4	

Regiment	Brig	Unit-ID	Unit-ID	Unit-ID	Unit-ID	Task-Force
		12p gun	8p gun	6p gun	6in-hwt	
2nd Foot Arty Reg	7th	295			296	4
6th Foot Arty Reg	18th		297	298		4
2nd Foot Arty Reg	2nd		299	300		4
6th Foot Arty Reg	1st		301	302		4
4th Horse Arty Reg	2nd		303	304		4
Total	5	1	4	4	1	

C. BRITISH TROOPS

SIDE 2-RED FORCES

The infantry is the most important branch in the British camp and will be defined first in this section.

1. INFANTRY TROOPS (Task Force 1)

a. Organization

The British Infantry was composed of

b. British Structures

i. The Company

Strength 50 men (2 platoon of 25 men)

Equipment

Tactical disposition in the square, 25 fired with their muskets
25 used their bayonets

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

ii. The Battalion

Strength

10 companies, two of which were the 'flank' companies: the Grenadier and the Light (skirmishing) company..

Tactical disposition 1. A square about 60 feet (against cavalry)

Squares were formed four ranks deep.

Three companies in front and in the rear, with two for each side.

2. A line two ranks deep (against infantry)

The Grenadier on the right

The eight line companies in the center

The light company on the left.

3. A column known as an 'open' column

All companies pivoting

c. Modeling on the Janus System

basic unit : a company of 50 men

d. Troops committed

* The French cavalry focused its attacks on the I Army Corps of Anglo-Allied Army at Waterloo. This corps was composed of :

- 1st Infantry Division commanded by Major General Cooke with 1st Brigade (Major General Maitland) and 2nd Brigade (Major General Byng).

- 3rd Infantry Division commanded by Lt. General Alten with 5th British Brigade (Major General Colin Halkett), 2nd King's German Legion Brigade (Colonel Ompteda) and 1st Hanoverian Brigade (Major General Kielmansegge).

Task-Force 1

Battalion	Div	Brig	Commander	Strength	NB	Unit-ID
1st Foot Guards/2nd	1st	1st Br	Major Askew	798	16	1-16
1st Foot Guards/3rd	1st	1st Br	Major Stewart	840	17	17-33
Coldstream Guards/2nd	1st	2nd Br	Major Woodford	1120	22	34-55
3rd Foot Guards/2nd	1st	2nd Br	Major Hepburn	1174	23	56-78
30th Reg of Foot/2nd	3rd	5th Br	Major Bailey	649	13	79-91
33rd Reg of Foot	3rd	5th Br	LCL Elphinstone	596	12	92-103
69th Reg of Foot/2nd	3rd	5th Br	LCL Morice	577	12	104-115
73rd Reg of Foot/2nd	3rd	5th Br	LCL Harris	538	10	116-125
1st Light KGL Bn	3rd	2nd Kgl	LCL Bussche	519	11	127-136
2nd Light KGL Bn	3rd	2nd Kgl	Major Baring	463	9	137-145
5th Line KGL Bn	3rd	2nd Kgl	LCL Linsingen	529	10	146-155
8th Line KGL Bn	3rd	2nd Kgl	LCL Schroeder	636	13	156-168
Duke of York's 1st Field Battalion	3rd	1st Han	Major Bulow	632	12	169-180
Field Bn Grubenhagen	3rd	1st Han	LCL Wurmb	643	13	181-193
Field Bn Bremen	3rd	1st Han	LCL Langrehr	533	11	194-204
Field Bn Verden	3rd	1st Han	Maj de Schkopp	559	12	205-216
Field Bn Luneburg	3rd	1st Han	LCL Klencke	617	12	217-228
Field Jager Rifle Corps	3rd	1st Han	Cap von Reden	331	7	229-235
Total	3	5		11755	235	1-235

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

2. ARTILLERY TROOPS

a. Organization

The British artillery was composed of :
The horse artillery: assigned to cavalry, all the materiel and gunners were mounted.
The foot artillery : movements slower

b. British Structures: The Brigade

Equipment the 9 pounder gun and the 6 pounder gun
Tactical disposition seldom concentration of fire.
not for counter-battery work
direct support for his individual infantry units, particularly against the French columns.

c. Modeling in the Janus System

basic units: There is no real basic unit. We have created units under the type of the guns and their number

d. Troops committed

* Duke of Wellington deployed its artillery on the crest north of road between chateau of Hougomont and road to Brussels. There were 13 batteries along the ridge.

Task-Force 2

Unit	Commander	Pieces	9-pounder gun	6-pounder gun
Royal Horse Arty of Cav Corps	Major Bull	6	6	
Royal Horse Arty of Cav Corps	Major Ramsay	6	6	
Horse Arty Battery of Attached Horse Arty	Captains Petter & Gey	8	2	6
Royal Horse Arty of Cav Corps	Lt. Col. Webber Smith	6	1	5
Royal Horse Arty of British Reserve Arty	Major Beane	6	1	5
2nd KGL Horse Arty Battery of 1st Inf Div	Major Kuhlmann	6	6	
Royal Foot Arty of 1st Inf Div	Captain Sandham	6	6	
Royal Foot Arty of 3rd Inf Div	Major Lloyd	6	6	
1st KGL Foot Battery of 3rd Inf Div	Captain Cleeves	6	6	
Royal Horse Arty of British Reserve Arty	Lt. Col. Ross	6	6	
Royal Foot Arty of 5th Inf Div	Major Rogers	6	6	
Royal Horse Arty of Cav Corps	Captain Mercer	6	6	
Royal Foot Arty of 2nd Inf Div	Captain Bolton	6	6	
1st KGL Horse Arty Battery of 2nd Inf Div	Major Sympher	6	6	
Total		86	70	16

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

Unit	Unit-ID	Unit-ID
	9-pounder gun	6-pounder gun
Royal Horse Arty of Cav Corps	236	
Royal Horse Arty of Cav Corps	237	
Horse Arty Battery of Attached Horse Arty	238	239
Royal Horse Arty of Cav Corps	240	241
Royal Horse Arty of British Reserve Arty	242	243
2nd KGL Horse Arty Battery of 1st Inf Div	244	
Royal Foot Arty of 1st Inf Div	245	
Royal Foot Arty of 3rd Inf Div	246	
1st KGL Foot Battery of 3rd Inf Div	247	
Royal Horse Arty of British Reserve Arty	248	
Royal Foot Arty of 5th Inf Div	249	
Royal Horse Arty of Cav Corps	250	
Royal Foot Arty of 2nd Inf Div	251	
1st KGL Horse Arty Battery of 2nd Inf Div	252	
Total	14	3

3. CAVALRY TROOPS (Task-Force 3)

a. Organization

There were two main types of British Cavalry

1. Light cavalry: Dragoons, Hussars, Carabiniers
2. Heavy cavalry: Uhlans

b. British Structures

We have considered the British structures similar to the French one.

c. Modeling with the Janus System

Basic unit : a squadron of 60 horsemen

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

d. Troops Committed

* The **Cavalry Corps** was commanded by Lieutenant General The Earl of Uxbridge. This corps counterattacked French cavalry during their retreat.

****Cavalry from Brunswick contingent**

Squadron	Brigade	Commander	Strength	Num unit	Unit-ID
Squadron of Uhlans	Line Brigade	Lt Colonel von Buttler	249	4	253-256
Total	1		249	4	253-256

***** Cavalry Corps**

Regiment	Brigade	Commander	Squad	Strength	n squad	Unit-ID
23rd Light Dragoons	3rd	LCL Portarlington	3	360	6	257-262
1st Light Dragoons	3rd	LCL Bulow	4	572	9	263-271
2nd Light Dragoons	3rd	LCL de Jonquieres	4	553	9	272-280
13th Light Dragoons	7th	LCL Doherty	3	456	8	281-288
3rd Hussars	7th	LCL Meyer	4	875	15	289-303
1st Dutch Carabiniers	HC Brig	LCL Coenegracht	3	446	7	304-310
2nd Belgian Carabiniers	HC Brig	LCL de Bruijn	3	399	7	311-317
3rd Dutch Carabiniers	HC Brig	LCL Lechleitner	3	392	7	318-324
4th Dutch Light Dragoons	1st LC Brig	LCL Renno	4	647	11	325-335
8th Belgian Hussars	1st LC Brig	LCL Davivier	3	439	7	336-342
5th Belgian Light Dragoons	2nd LC Brig	LCL de Merex	3	441	7	343-349
6th Dutch Hussars	2nd LC Brig	LCL Bereel	4	641	11	350-360
Total	5		41	6221	104	257-360

3. WATERLOO AT 1600 HRS

A. CARTOGRAPHY

- 1. RESOLUTION**
- 2. UTM GRID COORDINATES**
- 3. SIZE OF THE TERRAIN AND THE CONTOUR INTERVAL**

B. TERRAIN

- 1. REPRESENTATION ON THE JANUS SYSTEM**
- 2. GEOGRAPHIC MAPS AND BUILDINGS**
 - a. Main elements of the terrain**
 - b. The Terrain**
 - c. Historical Map**

C. TROOPS

- 1. REPRESENTATION ON THE JANUS SYSTEM**
 - a. Positioning Of The Troops**
 - b. Planning Of The Movements**
 - c. Planning Of The Artillery Fires And Barriers**
 - i. Planning Artillery Missions**
 - ii. Positioning Craters**
- 2. MAPS OF THE BATTLE WATERLOO 16.00 HRS**

3. WATERLOO AT 1600 HRS

The simulation uses digitized terrain developed by the Defense Mapping Agency, displaying it in a form familiar to military users with contour lines, roads, rivers, vegetation, and urban areas. Also the main elements of the terrain: buildings, fences, generic areas, and generic strings can be represented.

Eventually, to model the battle of Waterloo at 1600 hrs, our tasks were to:

1. position the units.
2. establish the movement routes.
3. to plan the fire artillery missions.
4. to position the barriers in order to simulate the casualties on the battlefield.

A. CARTOGRAPHY

The Janus Terrain Editor prepares a scenario terrain file from one of the Master Terrain Files (MTF). MTF are based on Defense Mapping Agency digitized terrain base files. The results of this customizing process are used by the Janus model to display terrain and determine lines of sight and movement factors.

1. RESOLUTION

The size of each grid cell is referred to as the "resolution" of the grid cell data. A scenario terrain file will always be displayed as 1000 grid cells wide (east to west on the display screen) and 1000 grid cells long (north to south on the screen) independent of the data resolution. Thus, the size (square kilometers) of a map area for a particular scenario terrain file is dependent upon the resolution of the data found within the grid cell. The higher the resolution, the less terrain displayed on the screen.

In the case of the battle of Waterloo, the resolution is one meter.

<u>Common Resolutions</u>	<u>Maximum Man Size</u>
100m	100Km
50m	50Km
25 m	25Km

2. UTM GRID COORDINATES

The UTM 8-digit grid coordinate of the southwest corner of the map segment you want to edit.

In the case of the battle of Waterloo, the coordinates (kilometers) of this point chosen are

X: 9700

Y: 1600

3. SIZE OF THE TERRAIN AND THE CONTOUR INTERVAL

The size is expressed as the width and length (as in screen height) in even kilometers. For example, you may want to edit a piece of terrain with dimensions of thirty kilometers on each side. This dimension will always be the same for both width and length.

In the case of the battle of Waterloo, the size (kilometers) of the terrain is 5

In the case of the battle of Waterloo, the contour interval is 2 meters. The contour lines are brown.

B. TERRAIN

1. REPRESENTATION ON THE JANUS SYSTEM

The Terrain Editor (TED) is an interactive graphics computer program which allows the Janus database manager to prepare a Janus terrain file and Janus map file from an existing terrain file. This allows the customizing of terrain files to meet specific scenario requirements.

TED supports general categories of terrain features.

Buildings (Yellow).

The user may define up to 99 different types of buildings. For each building type, the following data are specified by the user and stored in the terrain file.

- Total height (meters).
- Number of floors.
- Total number of rooms.
- Construction type.
- Functional classification.
- Opening (percent of exterior area).
- Fortification times (four levels).

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

- **Fences. (Green)**

The user may define up to 20 different types. For each type of fence, the following data are stored:

- 1 6-character descriptive name.
- Height (meters).
- Percent Line Of Sight (LOS) (perpendicular to the fence).
- Opaque angle (degrees).
- Crossing or clearing times (for each of seven categories of system types).

Roads (Brown or Gray).

The user may define up to 20 different types. For each type of road, the following data are stored:

- 16-character descriptive name.
- Class(primary or secondary).
- width (in meters).
- Speed degradation factors (wheeled, tracked, footed).

The "class of a road" (primary or secondary) determines the color used to draw the road on the graphics screen, but is otherwise not used by the simulation itself.

Trees. (Green) and Urban/City Areas (Yellow)

The user may define up to 7 different types.. For each type (whether vegetation or urban buildup), the attributes are as follows:

- 1 6-character descriptive name.
- Height (meters).
- Line Of Sight (per 25 meters).
- Speed degradation factors (wheeled, tracked, footed).

Graphically, vegetation areas are still drawn in green (with seven different fill greens corresponding to the seven different types of vegetation), and urban buildup areas are still drawn in yellow (with seven different fill patterns corresponding to the seven different types of urban buildup).

Generic Areas

Generic areas are a type of polygonal terrain feature similar to vegetation areas or urban areas. Generic areas allow the user to create terrain features unique to his needs or perhaps unique to certain regions of terrain. The user may define up to 20 types of generic strings in the terrain file. For each type of generic string, the following data are stored.

- 16-character descriptive name.
- Height (meters).
- LOS (per 25 meters).
- Color.
- Fill pattern

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

River (Blue):.

Up to 20 different types of rivers can be defined by the user. For each type of river, the following data are stored:

1 6-character descriptive name.

Class (primary, secondary, or lake).

Width (in meters).

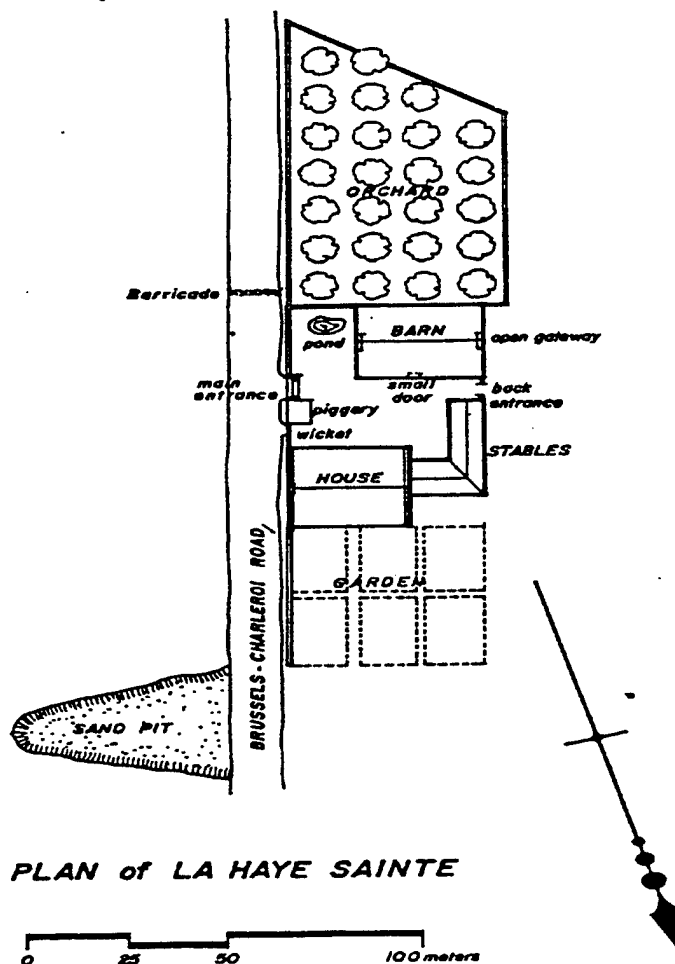
Crossing times (wheeled, tracked, footed, amphibious).

The "class" of a river (primary, secondary, or lake) determines the color used to draw the river on the graphics screen, but is otherwise not used by the simulation itself. If a river's class is a "lake", the terrain editor will ensure that the string forms a closed polygon, and the interior of the polygon will be filled with a dark blue color.

2. GEOGRAPHIC MAPS AND BUILDINGS

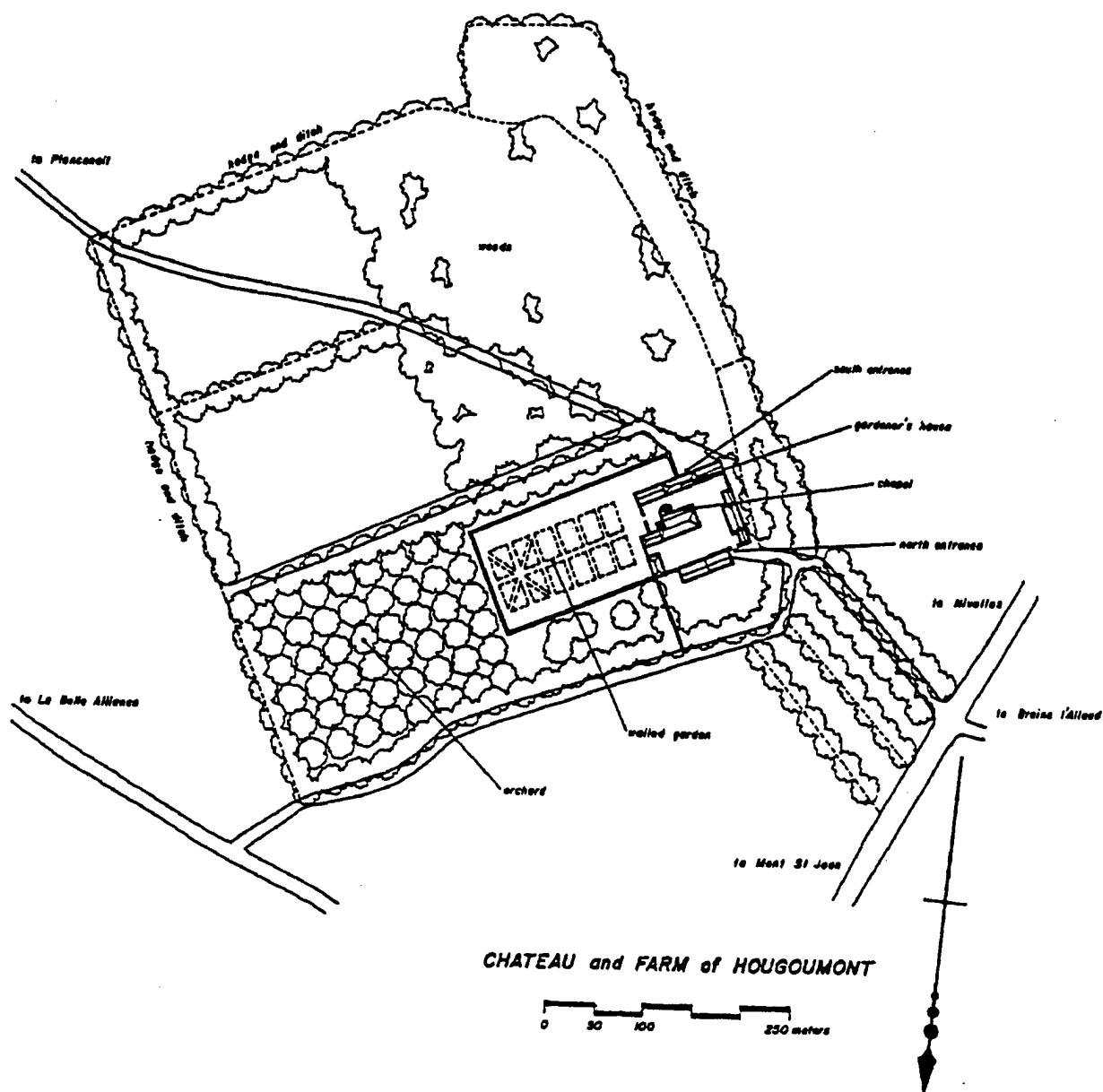
a. Main elements of the terrain

i. Plan of La Haye Sainte



THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

ii. Castle of HOUGOUMONT



b. The Terrain

The battlefield of Waterloo is extremely small in area. the opposing armies occupied two low ridges, separated by a gentle valley extending over a distance of some 1,500 yards. In width, the battle zone barely extended over 5,000 yards stretching from the chateau of Hougoumont in the West to the town of Papelotte in the East. From the

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

the chateau of Hougomont in the West to the town of Papelotte in the East. From the center of the French position around the small Hamlet of La Belle Alliance the Brussels-Charleroi highway traversed the area of ground reaching the crest and running down the reverse slope toward Mont St Jean beyond. This road, in fact, neatly bisected the battlefield and provided the French with their main axis of advance.

C. TROOPS

1. REPRESENTATION ON THE JANUS SYSTEM

The menu section MANEUVER PLAN contains the menu items EXT, ALT, DEL, CAN, SHOW, XINL, XONL, STOP, GO, LOS, MOUNT, DISMOUNT, DEPLOY, and PREPOS. Those menu items permit the user to position units, to position barriers, and to create or alter movement routes, among other things.

a. Positioning of the troops

The first step in initial planning is usually positioning the units, and the first step in positioning them is grouping them by task force. All the units defined in the last chapter appear in rows, in the same order as they are in the Force File. Each row will have all the units assigned to a particular task force.

To deploy units, the user employs the option DEPLOY in the MANEUVER PLAN area of the menu.

The menu has the options as follows:

1. Changing the Task Organization on Your Workstation

When you have completed your positioning, you may need to organize your forces differently.

2. Transferring Units to Another Workstation

If you have more than one workstation on your side, you can transfer units from one workstation to another by using RE-ORG in a slightly different way.

3. Determining Line-of-Sight (LOS)

LOS offers the user the ability to display the line of sight fan of a system at any location in the current view display.

LOS is used during the planning or execution phases to determine suitable locations for placing weapons, positioning reconnaissance assets, and selecting routes that either obscure or expose a tactical unit.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

primary weapon system range limit (purple arc), and sight radials (orange lines). VIEW can be used as well to check the coverage of a group of units.

There are two primary differences between LOS and VIEW:

- A LOS fan cannot be modified. Once LOS is selected from the menu and a system is picked (displaying the system's current VIEW fan), that system's LOS fan at any other location on the screen will always be a 360-degree fan, no more and no less. The LOS fan at a different location cannot be made wider or narrower; it will remain a 360-degree fan.
- A VIEW fan cannot be displayed anywhere on the screen except at a system's current location.

Of these two menu selections, LOS has greater utility in planning site selection and movement routes, because it enables the user to project a unit's line of sight to any given location on the screen. Once in a position, however, VIEW is the only function that can be used to rotate, enlarge, or narrow a unit's fan.

6. Aligning Artillery Units

The ROTATE function allows the user to align or re-align artillery units

The reason for aligning the artillery unit is that the artillery formation affects the way the fired rounds land: the orientation of the sheaf corresponds to the orientation of the firing tubes-if the artillery formation runs east-west, the parallel sheaf it fires will land in a line running east-west. The way a sheaf lands is important when you are engaging a linear target.

b. Planning of the movements

Planning Movement Routes

During initial planning, the user establishes movement routes for his units to follow during the execution phase of the simulation; those routes control the time and direction of unit movement. The user may set them so that his units begin moving as soon as the game starts, begin moving at a prearranged time, or begin moving in order.

Ground Movement

Ground movement routes are defined under three nodes:

1. A GO node (a regular triangle with its point up) signifies a change of direction
2. A STOP node (an inverted triangle) halts a unit.
3. A TIME node, appearing as a STOP node with a number under it. A unit at a

TIME node must wait until the displayed time matches the time on the simulation clock.

The menu has the options as follows:

- Creating and Extending a Route (option EXT)
- Changing a Route (ALT) or change the type of node.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

- Deleting a Node (DEL)
- Canceling a Route (CAN)
- Showing Movement Routes (SHOW)
- Line-of-Sight (LOS)
- You can determine the line of sight from a node before placing the node
- Using ZOOM while Planning Movement
- Copying Routes (XINL/XONL)
- The STOP and GO Menu Selections

It permits to change the initial nodes for an entire task force. This STOP and GO capability has limited application during planning, but is powerful during the execution phase.

c. Planning of the artillery fires and barriers

i. Planning Artillery Missions

There are three types of planning artillery missions:

1. those planned to fire when the simulation starts
2. those planned to fire at a scheduled time
3. those that the user fires on call during the simulation.

During the planning phase, the user needs consider only the first-two.

The different **options** are as follows:

Number of Volleys

Converged and Parallel Sheaf

The alignment of the unit (ROTATE-FORM function) at right angles to the direction of fire.

Assigning Missions

The range of the artillery is defined by two white circles appearing around the unit The small circle shows the unit's minimum range; the large circle, its maximum range. As the user assigns missions, as many as twelve, the units will begin firing those missions as soon as possible unless the user has entered timed missions.

- Alter Missions
- Cancel Missions
- Mission Queue
- Timed Fires
- Using ZOOM for Missions
- Battery Reports
- Planning Target Reference Points (TRP)

When batteries are not firing other missions, they are considered to be laying on a priority target denoted by a priority TRP.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

ii. Positioning craters

In the case of the battle of Waterloo, we have created some craters in order to simulate the delay due to the dead corps of men and horses on the battlefield which increased during the battle. Thus, we have created craters in front of the British squads whose activity remains under our control.

Craters have a line extending from the center of the symbol. This line shows the orientation and length of the crater. Its symbol is drawn to scale and is rotated in the direction of orientation.

The menu has the **options** as follows:

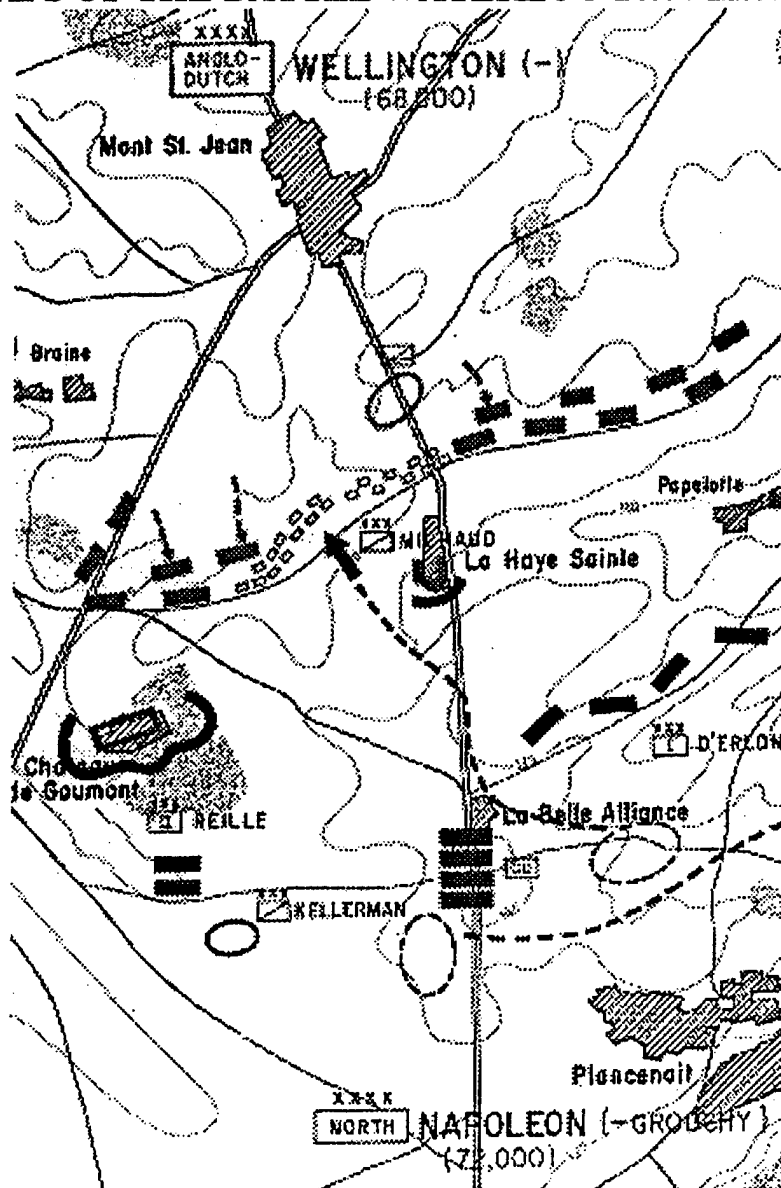
Craters Alignment

Deploying Craters

Prepared Fighting Positions (PREPOS) not used in our simulation

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

2. MAPS OF THE BATTLE WATERLOO 16.00 HRS



IV. SIMULATION ON JANUS SYSTEM

1. THE SIMULATION

A. DESCRIPTION OF THE SCENARIOS

- 1. PRESENTATION OF THE RUNS**
- 2. TIME**
- 3. THE FOUR SCENARIOS**

B. WATERLOO AND COURSE OF ACTIONS SIMULATION

- 1. SCENARIO I:**
The actual battle of Waterloo
- 2. SCENARIO II:**
The combined arms attack (1600 hours)
- 3. SCENARIO III:**
Attack of the English with the only cavalry
- 4. SCENARIO IV:**
Combined arms attack

1. THE SIMULATION

A. DESCRIPTION OF THE SCENARIOS

The scenarios of the battle of Waterloo whose choice is explained in the historical presentation (chapter I of the paper) have been executed several times (3-5 runs) in order to ensure the reliability of the results. Each run requires an exact time line and the use of the options as regards the time.

1. PRESENTATION OF THE RUNS

Multiple Runs and Branchpoints

One feature of Janus is the capability to re-fight the battle using different tactics, techniques, or procedures. As an example, after one run users could rerun the fight with more or fewer forces in the security area, a larger or smaller reserve, earlier or later commitment of the reserve, a different fire support plan, and so forth. A branchpoint capability permits stopping the scenario at any point and capturing the data, then continuing the run. After the first run is complete, users can restart the scenario at the branch point and run it again using different settings.

In the case of the battle of Waterloo, we have executed five runs for each scenario.

2. TIME

Janus as regards the time has the options as follows:

1. TIMER.

The TIMER function is used in conjunction with other functions to plan future events, such as: prearranged artillery fires, scheduled unit movements, and so on.

The scenarios of the battle of Waterloo often last about 90 minutes.

2. Run Speed (Option RS)

The Run Speed option allows the user to change the speed at which the simulation runs. The default run speed factor of 1.00 runs the simulation at or near real time. The higher the run speed factor the faster the simulation will run. A run speed factor of 2.00 will run at approximately two minutes of simulated time for every minute of real time.

The run speed factor we used was 5.0.

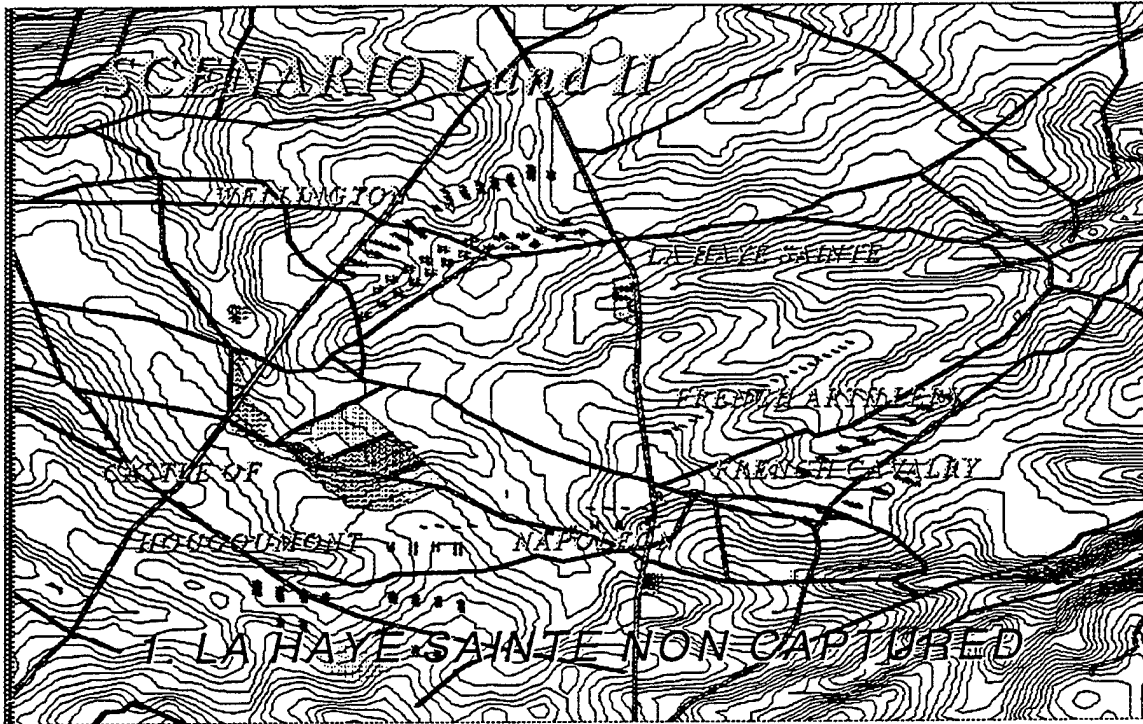
3. THE FOUR SCENARIOS

The importance of La Haye Sainte drove us to consider four scenarios differentiated by whether or not the French troops captured this position. Thus, the scenarios set up the events:

SLT HUBERT
SLT MACHAC

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

SCENARIO I and II: La Haye Sainte not captured before 1600 hrs



SCENARIO III and IV: La Haye Sainte captured before 1600 hrs



THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

The different scenarios are as follows:

SCENARIO I: The actual French Cavalry Attack (1600 hours)

Napoleon's first attacks had thus been repulsed. Without an order from the Emperor, Ney, carried away by an excess of ardor, at once ordered up a brigade of Milhaud's cuirassiers hoping to convert the allied retreat into a full scale rout without further delay.

In the excitement the number of the cavalry troops escalated out of all proportion.

SCENARIO II: The combined arms attack (1600 hours)

This alternative sets up the different events as follows:

- a. d'Erlon's troops sustains heavy losses but does not succeed in taking positions at La Haye Sainte and the battle continues.
- b. Foy and Bachelu's troops support the cavalry during the attack of the English center.

SCENARIO III: The attack of the English with the only cavalry

This alternative sets up the different events as follows:

- a. The d'Erlon's troops sustains heavy losses but succeeds in taking positions at La Haye Sainte and can not support the cavalry during the attack of the English center.
- b. The field artillery batteries are settled at La Haye Sainte and can provide fires before the onslaught.
- c. No troops (Foy or Bachelu) attack during this alternative.

SCENARIO IV: The combined arms attack

This alternative sets up the different events as follows:

- a. Ney had resorted to the correct tactical formula, a coordinated attack with all arms. The French troops sustain lighter losses and succeed in taking positions at La Haye Sainte.
- b. Infantry troops (Lobau, Foy or Bachelu) can support the cavalry during the attack of the English center.
- c. The field artillery batteries are settled at La Haye Sainte and can provide fires before the onslaught.

These four scenarios have the common elements as follows:

- 1. The French and British troops are present on the battlefield
- 2. The time-line of the events before 16.00 hrs

14.00-16.00 hrs:

Arty fires of the French Artillery at the British positions

Janus fire of all the units (275 to 304) of the Task Force 4 and 5 of side 1

These fires are to simulate the losses sustained by the British infantry during the attack of the d'Erlon's Corps and the short fire of the French Artillery in order to prepare the assault of the cavalry.

B. Waterloo Courses of Action and Simulations

The number of units refer to the tables on pages 40-48.

Side 1= French Troops

Side 2= British Troops

1. SCENARIO I:

The actual battle of Waterloo

a. FIRST ATTACK

16.00 hrs

Side 1 (French)

.Cav Based between the road to Charleroi and the corner SE of Goumont's wood, the entire cuirassier corps of Mislaid was launched.

Janus: Units (1 to 48) of the Task Force 1 (page 40) from its initial position to British positions.

Side 2 (Allied)

.Inf The British front transformed itself into a series of 20 squares.

Janus: Units (1 to 235) Task Force 1 (1st & 3rd Divisions) form the squads.

.Art There were 13 British batteries. The gunners manned their pieces until the very last moment, and then run for cover within the neighboring squares. The artillery men were then to emerge as the French recoiled and reopen fire against their retreating backs. Although all batteries of abandoned cannons were in French hands for minutes, they never destroyed them.

Janus: movements of retreat of the Task Force 3 behind the front line.

16.05 hrs

Side 1 (French)

Cav Lefebvre-Denouettes (lancers and chasseurs de la garde) was launched in order to support Milhaud. They tried to maneuver on the left wing.

Janus: movements of the units (49 to 83) of the Task Force 1 from its initial position to British positions

16.30 hrs

Art The British artillery could fire at the French Cavalry during the retreat.

Janus: movements of advance of the Task Force 3 in order to retake initial positions.

b. SECOND ATTACK

16.35 hrs

Cav Lord Uxbridge launched three brigades of cavalry against the tiring French horsemen.

Janus: Movements of the units (257-360) of the Task Force 2 to increase French losses during their retreat.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

16.40 hrs

Side 1 (French)

Cav However, no sooner were they at the foot of the slope than the French officers reformed their squadrons and walked them forward again in a renewed attack. The British cavalry brigades sustained heavy losses,

Janus: Units (1 to 83) of the Task Force 1 move from the foot of the slope to British positions.

The massed fire of the allied forces broke up a new attack before it even reached the corpse strewn crest. In the meantime, Prussian troops threatened the right wing of the French army and stormed the village of Planchenoit.

c. THIRD ATTACK

17.00 hrs

Side 1 (French)

Cav Napoleon had no alternative but to order forward Kellerman's (four brigades) and Flahaut's (the Guard attacked the second time on the right wing) cavalry.

Janus: movements of the units (84 to 142) of the Task Force 2 from its initial position to British positions.

Arty The French artillery fired until the cavalry reached the crest; however, the British kept on firing during the attack. The single battery of horse artillery which accompanied this new attack was incapable of beating the British

Janus: Artillery barrage of all the units (275 to 304) of the Task Force 4 prepares the assault of cavalry. The battery of horse artillery (units 303 to 304) of the Task Force 5 of side 1 to support the French attack.

17.25 hrs

Side 2 (Allied)

Cav Wellington still launched his cavalry at the end of the attack.

Janus: Units (257 to 360) of the Task Force 2 (Allied) attack to the French during the French retreat.

At 1700 hrs, Napoleon had no formed cavalry reserve left, and between nine and ten thousand horsemen were pounding once more toward the British line.

Wellington's squares just managed to survive this second crisis.

d. FOURTH ATTACK

17.35 hrs

Side 1 (French)

Cav Ney commanded this last attack at the head of the Blancard's brigade. The French remained longer at the bottom but retreated once again.

Janus: Units (143 to 169) of the Task Force 3 attack from initial positions towards British positions.

THE BATTLE OF WATERLOO ON THE JANUS SYSTEM

Side 2 (Allied)

Inf The infantry were protected by the corpses of horses and men strewn the crest.

Janus: We designed engineering traps to show the effects of the corpses in slowing the French cavalry.

18.00 hrs End of the charge

Side 1 (French)

Inf The Reille's corps were conveniently placed to join in the struggle at the second attack were only committed at 1800 hrs.

2. SCENARIO II: La Haye Sainte Not Captured

The combined arms attack (1600 hours)

a. 16.00 hrs

Side 1 (French)

.Cav Based between the road to Charleroi and the corner SE of Goumont's wood, the entire cuirassier corps of Mislaid was launched.

Janus: movements of the units (1 to 48) of the Task Force 1 attack towards the British positions.

Side 2 (Allied)

.Inf The British front transformed itself into a series of 20 squares.

Janus: Units (1 to 235) Task Force 1 of side 2 to form the squads.

b. 16.05 hrs

Side 1 (French)

Cav Lefebvre-Denouettes (lancers and chasseurs de la garde) was launched in order to support Milhaud. They tried to maneuver on the left wing.

Janus: movements of the units (49 to 83) of the Task Force 1 from its initial position to British positions

c. 16.10 hrs

Side 1 (French)

.Inf b. Foy and Bachelu's infantry troops support the cavalry during the attack of the English center.

Janus: movements of the units (170 to 274) of the Task Force 3 of side 1 from its initial position to British positions. just behind the French Cavalry.

Side 2 (Allied)

.Arty There were 13 British batteries. The gunners manned their pieces until the very last moment, and then ran for cover within the neighboring squares. The artillery men were then to emerge as the French recoiled and reopen fire against the retreating French. Although all batteries of abandoned cannons were in French hands for minutes, they never destroyed them.

Janus: Task Force 3 of side 2 (Allied artillery) engages behind the front line.

3. SCENARIO III:

French Attack (Cavalry Only) On The English While La Haye Sainte Has Already In Captured By The French

a. 16.00 hrs

Side 1 (French)

.Cav Based between the road to Charleroi and the corner SE of Goumont's wood, the entire French cuirassier corps of Mislaid was launched.

Janus: French units (1 to 48) of the Task Force 1 of side 1 attack from their initial position towards British positions.

Side 2 (Allied)

.Inf The British front transformed itself into a series of 20 squares.

Janus: Allied units (1 to 235) Task Force 1 of side 2 to form the squads of infantry squares.

b. 16.05 hrs

Side 1 (French)

Cav Lefebvre-Denouettes (lancers and chasseurs de la garde) attacks in order to support Milhaud. They maneuver on the left wing.

Janus: French Units (49 to 83) of the Task Force 1 attack from their initial positions toward British positions.

Side 2 (Allied)

.Inf The British front transformed itself into a series of 20 squares.

Janus: movements of the units (1 to 235) Task Force 1 of side 2 to form the squads.

.Arty There were 13 British batteries. The gunners manned their pieces until the very last moment, and then run for cover within the neighboring squares. The artillery men were then to emerge as the French recoiled and reopen fire against their retreating backs. Although all batteries of abandoned cannons were in French hands for minutes, they never destroyed them.

Janus: Allied Task Force 3 of side 2 retreats behind their front line.

4. SCENARIO IV:

Combined Arms Attack With La Haye Sainte Previously Captured By The French

a. 16.00 hrs

Side 1 (French)

.Cav Based between the road to Charleroi and the corner SE of Goumont's wood, the entire French cuirassier corps of Mislaid attacked.

Janus: French units (1 to 48) of the Task Force 1 of side 1 move from initial positions and attack towards British positions.

Side 2 (Allied)

.Inf The British front transformed itself into a series of 20 squares.

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Janus: Allied units (1 to 235) Task Force 1 of side 2 form the squads into infantry squares.

.Arty There were 13 British batteries. The gunners manned their pieces until the very last moment, and then ran for cover within the neighboring squares. The artillery men were then to emerge as the French recoiled and the Allied artillery reopen fire against their retreating backs. Although all batteries of abandoned cannons were in French hands for minutes, they never destroyed them.

Janus: Allied artillery units of Task Force 3 of side 2 retreat behind the front line.

b. 16.10 hrs

Side 1 (French)

.Inf b. Foy and Bachelu's troops support the cavalry during the attack of the English center.

Janus: French infantry units (170 to 274) of the Task Force 3 of side 1 move from their initial position to British positions, just behind the French Cavalry.

2. INTERPRETATION OF THE SIMULATION

A. RESULTS OF THE SCENARIOS

1. DESCRIPTION OF JETS

2. SCENARIO I

- a) First runs and identification to reality**
- b) Validation of runs**
- c) Interpretation of results**

3. CONTROVERSY SCENARIOS

- a) Scenario II: La HAYE SAINTE not captured, cavalry and infantry**
- b) Scenario III: La HAYE SAINTE captured, only cavalry**
- c) Scenario IV: La HAYE SAINTE captured, cavalry and infantry**

B. INTERPRETATION OF THE RESULTS

2. INTERPRETATION OF THE SIMULATION

Besides its value as a training vehicle, Janus offers a unique capability for battle analysis and After Action Review (AAR). Battle results are available for review and analysis in two ways. First, the Janus Analyst Work Station (JAWS) provides the capability to replay the battle exactly as it ran during the simulation, or, when a simple graphic replay provides insufficient detail for battle analysis, JAWS offers the selective retrieval and graphic display of simulation results like time and location of direct fire kills. Also, the Post Processor and its enhanced tool Jets displays battle reports, either on the screen or in printed form.

A. RESULTS OF THE SCENARIOS

1. DESCRIPTION OF JETS

JETS: The Janus Evaluator's Tool Set

The Janus Evaluator's Tool Set (JETS) is a database tool for rapidly analyzing Janus output. It was developed in the Combat Simulation Laboratory of the United States Military Academy's Department of Systems Engineering with seven basic principles in mind:

1. It must be fast.
2. It must be intuitive and easy to use.
3. It must be completely flexible to user queries.
4. It must provide meaningful graphical interpretation of user queries.
5. It must provide concise tables of query results.
6. It must be exportable to word processing, graphics, and spreadsheet packages.
7. It must be something Janus users want to use.

JETS begins in Unix. A simple interface guides users through archiving run data, transferring data to a PC, and removing remnant files. JETS then returns the user to the main Janus screen.

JETS' PC user interface is a tabbed card catalog. It is divided into six areas:

A DATA allows users to select runs to analyze. Users may select one or more runs from the default directory, or browse.

B KILLS examines percent contribution, number by time or range, and attrition. All systems and weapons is the default, but JETS can discriminate down to a given system firing a specific ammunition from an individual weapon at an exact time.

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- C DETECTS shows sensor contribution, again by percent contribution and number by time or range.
- D FIRES reveals weapons utilization with the same level of detail as Kills and Detects.
- E RATIOS provides instant output of commonly used ratios, such as LER and PER.
- F SELECT allows users to switch from analysis of Blue to Red and to isolate system and weapon types

2. SCENARIO I

a) Trial runs and modifications

It appeared routes of units were not accurate enough and close combat did not exist. JETS showed bayonets were never used because French cavalry was too far from British infantry. The first adjustment was the accuracy of units' routes: it was upgraded to one-meter precision at the point of contact. In the same time, we had to coordinate troops' movements. This work consisted in running several simulations in order to find time of departure of each units.

As soon as this problem was resolved, different runs showed the real importance of weapon choice. First, selection of weapons according to range was a sizable factor in getting more or less losses. For example, if the shorter range of pistols was increased, French horsemen fired their weapons too much and did not use their sabers enough. So British losses were too heavy. But they were also heavy because Janus was unable to understand horsemen could fire only once during the charge. That's why the basic load of cavalry rifles was decreased to one round. Another difficulty due to weapon choice was the using of spears and sabers that have the same range: Janus considered only one weapon. Secondly, after these different corrections, it appeared there were too many losses in both sides. The minimum Single Shot Kill Probability (SSKP) were increased by about 10% and PK of weapons were decreased in order to obtain better results.

First simulations also showed the problem of time. There were too many troops and the simulation of the actual battle would have taken about two hours even with a run speed equal to five. The great number of direct fires made simulations run slowly. So, the duration of battle was limited to the action of Ney's cavalry during the four charges at the British infantry squares and the real results were looked for with this shorter scenario. We also adjusted the British cavalry to gain time. This decision was made after a dozen of runs showed Uxbridge cavalry was not enough effective to have important impact on the battle. Thus, their presence in the simulation would only slow down the runs with no additional information attained for the study.

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b) Validation of runs

Thanks to books of BOOTH (The Battle of Waterloo, p 112-113-114) and BOWDEN (Armies at Waterloo, p 331 to 336), we succeeded in finding approximate losses in both sides and better data for simulation. Total French cavalry losses for this part of the battle were estimated to about 6450 killed and British ones about 1530. Considering the number of soldiers this results represent 64.37% of losses for French troops and 13% for Allied troops.

In order to be validated the scenario has been ran five times with five different random numbers (10480, 85590, 44947, 90511, 22785).

The following table shows the results of losses:

Run Number	Allied Losses			French Losses	
	Inf by cav	Inf by arty	Arty by arty	Cav by inf	Cav by arty
1	1592	153	35	6460	135
2	1632	165	44	6340	158
3	1631	184	27	6461	200
4	1613	108	41	6301	153
5	1772	181	43	6460	145
Average	1648	158.2	38	6404.4	158.2
Total in unit	11755	11755	172	10020	10020
Percent killed	.1401	.0134	.2209	.6391	.0157

Results of losses for the simulation of the actual battle.

<i>French Forces</i>		<i>Allied Forces</i>	
Actual Battle Losses	Simulation Battle Losses	Actual Battle Losses	Simulation Battle Losses
6450	6562	1530	1806

Comparison of the Actual Battle Results with Simulation Results

As we can see it, results are close to the reality of the battle. It is to notice that they are also very close to each others compared to the high number of soldiers. But it is only a general analysis of the results and we must go deeper thanks to JETS.

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c) Interpretation of results

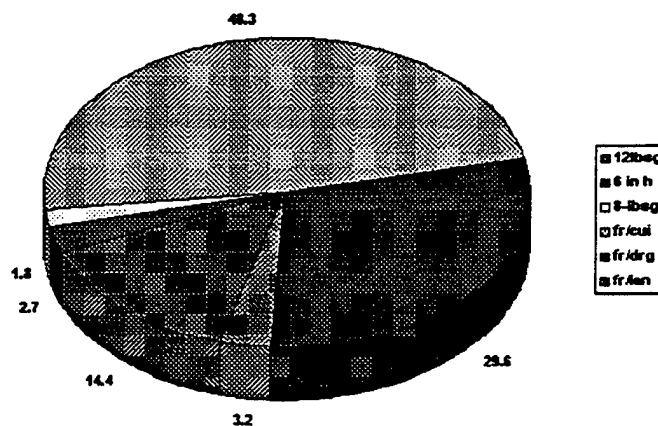
The analysis on JETS allows to exceed general results and easily see results concerning kills, direct fire reports, weapons or systems.

**Inaccuracy with history*

Statistics and tables show use of weapons for each system. It appears horsemen only used sabers. The choice consisting in being careless about firing weapons was taken in order to decrease Allied losses. But even if it doesn't represent actual facts, use of sabers instead of pistols permitted to find good results.

***Accuracy with history*

We have seen losses of simulations were close to reality. Now, let's have a look at details of killers and victims.



French Percentage of Kills by System

This graph shows effectiveness and kills of French Systems. In accordance to history French Cuirassiers are the most effective troops. Nearly half of British losses are due to these horsemen. Actually they were more protected and powerful than other soldiers. But such a statistic can be explained by the high number of Cuirassiers participating to charges. The low percentage of kills by French Lancers is due to the fact they only attack once. Artillery results were also similar to real battle. Guns were located far from British squares (about 1500 meters) and 12-pounder guns were more accurate and numerous than others.

These five runs validated scenario I on Janus System with the actual fight. Despite some differences with actual battle and history, results are precise enough to start other scenarios.

3. COURSES OF ACTION SCENARIOS

a) Scenario II: La HAYE SAINTE Not Captured, Cavalry And Infantry Employed in the French Attack

In this scenario cavalry is followed by infantry. During the withdrawal of horsemen, infantrymen attack British squares and destroy guns. When cavalry attack a second time, infantry withdraw. Each attack is supported by an Infantry Division.

Run Nb	Allied Losses				French Losses		
	Inf vs Cav	Inf vs Inf	Inf vs Arty	Arty vs Arty	Cav vs Inf	Inf vs Inf	Inf vs Arty
1	1565	572	146	38	6259	948	29
2	1684	712	143	45	6050	760	40
3	1573	656	180	30	6643	1033	34
Average	1607.3	646.6	156.3	37.6	6317	913.6	34.3
Total	11755	11755	11755	172	10020	9409	9409
Percent	.1367	.0550	.0132	.2186	.6304	.0970	.0036

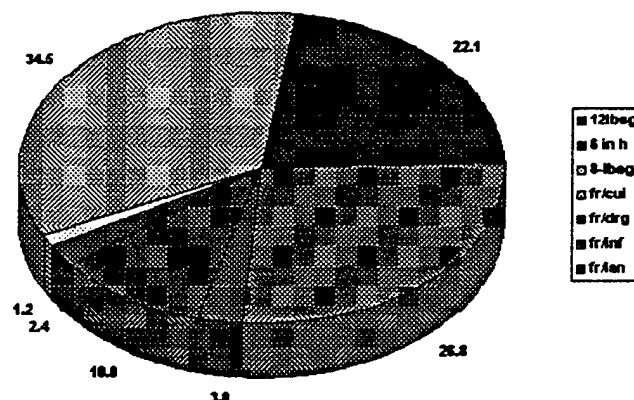
Results of losses for Scenario II (Only French Cavalry and Infantry forces in attack)

French Forces		Allied Forces	
Scenario of Actual Battle Tactics	Scenario with only French Cav and Inf forces in attack	Scenario of Actual Battle Tactics	Scenario with only French Cav and Inf forces in attack
6562	7264	1806	2310

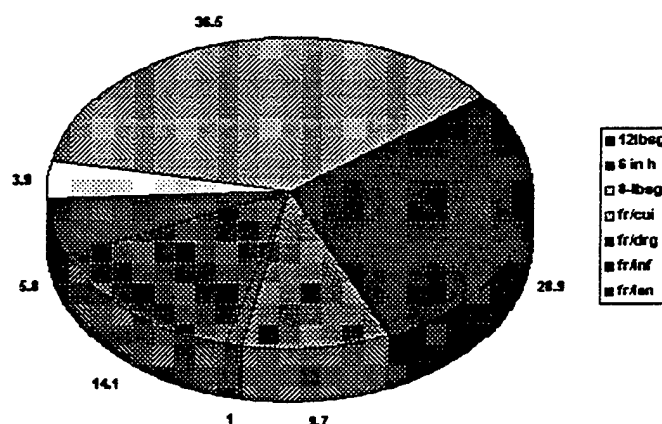
Comparison of the Actual Battle Simulation Results with Scenario II (only French Cav and Inf forces in attack) Results

Results show action of French infantry increase the number of British losses by about 604 men and decrease French cavalry losses by about 245 horsemen. But French infantry also suffer losses estimated to about 948 soldiers. By comparing these numbers, it seems to be a status quo.

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French Percentage Of Kills By System With Scenario II (Only French Cavalry And Infantry Forces In Attack) Results



French Direct Fire Report With Scenario II (Only French Cavalry And Infantry Forces In Attack) Results

These two graphs show the effectiveness of the infantry during this battle. Despite a low percentage of direct fire, French infantry represents more than 26% of kills. They also raise the problem of range for guns: 24% of direct fire for 13% of kills.

This scenario proves the usefulness of infantry as a support of cavalry even if French losses are increased.

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b) Scenario III: La HAYE SAINTE Captured, Cavalry and Artillery Employed in the Attack

La HAYE SAINTE is captured and Napoleon put his Great Battery on the crest south of the farm. Action of cavalry is still the same.

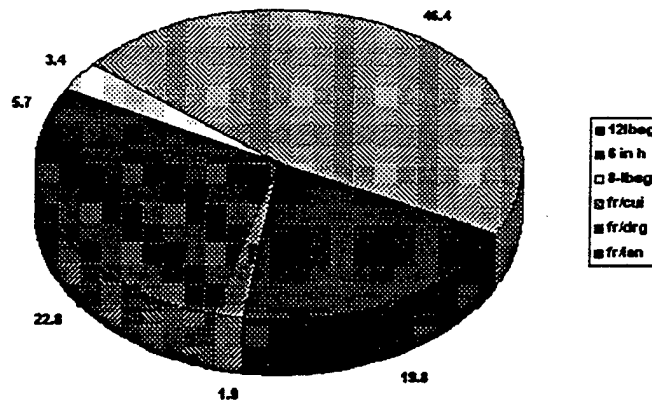
Run Nb	Allied Losses			French Losses	
	Inf by cav	Inf by arty	Arty by arty	Cav by inf	Cav by arty
1	1901	232	52	5731	142
2	1905	235	56	5726	58
3	1751	272	47	6093	14
4	1665	220	45	6033	3
5	1864	193	37	6011	3
Average	1817.2	230.4	47.4	5918.8	44
Total in unit	11755	11755	172	10020	10020
Percent killed	.1545	.0196	.2755	.5906	.0043

Results Of Losses For Scenario III: French Cavalry And Artillery Employed In The Attack

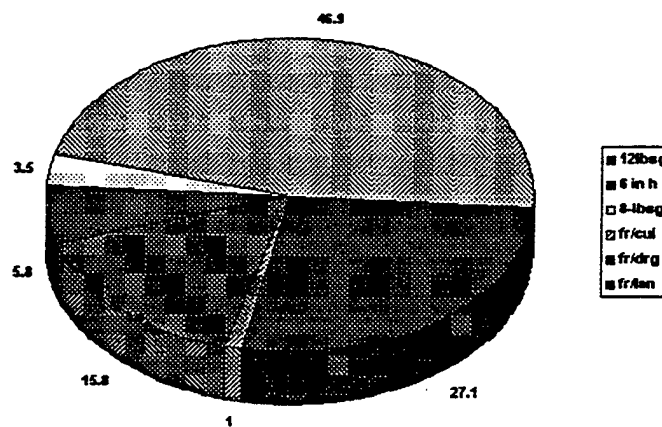
	French Losses	Allied Losses
<i>Scenario of Actual Battle Tactics (Scenario I)</i>	6562	1806
Scenario with only French Cav and Inf forces in attack (Scenario II)	7264	2310
Scenario with only French Cav and Arty forces in attack (Scenario III)	5962	2094

Comparison of The Combat Losses of The First Three Simulation Courses of Action of Ney's Attack

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French Percentage of Kills by Systems For Scenario III: French Cavalry And Artillery Employed In The Attack



French Direct Fire Report For Scenario III: French Cavalry And Artillery Employed In The Attack

This scenario proves the importance of the position of artillery. The two figures show guns' effectiveness is much more better, if the Great Battery is located at La HAYE SAINTE. The French guns destroy much more British ones. That's why cavalry suffers less losses and is more effective. But, despite such results, it seems French losses are still too heavy to hope victory.

The choice of the place of guns is not so crucial as it was said. This solution is not sufficient to challenge Allied supremacy.

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c) Scenario IV: La HAYE SAINTE Captured, Cavalry and Infantry, as well as, Artillery Employed in the Attack

The Great Battery is still south of La HAYE SAINTE but cavalry is supported by infantry action.

Run Nb	Allied Losses				French Losses		
	Inf vs Cav	Inf vs Inf	Inf vs Arty	Arty vs Arty	Cav vs Inf	Inf vs Inf	Inf vs Arty
1	1811	578	284	52	6125	1152	42
2	1423	603	295	55	6673	1283	64
3	1715	740	272	55	6231	1210	72
Average	1649.6	640.3	283.6	54	6343	1215	59.3
Total	11755	11755	11755	172	10020	9409	9409
Percent	.1403	.0544	.0241	.3139	.6330	.1291	.0063

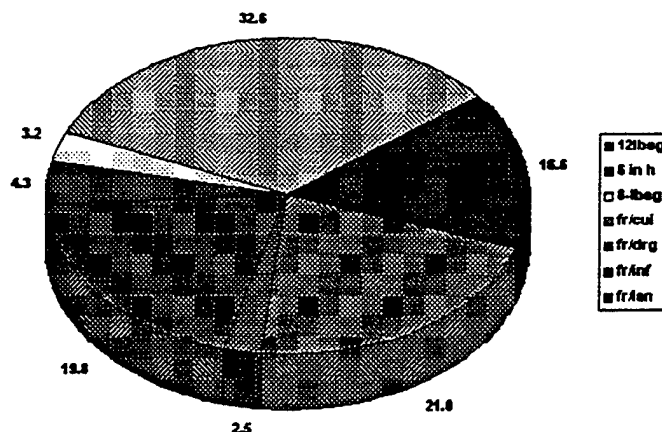
Results of Losses for Scenario IV: Cavalry and Infantry, as well as, Artillery Employed in the French Attack

	French Losses	Allied Losses
<i>Scenario of Actual Battle Tactics</i> (Scenario I)	6562	1806
Scenario with only French Cav and Inf forces in attack (Scenario II)	7264	2310
Scenario with only French Cav and Arty forces in attack (Scenario III)	5962	2094
Scenario with French Cav, Inf and Arty forces in attack (Scenario IV)	7528	2372

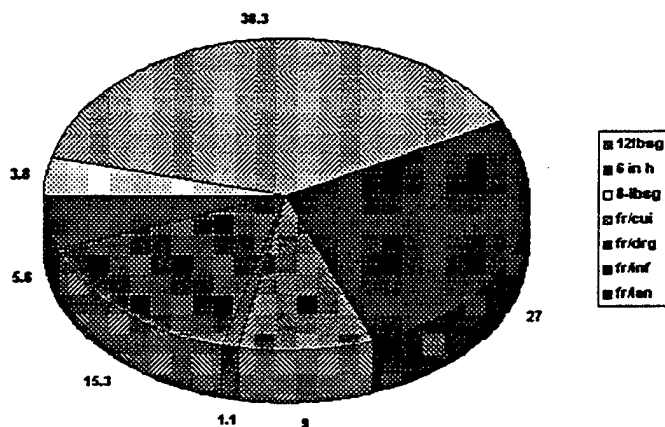
Comparison of The Combat Losses of The Four Simulation Courses of Action of Ney's Attack

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Even if French troops sustain heavier losses, it is to notice that Allied ones have been increased because of infantry and artillery actions.



French Percentage of Kills by System in Scenario IV: Cavalry and Infantry, as well as, Artillery Employed in the French Attack



French Direct Fire Report in Scenario IV: Cavalry and Infantry, as well as, Artillery Employed in the French Attack

Once more, graphs show the effectiveness of infantry combined with artillery. But French losses are very heavy compared to the base case.

B. INTERPRETATION OF THE RESULTS

Modeling Realism

Since Janus models weapons systems as a function of each system's capabilities as affected by terrain and weather, users must consider all military aspects of employing their forces just as they would in actual combat. If for example, someone positions an antitank system without considering line-of-sight and defilade, that system will be less effective than if the user had considered those aspects. To be successful, users acting as commanders and staff officers must consider METT-T (Mission, Enemy, Terrain, Troops, and Time available) and fully synchronize the plan they run with Janus. If the plan is tactically flawed, the simulation will reveal the plan's weaknesses. Conversely, Janus will reward the commanders who have tactically sound plans.

After Action Review & Analysis

** Each scenario presents its own interests:*

- Scenario II (**La HAYE SAINTE Not Captured, Cavalry And Infantry Employed in the French Attack**) shows the role of infantry but French losses remain heavy because of Allied artillery and the French artillery is too far from squares.

- Scenario III (**La HAYE SAINTE Captured, Cavalry and Artillery Employed in the Attack**) shows the importance of the place where guns are located. Destroying enemy artillery and Allied squares, the Great Battery permits to insure safety until contact. Still, the combined assault of the French artillery and cavalry was not effective enough to show a significant increase in the number of Allied losses.

- Scenario IV (**La HAYE SAINTE Captured, Cavalry, Infantry and Artillery Employed in the Attack**) demonstrated an increase in both French and Allied losses. Even if French losses are heavier, Allied losses were also increased.

*** Conclusions concerning the study of scenarios:*

- Even if it seems La HAYE SAINTE provides good location for artillery, this place is not so important as it was said. The crest south of Allied troops still denies good fire support to cavalry attacks. During the actual battle, Napoleon did not have time to prepare a solid artillery plan. That is why the artillery preparation was only 30-minutes long. Attacks could have been conducted after a longer fire support.

-One could object that infantry action increases French losses. Napoleon's dilemma was the destruction of Allied armies before the arrival of Prussians. During the

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French cavalry attacks, Foy's and Bachelu's French infantry divisions did not move. By examining the possible courses of actions and scenarios, it seems these two infantry divisions were not sufficient to break Allied line with a frontal assault. However, Napoleon had reserves like d'Erlon's Corps or Imperial Guard, and he could have given orders to these troops to attack behind the cavalry.

- Statistics also show cavalry was more effective at the first attack and declined after. Repeating charges (four charges in total) was an error contrary to tactics and the use of cavalry. That is why it could have been better to concentrate efforts on one main attack combining arms.

- The four scenarios do not give real solutions to change history; however, each of them demonstrated the effectiveness of a combat arm. These simulations showed the tactical errors of French staff. The French command could have used other tactics such as a flank attack, a more concentrated frontal attack, or improved massing of fires within the artillery plan all with the use of the combined arms: infantry, cavalry and artillery.

3. IMPROVEMENTS OF THE SIMULATION

A. MODELING CHARACTERISTICS

1. WEAPONS

- a. Weapons characteristics**
- b. Hand to hand battle**
- c. Modeling the**

2. TROOPS

- a. Importance of the troops**
- b. Psychological factor**
- c. Assessment of the personal value**

3. MAPS

- a. Historical maps**
- b. Grid coordinates**

B. RELIABILITY OF THE JANUS SYSTEM

1. SIMULATION

- a. The Simulation Of The Square**
- b. The Simulation Of The Cavalry**
- c. The Losses On The Battlefield**

2. THE INTERPRETATION

3. IMPROVEMENTS

- a. Modeling**
- b. Simulation**
- c. Interpretation**

3. IMPROVEMENTS OF THE SIMULATION

A. MODELING CHARACTERISTICS

1. WEAPONS

The main difficulties we encountered as regards the weapons are as follows:

a. Weapon characteristics

The books describing the weapons are presented in the bibliography. The different data we collected did not establish the specific data we needed to enter in the database (specifics on the PH and PK). This data input was validated and verified by simulation runs.

b. Hand to hand battle

An important characteristics of combat up to and including this century is the importance of the hand to hand combat. Indeed, the cavalry charge brought about such battle. To model this feature, we established some priorities in the use of the weapons (rifle or bayonets for the infantrymen).

2. TROOPS

The main difficulties we encountered with the troops are as follows:

a. Importance of the troops

The total of the forces committed in the battle of Waterloo which we simulated was about 40,000 soldiers. This huge number compared to the usual simulation has shown the limits in calculation of the system. The Janus System was not able to work in simulation high-speed.

Besides, the limited number of task-forces and of elements in a system have obliged us to modify the organization of the armies and deterred us from considering different troops.

b. Psychological factor

In the French Revolutionary battles and later throughout the Empire, French infantry in column often broke enemy lines without taking their muskets from their shoulders. They were not actually exerting shock for no fighting took place. The power applied by columns was psychological, but it was just as effective. If disorganizing fear could be induced into the minds of the enemy immediately in front of the head of a French column, physical shock was unnecessary. This combat multiplier remains today in the modern battles and is not taken into account by the Janus System.

c. Assessment of the personal value

The Imperial Guard which contained infantry, cavalry and artillery was not a corps: divisions in this elite body of troops were different from those found elsewhere. Napoleon's Guard was composed of all the various types of soldiers which he found to be of greatest value. The definition of the forces in the database obliged us to define first the weapon system and then to create the troops without considering the difference between the infantryman of the Imperial Guard and the infantryman of the d'Erlon's corps.

3. MAPS

a. Terrain

The main terrain problem occurs with the comparison of the Janus terrain data with the real terrain of Waterloo on June the 18th 1815. The map was established according a recent map and the disposition of the troops were defined by historical plans.

b. Grid coordinates

Once the realization of the map finished, we observed a slight difference in the coordinates between the map and the Janus System's.

B. RELIABILITY OF THE JANUS SYSTEM

1. THE SIMULATION

a. The simulation of the square

The British square could be formed in several ways; if isolated from all other friendly infantry, it was probably as nearly perfect as it could be; it had equal sides and rounded corners. But where other battalion squares were present and a checkerboard alignment desirable, the front and rear were more important than the sides. The square remained very effective as long as no horsemen succeeded in entering the square. However, in this latter case, the disorganization of the sides of the squares brought about a lot of losses and increased a lot the vulnerability of the infantrymen. In the Battle of Waterloo, the French Cavalry was not able to break the squares, the simulation did not permit us to define a breakpoint of the square and to consider other dispositions of the British infantry.

b. The simulation of the cavalry

The squadrons usually numbered about 120 horsemen and occupied in the normal two-rank order a front of between 180 and 200 feet, if they were closed up properly on the center. Any irregularity would have increased the width. The effectiveness of the charge mainly depended on the strict disposition of the troops. On the other hand, all authorities seem to agree that British cavalry units could not be controlled once they were launched in a charge. Wellington hesitated to mass great bodies of horse, because he doubted the tactical skill of his officers, and the power of the regiments to maneuver. The

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Janus system obliged us to define a cavalry squadron and to determine the accurate movements of these troops. Thus, we were not able to take into account the different elements we have just underlined.

c. The losses on the battlefield

The total losses of the battle were about 8,000 men. We have to consider these losses on the battlefield which disrupted the cavalry charges. In fact, the Janus System does not take into account this element.

In the case of the battle of Waterloo, we have created some craters in order to simulate the delay due to the dead corps of men and horses on the battlefield which increased during the battle. Thus, we have created craters in front of the British squads whose activity remains under our control.

2. THE INTERPRETATION

Added to the post processor, the Jets remains a very efficient tool still unknown in France

The Positive Insights to the program are as follows:

1. User friendly. The entire program is menu driven so it meets the "green suit" practicality and simplicity test. This is an excellent tool for the guy just coming off the street to use or for the civilian analyst with 15 years' experience.

2. Pregame Workshop. The program is an excellent tool for quick error checking 1 trouble shooting during pregame workshops. It allows for easy visualization of problem areas with the JANUS database.

3. Postgame Insights. Excellent tool for quick, down and dirty After Action Report (AAR) and initial insights right after gaming.

Excellent tool for analytical hot wash scrub. The analyst can rapidly and easily identify "data spikes" for further in-depth cause and effect analysis. The analytical and training communities can both use this program.

In seconds, JETS takes multiple Janus runs and delivers detailed analysis and presentation-quality printouts. JETS is the tool for Janus analysis.

3. IMPROVEMENTS

a. Modeling

The weapons are defined under the own characteristics and the targets. In fact, the soldier should be considered as an element not only defined by his weapon and the system he belongs to but by his personal value. His resistance to the environment (noises, strength of the enemy, losses already sustained by the unit, proximity of the fires...) and his fighting spirit could be taken into account. One of the solutions could have been the definition of weapons more effective for the Imperial Guards but the limited number of task forces (five) prevented us from doing that.

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b. Simulation

As regards the simulation, the main improvement would be the simulation of the dead soldiers on the battlefield.

c. Interpretation

One improvement could be to enhance the speed of the simulation to increase the number of runs and decrease the time to make the runs necessary to validate each scenario.

V. CONCLUSION

The results of our project are revealing and insightful for understanding the Battle of Waterloo and combat simulations:

- With regards the Janus System, the simulation of the Battle of Waterloo obliged us to consider first the results. Indeed, instead of studying the results of well-known situations, our work consisted of getting closer to the real losses on the battlefield and thus of creating data about weapons. The accuracy of the results in terms of losses even in the different regiments validate the effectiveness and the accuracy of the Janus System.

-With respect to history, the different alternatives drive us to devalue the importance of La Haye Sainte and underline the tactical decision making failures of Napoleon: a combined arms attack would have brought about less losses. However, the frontal attack with lone cavalry or even with the full combined arms team would not lead to a French victory. Instead, a flank attack and the simultaneous synchronized employment of all the French forces could have led to a French victory.

Yet, the limits of the Janus System prevent us from drawing up an extraordinary assessment. Whereas the main factor of the battles remain the soldiers, the Janus System does not take into account the psychological factor. Thus, modeling the troops under this factor by defining the environment and the capabilities of the soldiers instead of modeling him by his weapon could open new perspectives for the simulation.

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La puissance de feu

Major General HUGHES