A MEASURE
OF THE
REAL-WORLD VALUE
OF
MIXED MINE SYSTEMS

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SUMMARY

Two battles in World War II, Second Alamein and Kursk, saw what is probably the greatest use of mines ever, and what is undoubtedly the single greatest use of antitank mines in the history of warfare. At Kursk antipersonnel and antitank mines were emplaced in roughly equal proportions, a total of 291,797 antitank and 284,378 antipersonnel mines. At El Alamein mines were used in similar total numbers – at least 466,000 – but the antipersonnel mines made up only 6 percent of those used, approximately 26,000 of them. However, a comparison of the two battles, while exhibiting striking similarities, are probably more significant for the differences that can be found between them. One of the major findings in this study is that the difference in the planning and preparation times between the British at El Alamein and the Germans at Kursk was almost entirely driven by doctrinal differences and the intent of senior commanders. The threat presented by mines and the mixture of antitank and antipersonnel mines in the defenses had little to do with the eventual and differing outcome of the two battles. Some of the comparative findings between the two battles were:

At El Alamein the British made extensive preparations before the battle to account for the extensive German minefields. Training was thorough, specialized, and extensive. The time required to breach the two minefield belts present varied considerably, but appears to have been about 4 hours for each. In other words, about 8 hours were necessary to achieve an effective breach of the mine defenses. At the end of the first day, both minefield belts had been breached.

At Kursk the Germans did not make any unusual preparations before the battle to account for the presence of the minefields. Planning and training were neither specialized nor intensive. The time required to breach the mined, fortified, defended positions was about 4 hours. Again, two major defensive belts were present, but unlike El Alamein they were breached on successive days, rather than in one day.

At El Alamein casualties due to mines in the first 32 hours of the attack may have been noticeable. After the initial attack casualties remained remarkably consistent with the intensity of operations. However, there is no indication that the casualties caused by the minefields hindered the breakout, rather it appears that the secondary affects of the minefields – traffic congestion, restricted maneuver, constricted logistical communications were a greater factor in limiting the early British success.

At Kursk casualties due to mines were significant. The fortified belt was certainly responsible for 2,000 or more additional personnel casualties (total German force strength was initially 337,705 in 16 divisions and total German battle casualties for the 17 participating divisions from 4 to 18 July was 34,354). Certainly a significant percentage of the loss were actually mine casualties. Over the first two days of battle, the minefields probably caused the loss of 200 tanks (although most were temporary losses) of a total of 1,525 lost to all causes (most of which were only damaged and were eventually repaired), out of a total of 1,538 tanks committed.

At El Alamein the presence of the minefields had a definite impact in reducing the success of the initial British attack. However, the later failure by the British to achieve significant advances appears to be more due to an unwillingness to accept the casualties that might have ensued from an all-out attack, rather than to any effect of the presence of mines on the battlefield.

At Kursk the fortified positions certainly slowed the German advance and delayed the attack, but not significantly. Minefields were part of that delay, in addition to other obstacles, defensive works, and the opposing forces of the Soviet Army. There is no clear indication that minefields with a mixture of more antipersonnel than antitank mines caused a greater delay than minefields where the ratio was 50:50.

Overall, at Second El Alamein, the defensive works prepared by the Axis had a significant role in slowing the British attack. However, ultimately the Axis lost not because the minefields and other defenses were quickly or easily breached, but rather because the Axis forces had insufficient strength to accept the attrition that was inflicted on them by the British attack.

Overall, at Kursk the defensive works prepared by the Soviets, although significant in some ways, had little final effect on the outcome of the battle. Ultimately the German attack was defeated, not by the presence of mines or by fortifications, but rather to a combination of factors, including the unfavorable force ratio and an especially stubborn resistance by the Soviet forces.

Finally, the general conclusions drawn from this study are:

1) **The mixture of antitank and antipersonnel mines in the minefields was not a significant factor in determining casualties.**
2) **Minefield density (measured as mines per kilometer) was not a significant factor in determining casualties.**
3) **Minefields have greater attrition effect against armor than against personnel.**
4) **Minefields have greater value in delaying armor than in delaying infantry.**
5) **Minefields are primarily barriers.**
6) **Minefields did not appear to be a decisive determinant of the outcome of the engagements.**
7) **Minefields did not guarantee that casualties would be inflicted on the attacker.**
8) **Minefields that were undefended or undefended sections of minefields were an annoyance but had little impact on combat.**
9) **Defended minefields that were a surprise to the attacker could be particularly disruptive.**
10) **Preparation and special equipment results in fewer losses.**
11) **A more aggressive attack resulted in increased casualties and shorter breaching times.** This is best expressed by three corollaries:
    - A. **If the attacker is willing to accept casualties, the capability of the mines to act as a barrier and delay the attacker is reduced.**
    - B. **If the attacker is unwilling to accept casualties, the result is an increase in breaching time.**
    - C. **Minefields force the attacker to make a trade-off between time and casualties.**

INTRODUCTION

Two of the most extensive uses of antitank mines in the history of warfare were at the Battle of Kursk (4 July – 23 August 1943) and the Second Battle of El Alamein (23 October – 4 November 1942). At these two battles, mines of all types, and in particular antitank mines, were laid in unprecedented numbers and density. Hence, these two are the "best case" scenarios for measuring the effectiveness antitank (AT) and antipersonnel (AP) mines in combat.

Particularly striking in these two cases is that at Kursk the antipersonnel and antitank mines were emplaced in roughly equal proportions (a total of 291,797 AT mines and 284,378 AP mines). At El Alamein, the antipersonnel mines made up only 6 percent of those used (approximately 26,000 AP mines and 440,000 AT mines). This creates the possibility for an interesting comparison of two very different employment philosophies that may be used to determine if the relative mixture of antipersonnel to antitank mines changes their combat effectiveness.

The Dupuy Institute will compare and contrast El Alamein and Kursk in four areas.

1) The time required planning the breach of the minefields and defensive works.
2) The actual time units were delayed by the minefields and defensive works (the breaching time).
3) The casualties suffered – both personnel and tanks – as a result of breaching the minefields and defensive works.
4) The results of the battle that occurred after the minefield were breached.

This study represents the independent analysis of *The Dupuy Institute*. The contents, analysis, conclusions and any opinions expressed are entirely those of *The Dupuy Institute*. A slightly different version of this study was originally prepared under contract for Los Alamos National Laboratories.

This study was the work of Christopher A. Lawrence, Executive Director of *The Dupuy Institute* (Kursk analysis), and Richard C. Anderson (Second El Alamein analysis). Nicholas Krawciw, Major General, USA, Ret., President of The Dupuy Institute, supported us in our work.

BACKGROUND

The Second Battle of El Alamein

In May and June of 1942 the German-Italian Army badly defeated the British Army in the Battle of Gazala. This defeat was quickly followed by the capture of Tobruk on 21 June 1942. The two disastrous defeats cost the British the loss of over 46,000 men of which over 39,000 were prisoners of war. The German-Italian Panzer Army then pursued the weakened British Eighth Army into Egypt, seizing Mersa Matruh on 29 June. Two days later the pursuit ended at a British blocking position that extended south from the Mediterranean coast near the railroad stop at El Alamein.

What then followed were, in effect, three battles of El Alamein. The First Battle of El Alamein may be said to have begun with German probing attacks on the British positions that lasted until about 7 July. However, the battle proper – an ultimately unsuccessful attempt by the Germans to break the British line that ended with a British counterattack that also failed – lasted from 7 July to 23 July. Neither side was successful and there followed a brief lull. The British had lost another 15,400 men of which 13,500 were prisoners and it was estimated that as many as 892 tanks had been lost and only 411 tanks remained operational with the Eighth Army.[1]Then there followed a month-long lull and, on the night of 30-31 August, Rommel made a second and final attempt to clear the way to the Suez Canal. This 'second' battle of El Alamein is commonly referred to as the Battle of Alam el Halfa Ridge and lasted until 7 September. There then followed a second, longer lull until the night of 23-24 October, when Montgomery's offensive began – which is commonly known as the Second Battle of El Alamein.

The German Mine Defenses at El Alamein

The available documentation on the preparations made by the German-Italian Panzer Army at El Alamein is extensive and detailed. An overview of the mine laying that was conducted prior to the opening of the battle on the night of 23 October 1942 may be found in a memo from the Panzer Army Pionier-Führer (engineer commander) to the Army Ia (operations officer) on 21 October. The Pionier-Führer stated that between 5 July and 20 October, German engineers had emplaced 190,509 antitank mines and 14,509 antipersonnel mines. Italian engineers in the same period emplaced 59,340 antitank mines and 7,014 antipersonnel mines. The total of Axis mines emplaced was 271,372 of which 249,849 were antitank and 21,523 were antipersonnel. In addition, when they emplaced these mines the German-Italian engineers had discovered approximately 181,000 British mines in fields stretching from Deir el Shein to Bab el Qattara. Of these, 180,000 were usable – either removed and re-emplaced in new fields along the southern (right) side of the Axis position or incorporated as they lay into the German minefield plan. Thus, the engineers had emplaced a grand total of 451,372 mines of all types on the El Alamein front by 20 October.[2] A later document summarizes the numbers emplaced in two other periods, 20 to 30 September (27,765 antitank and 1,997 antipersonnel) and 1 to 20 October (34,721 antitank and 12,776 antipersonnel).

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[1] British Public Records Office (PRO), WO 169/3861, 'A.F.V. State (British Troops Middle East), Tank Casualty Estimate, 25 July 1942.'

[2] *Anlage 2, Panzer-Armee Afrika Kriegestagebüch, 22 Oktober 1942* (Annex to Army War Diary) National Archives and Records Administration (NARA) Microfilm Record T-313, Roll 467.

That figure of nearly one-half million mines is the one most frequently quoted for the battle, and this document appears to be the basis for it.[3] However, a more detailed view of the German-Italian mine-laying activities at El Alamein that match the ebb and flow of the campaign may be revealing.

From 10 to 23 July during the First Battle of El Alamein, German and Italian pioneers emplaced 33,043 antitank mines. Of those, 14,415 were British Mark II, IV, and V antitank mines. No antipersonnel mines were laid during this period. Then, during the lull from 24 July to 30 August, 143,069 antitank and 1,915 antipersonnel mines (the antipersonnel mines made up barely 1.08 percent of the total number of mines emplaced since 10 July) were laid. In addition, 874 aerial bombs had been emplaced as extemporaneous mines, most tripwire-armed. The bombs – ranging in size from 50 to 250 kilograms (110 to 550 pounds) – were effective both as antitank/anti-vehicular mines and as antipersonnel mines. During the Battle of Alam el Halfa Ridge, from 1 to 7 September, 6,557 antitank mines, 518 antipersonnel mines (still only 1.31 percent of the total emplaced since 10 July), and 134 aerial bombs were laid. Finally, during the second lull, from 8 September to 23 October, 145,487 antitank mines, 23,001 antipersonnel mines, and 305 aerial bombs were emplaced. By this count, a total of 328,156 antitank mines, 25,434 antipersonnel mines, and 1,313 aerial bombs were emplaced between 10 July and 23 October.[4]

Why this figure – 353,590 mines – is different from that given by the Armee-Pionier-Führer on 20 October – 451,372 – is not precisely known. That the two documents are similar is indisputable, it is apparent that the summary was derived from the daily accounting. It is possible that a gross accounting error was made in the summary, however, that appears to be unlikely. Rather, the key to the discrepancy appears to be the 180,000 'English' mines used by the Germans that are mentioned in the summary. Only 35,805 of the 'English' mines are mentioned in the daily accounting, which means that approximately 144,000 were simply used as they lay in their original 'English' minefields. The British had emplaced mines in two belts code-named January (the eastern belt) and February (the western belt).[5] It also appears that all of the 'English' mines were in fact antitank mines. If that is true then it is possible that as many as 497,590 mines of all types were either emplaced or used in place by the Axis at El Alamein. However, if the numbers reported in the summary – 451,372 – are added to those mines reported as emplaced from 20 to 23 October – 10,292 antitank and 4,736 antipersonnel, then 466,400 mines, of which 440,141 were antitank and 26,259 were antipersonnel mines, and 1,313 aerial bombs were laid.[6] This appears to be the most accurate count of the mines that is available, and is the number that we assume to be most correct. Thus, about 5.91 percent of the total were either antipersonnel mines or aerial bombs. This is in marked contrast to what was requested by the

[3] The figure of 500,000 mines at El Alamein has been used in TDI documents among others. See, The Dupuy Institute, *Military Consequences of Landmine Restrictions, VVAF Monograph Series, Volume 1, Number 2.* (Washington, DC: Vietnam Veterans of America Foundation, 2000), page 37 and *seriatim*.

[4] These figures, broken down by day and by the unit emplacing the mines may be found in the *Minenubersicht Ägypten, El-Alamein Stellung* (Egyptian Mine Survey, El Alamein Position), *KTB Armee-Pionier-Führer, 10 Jul – 1 Sep, 42*, NARA T-313, Roll 432.

[5] In the British planning for Second Alamein the code names were retained to identify the two main German mine belts.

[6] It is difficult to resolve the various discrepancies, it is not known for instance, if the summary total included the aerial bombs emplaced as mines and, confusingly, it is not known exactly which of the daily figures are included in the summary.

Panzer Army Quartermaster on 23 August – 500,000 mines, of which 70 percent were to be antitank and 30 percent were to be antipersonnel.[7]

Minefield Locations and Densities

It is actually possible to identify the minefields and, in some cases, the number and types of mines, that would face the British. The German documents previously cited usually give the locations of the mines, either by identifying the minefield or by identifying the unit sector, and usually by identifying both. The British 30th Corps attack zone ran through four major mine fields. From north to south these were:

1) Mine Sector 'J' – 9,672 AT mines, 430 AP mines, and 52 bombs, about 3 kilometers wide by 1.6 kilometers deep. The approximate density per square kilometer was 2015/AT, 90/AP, and 11/bombs. The linear density was 3,224/AT, 143/AP, and 17/bombs per kilometer.
2) Between Mine Sector 'J' and Mine Sector 'L' – 3,702 AT mines, 463 AP mines, and 28 bombs, about 1 kilometer wide by 2.5 kilometers deep. The approximate density per square kilometer was 1,481/AT, 185/AP, and 11/bombs. The linear density was 3,702/AT, 463/AP, and 28/bombs per kilometer.
3) Mine Sector 'L' – 13,014 AT mines, 828 AP mines, and 352 bombs, about 3.2 kilometers wide by up to 4 kilometers deep. The approximate density per square kilometer was 1,017/AT, 65/AP, and 27/bombs. The linear density was 4,067/AT, 259/AP, and 110/bombs per kilometer.
4) Mine Sector 'K' – 17,172 AT mines, 1,437 AP mines, and 47 bombs, about 4.8 kilometers wide by up to 2 kilometers deep. The approximate density per square kilometer was 1,789/AT, 150/AP, and 5/bombs. The linear density was 3,577/AT, 299/AP, and 10/bombs per kilometer.

The Italian XXI Corps and the German 164th Division also reported laying mines in these areas. It is not possible to identify exactly where these were emplaced. However, an approximate number – given that about 55 percent of the front of the XXI Corps and 75 percent of the front of the 164th Division fell within the zone of the British attack – may be determined. By using the frontage percentages and the known totals of mines, an estimated number of mines emplaced may be derived: 6,901 AT mines and 2,826 AP mines for the XXI Corps and 1,252 AT mines, 1,096 AP mines, and 2 bombs for the 164th Division. It appears likely – if the densities by square kilometer found above are correct – that many of these AT mines were emplaced in Mine Sector 'L' and between 'J' and 'L'. It also appears that many of the AP mines would have been emplaced in 'J' and 'L'. However, neither supposition is proven and may be incorrect if it could be shown that the linear density was the more accurate measure. Overall, the linear density for the approximately 12-kilometer wide sector was about 4,309 AT mines, 590 AP mines, and 40 bombs per kilometer. The 51,713 antitank mines, 7,080 antipersonnel mines, and 481 bombs emplaced in this sector represent 11.75 percent, 26.96 percent, and 36.63 percent, respectively of the known totals for these types of mines used by the Axis forces.

Finally, a brief discussion of the Axis mine emplacement *after* the British attack began is in order. Between 25 and 31 October Axis engineers laid 31,665 antitank mines, 2000

[7] Found in *Minennachschub – Deutsch und Italienisch* (mine supply – German and Italian), *KTB Armee-Pionier-Führer, 21 Aug – 31 Okt, 42*, NARA T-313, Roll 431.

antipersonnel mines, and emplaced 7,800 kilograms of explosives.[8] Of these, the German 164th Division laid 8,250 antitank mines and the Italian XXI Corps 7,365 antitank mines. The location and timing for 4,751 of the mines emplaced by the 164th Division during the battle can be accurately described:

1) On the night of 24-25 October 600 were emplaced between Sector 'J' and 'L'.
2) On the night of 25-26 October 106 were emplaced between Sector 'J' and 'L'.
3) On the night of 26-27 October 400 were emplaced between Sector 'J' and 'L' and 650 at a location that cannot be identified.
4) On the night of 28-29 October 979 were emplaced, extending north (?) from Sector 'L'.
5) On the night of 30-31 October 1,346 were emplaced between Sector 'L' and 'K'.
6) On the night of 31 October-1 November 670 were emplaced between Sector 'L' and 'K'.

Many of these minefields emplaced by the 164th Division during the battle were noted to be *Alarmriegel* – that is, switch-line or tripwire barriers. It may be significant that those emplaced between 24-25 October and 28-29 October were all in the northern zone of the British attack, where the 9th Australian Division made some of the greatest initial gains (see the battle narrative in Appendix I). Those emplaced later were all further to the south, where British attacks had nearly ceased by 30 October. Given that the final, successful, British breakthrough occurred in the north, then this miscalculation may have had some effect. However, since just over one-half of those emplaced during this time have known locations, this could as easily be simple coincidence.

The locations of the Italian XXI Corps mines that were emplaced have not been identified.

The Battle of Kursk

In July of 1943 during World War II a huge battle occurred on the Eastern Front that has come to be known as the Battle of Kursk. It was fought in an area of the front where Soviet forces occupied a 150-kilometer deep by 200-kilometer wide salient in the lines. The Germans planned to attack this salient at its base from both north and south, the armored pinchers were to meet around the city of Kursk, isolating and destroying the Soviet forces trapped in the bulge.

Like the six-week long lull prior to Second El Alamein, the three months on the Eastern Front before the Battle of Kursk were quiet, allowing the Soviets an unprecedented opportunity to prepare for the battle. Soviet positions at Kursk were far more extensive and heavily mined than any seen in the previous two years of fighting on the Eastern Front. It was the most extensive use of mines during four years of war on the Eastern Front, which was the largest land campaign in history. The Battle of Kursk offers a unique opportunity to analyze the effectiveness of mine warfare. It not only was one of the two largest uses of antitank mines in history; it is also the largest armor battle in history. As such, it can provide a fairly definitive set of statistics on the maximum effectiveness that can be expected from antitank mines. Kursk represents – quite literally – the 'best case' antitank mine scenario.

A thorough examination of the Soviet use of mines at Kursk was included in the TDI report *Military Consequences of Landmine Restrictions,* presented to the US Joint Staff in 1996 and, more recently, in *The Military Consequences of a Complete Landmine Ban* prepared for the Vietnam

[8] *Anlage 2, Panzer-Armee Afrika Kriegestagebüch, 1 November 1942*, NARA Microfilm Record T-313, Roll 467.

Veterans of America Foundation.[9] Some of the data presented in these reports is repeated here. Our analysis in this report will be restricted to the German offensive around Belgorod from 4 to 18 July. The Soviet counteroffensive from 18 July to 23 August and the similar battle fought north of Kursk are not considered.

For what is known as the Defensive Phase of the Battle of Kursk (4 – 18 July) the Soviet Army laid at least 291,797 antitank mines and 284,378 antipersonnel mines in the defensive lines of Voronezh Front on the southern face of the Kursk salient. It is probable that they also laid another 100,000 to 200,000 antitank mines and a similar number of antipersonnel mines in the defensive lines of Central Front on the northern face of the salient. In the south this produced the impressive average density of 1,779 antitank mines per kilometer, spread across 164 kilometers of front. Soviet era secondary sources record similar densities (1,500 antitank mines per kilometer and 1,700 antipersonnel mines per kilometer) with the additional caveat that this was four times the density of mines at Stalingrad (1942) and six times the density of mines in the defense of Moscow (1941).

Soviet mines at Kursk were for the most part laid in two extensive belts, integrated into the first and second defensive lines. Infantry divisions, supported by antitank and armored units manned these two defensive lines. There was an additional third defensive line that incorporated minefields. It played a minor role in the battle. However, most of the mines encountered, most of the casualties lost to mines, and most of the problems caused by mines, were in the fighting that occurred in the first two defensive lines and in the first days of the battle.

The German attack deployed three armored corps – from left to right – the XLVIII Panzer Corps (three armored divisions, including the *Grossdeutschland* Panzer Grenadier Division), the SS Panzer Corps (three SS armored divisions) and the III Panzer Corps (three armored divisions). All three of the armored corps were supported by infantry units and there were supporting infantry corps on each flank of the German attack (LII Corps and Corps *Raus*).

Number of Mines at Kursk

Like the data for Axis mine employment at El Alamein, *The Dupuy Institute* mine count for the Battle of Kursk comes from documentary sources collected from the Soviet Military Archives at Podolsk, and are from the original reports prepared by the units that were laying mines at the time.[10] These reports were supplemented by reliable Soviet secondary sources in the case of the 40th Army where no complete mine reports were evidently filed.

The Soviet official history of World War II states that the Voronezh Front had emplaced 637,500 antitank and antipersonnel mines by the start of the battle. Another Soviet secondary source states that the two fronts – Central and Voronezh – had together emplaced 503,663 antitank and 439,348 antipersonnel landmines. Of these, 434,667 antitank mines were emplaced in the main defensive zone with the other 68,996 in the second defensive zone and/or the rear area defensive zones. In addition, 410,980 antipersonnel mines were emplaced in the main defensive zone, with the another 28,368 in the second and/or rear area defensive zones. This represented an average mine density on the Central and Voronezh Fronts of 1,500 antitank and 1,700 antipersonnel mines per kilometer along the axis of the main German advance.

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[9] *The Dupuy Institute, Military Consequences of Landmine Restrictions*, republished as VVAF Monograph Series, Vol. 1, Number 2. (Washington, DC: The Vietnam Veterans of America Foundation, 2000) pp. 40-46.

[10] See the *Kursk Data Base* (KDB) and *Final Report*, US Army Center for Army Analysis report CAA-SR-98-7. Since that report was completed, TDI has made various detail edits and amendments to it, which are incorporated into this study.

Number of Mines Emplaced in the Sixth Guards Army Zone

In the Sixth Guards Army zone, according to a 1944 Soviet General Staff Study (a secondary source), the first two minefield belts consisted of:

	Main Belt	**Secondary Belt**	**Total**
AT Mines	69,688	20,200	89,888
AP Mines	64,340	9,097	73,437

Note that the number of mines emplaced in the Sixth Guards Army zone as reported in the 1944 Staff Study differs slightly from the totals given below, which is compiled from various reports of the Sixth Guards Army.

	AT	**AP**	**Total**
Laid as of 30 June	88,261	63,324	160,747
Laid as of 4 July			170,210
Laid 1-10 July	29,739		29,739
Laid 1-15 July		40,496	52,334
Total	118,000	103,820	242,820

The interesting point is that although the warning that the German attack was imminent had been issued on 30 June, four days later only 10,000 additional mines had been emplaced. Once the battle began it appears that about 72,000 more mines were emplaced up to 15 July when the Soviet defensive phase of the battle ended. Note that the report for 1-15 July cannot be correct if it includes the data from the report for 1-10 July.

Number of Mines Emplaced in the Seventh Guards Army Zone

	AT	**AP**	**Total**
Laid as of 5 July	66,814	85,140	151,954
Laid 6 - 18? July[11]	6,904+	2,257+	9,161+
Laid 5 - 18 July[12]	9,655+	3,654+	13,309+
Total	83,373+	81,051+	174,424+

The Seventh Guards Army emplaced a number of mines similar to that by the Sixth Guards Army before the battle began (151,954 versus 170,210). But while the Sixth Guards Army used more antitank than antipersonnel mines, the Seventh Guards Army used more antipersonnel mines than antitank mines. And – even though the records obtained for the Seventh Guards Army are incomplete – it appears that they emplaced more mines than did the Sixth Guards Army after the fighting began.

[11] Emplaced by divisional and army engineer battalions. The number emplaced in five of 20 fields was not given. However, the 11 antitank minefields averaged 627.6 mines per field and the four antipersonnel minefields averaged 564.3 mines per field.

[12] Emplaced by the attached 60th Engineer Sapper Brigade.

Other Minelaying in the Zone of Voronezh Front

General Moskalenko (commander of the Fortieth Army) claimed in his memoir that in the defensive zone of the Fortieth Army 59,032 antitank mines, 70,994 antipersonnel mines, and 6,377 "mine shells" (presumably artillery shells rigged to explode by contact or trip-wire, like a mine) were emplaced. This differs from the report obtained from the Fortieth Army records, which states that they emplaced 21,214 mines, by 4 July. The 4th Engineer Sapper Brigade (consisting of three battalions, plus a fourth battalion that was disbanded on 13 July) reports that from 5 to 18 July they emplaced 707 antitank mines. There is also a report from the 161st Rifle Division (RD), which reported emplacing 3,295 antitank mines and 469 antipersonnel mines from 7 to 17 July. Moskalenko also stated that wide use was made of delayed-action mines to create obstacles on roads and bridges. They were to be set to explode in the event that Soviet troops were forced to withdraw.

Overall, the first defensive line of Voronezh Front (including the first two echelons of the defending armies) had at least 221,846 antitank and 219,134 antipersonnel mines emplaced before the battle began (excluding the Thirty-eighth Army). The linear density of mines in this zone (175.1 kilometers wide) was some 1,267 antitank mines and 1,251 antipersonnel mines per kilometer. While this appears impressive, what it would really amount to over the entire width of the front is a two-row deep minefield, with a single mine per meter in each row – all in all, it amounts to just over one antitank mine and one antipersonnel mine per meter. For comparison, the modern US Army standard as outlined in FM 20-32, recommends block minefields of 546 AT mines, covering an area of 500 by 300 meters. This minefield is six rows deep with a linear density of 1.1 antitank mines per meter (1,092 antitank mines per kilometer).

The First Tank Army was initially intended as a mobile operational reserve. Still, at the start of the battle, it was located in the third defensive belt and reported having emplaced some 1,980 antitank mines and 1,520 antipersonnel mines by 4 July. Considering that the front of the First Tank Army was about 25 kilometers wide, it would have been a very thin line defensive barrier.

The Sixty-ninth Army reported emplacing 17,671 antitank mines and 16,848 antipersonnel mines as of 4 July. They were also deployed in the third defensive belt. Assuming that covered only the fixed positions of the 48th Rifle Corps, 81 kilometers in width (the 49th Rifle Corps was moving to new positions behind the Seventh Guards Army), then the linear density was some 218 antitank mines and 208 antipersonnel mines per kilometer. Assigned to the Sixty-ninth Army were the 5th Engineer Sapper Brigade, who reported that it emplaced 4,621 additional mines (types unspecified) from 4 to 18 July.

Overall, in the Voronezh Front's second echelon (the third defensive line), there were at least 19,651 AT mines and 18,366 AP mines laid. The density of mines along the third defensive line was not much different than that of the second line. Only the first defensive line had significant density to form actual defensive barriers across the entire front.

Finally, the Fifth Guards Army also emplaced mines. As this army arrived as reinforcement for Voronezh Front during the battle, its reports probably refer to the period from 11 to 18 July. The engineer units of the Fifth Guards Army (seven divisional and two army engineer battalions) reported having laid 2,670 mines during that period. The attached 14th Engineer Sapper Brigade (consisting of four battalions) reported having laid 5,988 mines during the same period. This means that Fifth Guards Army laid possibly 8,658 mines during the course of the battle. It also received some additional protection from its partial occupation of the third defensive line.

The Voronezh Front also deployed five mobile mine-obstacle detachments. Each detachment consisted on an engineer battalion with its own motor transport, between 2,000 and 5,000 mines and up to 500 kilograms (over one-half ton) of explosives

Summary of the Total Number of Mines Laid at Kursk

Army	AP Mines	AT Mines	Other	Not Specified	Total
1st Tank Army	1,520	1,980	-	-	3,500
5th Guards Army (10-18 July)	-	-	-	8,658	8,658
6th Guards Army	63,000	96,000	11,210	-	170,210
Laid 1-10 July	-	29,739	-	-	29,739
Laid 1-15 July	40,496	-	-	11,838	52,334
7th Guards Army	85,140	66,814	3,480	-	155,434
Laid 6-18? July	2,257+	6,904+	-	-	9,161+
Laid 5-18 July	3,654+	9,655+	-	-	13,309+
40th Army	-	-	-	-	(21,214)
Moskalenko	70,994	59,032	6,377	-	136,403
Laid 5-18 July	-	707	-	-	707
Laid 7-17 July	469	3,295	-	-	3,764
69th Army	16,848	17,671	-	-	34,519
5 Mobile Mine Det.	-	-	-	-	(10,000)
	284,378	291,797	21,067	20,496	617,738

(Parenthetical figures were not used in the final analysis)

Thus, the total count of mines at Kursk by *The Dupuy Institute* is 617,738. This is 19,762 less than the number of 637,500 given by the Soviet official history. However, it is not known if the mine figures we give for the Fortieth Army also include the Thirty-eighth Army (it appears that the Thirty-eighth Army was attached to the Fortieth Army administratively), which was not involved in the battle. Therefore, it is unknown if the difference between our numbers and the figures in the official history is due to the Soviet total including the Thirty-eighth Army while ours do not include the Thirty-eighth Army. However, they are sufficiently close to one another that we are comfortable that they reflect reality. Note that the total number we have arrived at in this study are somewhat higher than those used in our 1996 report to the Joint Staff.

According to a Soviet secondary source, the total number of mines laid for the Central and Voronezh Front was 439,348 antipersonnel and 503,663 antitank, for at total of 943,011 mines. If the count for Voronezh Front given above were accepted, then this would mean that no more than 154,970 antipersonnel mines, 211,866 antitank mines and a total of only 305,511 mines were laid

by Central Front! Of course this highlights the problems found in reconciling these accounts, since 154,970 antipersonnel mines plus 211,866 antitank mines actually equals 366,836, which is 61,325 more than the difference of the two totals!

Comparing Second El Alamein with Kursk

When comparing the two battles it may be seen they that there was similar time for the defender to prepare. In the case of Second El Alamein the Axis forces began intensive mining in August, some three months before the battle, about the same time the Soviets had for Kursk. However, the Axis at El Alamein had considerably fewer troops available to do the work of laying mines (some 107,000 Germans and Italians compared to well over 500,000 Russian solders in this part of the Voronezh Front sector). In the case of Second El Alamein, 440,000 antitank mines were emplaced compared to 241,497 at Kursk, while only 26,000 antipersonnel mines were emplaced at El Alamein, compared to 237,502 at Kursk. Overall at the start of the battle, the Axis troops had laid around 446,000 mines at El Alamein, compared to about 479,000 by the Soviets of Voronezh Front. The length of front at El Alamein was about 70 kilometers, compared to 175 kilometers at Kursk (in the sector being studied). This means that the linear density at Second El Alamein was much higher, with an average of 6,929 antitank mines per kilometer, compared to an overall average of 1,379 antitank mines per kilometer at Kursk. Thus, the density of antitank mines at El Alamein was just over five times higher than that at Kursk. However, the density of antipersonnel mines at El Alamein was much lower – at 214 per kilometer – than the 1,356 per kilometer at Kursk. Overall, the mine density at El Alamein was almost three times that at Kursk (2.6 to 1) with about 7,143 mines per kilometer, as compared to 2,736 mines per kilometer at Kursk.

PLANNING TIME

Second El Alamein: The British Mine Clearing Preparations

The Eighth Army plan for breaching the German-Italian minefields included both conventional and unconventional means. In September, prior to the battle, the Eighth Army set up a School of Minefield Clearance to develop doctrine and equipment to solve the problem of the extensive minefields.

The school designed a conventional minefield gapping drill that utilized a detachment of one officer and 44 NCO and enlisted, formed from the divisional Royal Engineer (RE) Field Companies. Each British infantry division had three RE Field Companies and a RE Field Park Company. The Field Company was lightly equipped for routine engineering duties and was normally assigned one per infantry brigade in the division. The Field Park Company contained the heavy engineering equipment of the division and was assigned as needed. Each Field Company had a headquarters and three sapper sections (platoons), each section had sufficient manpower to form a mine clearing detachment, and additionally the Field Park Company had one sapper section. Unlike German and US divisional engineers there was no battalion organization or headquarters in the British division. Instead, the division staff included a senior engineer officer, normally a colonel or lieutenant colonel, he was known as the Commander Royal Engineers (CRE). The CRE had a small staff for engineer planning. The British armored division organization was similar except that there were just two Field and one Park unit, which were termed 'squadrons' instead of companies. Effectively then, each infantry division could form a maximum of ten mine clearing detachments and each armored division could form seven, although additional RE Field Companies could be attached from army assets. In actual practice, each of the four infantry divisions of 30th Corps planned initially on opening four corridors, two per brigade. The two armored divisions of 10th Corps when committed were expected to clear their own corridors and formed their own 'Minefield Task Force' to do so. The 1st Armored Division – with one armored brigade under its command – planned on clearing three, and the 10th Armored Division – with two armored brigades under its command – planned on clearing four.[13]

Each detachment was divided into a command and reconnaissance party consisting of the officer, one NCO and nine men, and four gapping parties, each of one NCO and nine men. The reconnaissance party included a specially modified and heavily sandbagged truck, which was equipped with a concrete roller mounted on booms from the truck bed. The truck was to be driven in reverse until the roller exploded a mine, locating the minefield. Three of the gapping parties then began breaching operations – the fourth party acted as a relief and casualty reserve and handled engineer stores – all four of the parties rotated duties to prevent fatigue. One party marked the gap as it was completed, while the other two did the actual detection, marking and lifting of the mines. Three teams did the detecting, marking, and lifting of the mines. Each team consisted of a detector (using a magnetic induction detector or probing), a director (ensuring that the proper direction and interval were maintained), a marker (marking the location of individual mines), and a lifter (disabling tripwires and booby traps and moving the mines to the edge of the

[13] The 1st Armored Division Minefield Task Force included three tank troops (platoons), three RE Field Companies, and three infantry companies. The 10th Armored Division Minefield Task Force included only three RE Field Companies and a RE Field Park Company. The difference was because it was expected that the 1st Armored Division might have to fight for the gaps and would have to protect the engineers while they worked. That this was both prescient and that the means allocated remained inadequate will be seen later in the narrative.

corridor for later collection and destruction). Each team worked a 9-foot wide (2.7 meter) gap. The three overlapped to produce a gap 24 feet (7.3 meters) in width, which was considered sufficient for wheeled vehicles. Two mine detachments working side by side could clear a 16-yard wide (14.6 meter) gap, which was considered the minimum required for tanks to pass through at night.[14] The gaps were lit by green (for the inside or safe side of the corridor) and amber (for the outside or dangerous side of the corridor) battery-powered lights at night. For the daytime they were marked by crosses with a white (safe) and red (danger) cross-arm.

The unconventional means developed to aid in gapping the minefields was the 'Scorpion' mine-clearing tank. The 'Scorpion' was built on the chassis of the obsolescent 'Matilda' Infantry Tank. A girder framework was attached to the tank that supported a rotating drum to which a number of heavy chains were attached. An auxiliary motor was mounted in a housing of the tank to drive the drum. When rotated, the chains on the drum flailed the ground in front of the tank, theoretically exploding all mines in its path. Unfortunately, much of the performance of the 'Scorpion' was theoretical, in practice an assortment of problems meant that little real use was made of them in the battle. The auxiliary motor, mounted in its armored housing, suffered repeated failures from poor cooling and clogging from the masses of dust raised by the flails. The dust itself prevented accurate navigation and was a visible signature for the German and Italian artillery. Also, the exploding mine sometimes bent the girder frame connecting the roller to the chassis, and often the explosion turned the roller into a twisted wreck. The flailing chains also had the disturbing tendency to dig up the mines rather than explode them. The chains could even hurl the mines through the air, and often left them deposited unexploded on the deck of the 'Scorpion' itself. Finally, the 'Matilda' chassis were old and worn out, some apparently broke down even before operations began.

However, the worst problem with the 'Scorpion' was that, despite all of its faults, so few were actually available by the night of 23 October. Only 25 were operational with the South African Engineer Corps (SAEC) on 23 October.[15] Seven were assigned to the 7th Armored Division and 44th Infantry Division of 13 Corps, while it appears that the remaining 18 were split into six three-tank troops, two troops were assigned to the 2nd New Zealand Division, and one troop was assigned to the 9th Australian Division. It is difficult to discern the assignment of the other three troops (they may have been held in reserve) and – in any case – the 'Scorpion' troops tended to be assigned as needed. The few that were used mostly supported the conventional mine clearing parties and to provide a means to rapidly breach previously unknown minefields when they were encountered. They were also to be used if it appeared that the conventional mine clearing methods proved too slow to reach their assigned objectives in time.

Time was a major factor in the operation. The Eighth Army expected that the practical rate of advance of the mine clearing detachments would be 400 yards in two hours.[16] In practice,

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[14] Note that variations existed but this was the prescribed organization, see US Army Engineer Agency for Resources Inventories, *Landmine and Countermine Warfare: North Africa, 1940 – 1943*and *Appendices* (Washington, DC: NP, 1972) p. 84 and *seriatim*.

[15] The 'Scorpion' had been developed by a South African engineer officer, Major A. S. du Toit, Peter Chamberlain and Chris Ellis, "Churchill and Sherman Specials" in *Armoured Fighting Vehicles of the World, Volume 3: British & Commonwealth AFVs 1940-1946* (Berkshire, England: Profile Publications Limited, 1971), p. 121. Personnel for the 'Scorpion' troops were from the SAEC. In addition the 1st Army Tank Brigade was being converted from a conventional armored role to that of a dedicated 'Scorpion' unit. However, the conversion was incomplete at the start of the battle and the brigade did not join Eighth Army until after the battle had ended.

[16] Major General I. S. O. Playfair, *et al, The Mediterranean and Middle East, Volume IV: The Destruction of the Axis Forces in Africa* (London: Her Majesty's Stationery Office, 1966) p. 39.

the best rate was found to be 180 yards per hour, and to achieve even that it required little or no interference from the enemy.[17] Given that the operation was to begin at 2200 on 23 October, and that dawn was at about 0630, then there was enough time at the Eighth Army rate to clear minefields up to 1,800 yards in depth before dawn. At the more practical ideal rate there was sufficient time to clear minefields up to 1,530 yards in depth. In either case there should have been plenty of time to clear corridors through the two 250-yard deep minefield belts that Eighth Army expected 'January' and 'February' to be. Unfortunately, two factors worked against the British. The first was that it was well after midnight before the Commonwealth infantry had cleared the Axis battle outposts and advanced to the edge of the minefield. Most of the mine detachments did not begin operations to clear the minefields until well after midnight. Second was that the German mine fields were not simple 250-yard deep belts. Instead, the extraordinary density of the mines, and the use by the Germans of multiple layers of mine fields arraigned in a honeycomb, meant that in some areas of the front *each* of the belts were effectively as much as 1,600 yards deep.[18]

The Plan – Operation LIGHTFOOT

Operation LIGHTFOOT was planned as a deliberate attack to break through the German-Italian defenses at El Alamein. The battle was to begin with a massive artillery preparation, commencing at 2140 on 23 October. The main effort was to be executed at 2200 by 30th Corps, in the north, with four infantry divisions – deployed from right to left, 9th Australian, 51st Highland, 2nd New Zealand, and 1st South African – heavily supported by armor, artillery, and engineers. The task of 30th Corps was to clear the Axis defenses, while breaching the minefields. The penetration was to extend to a depth of about 4.5 kilometers, at its narrowest – in the sector of the 1st South African Division – to 8 kilometers, at its deepest – in the sector of the 9th Australian Division, by dawn on 24 October. The objective line to be reached, code-named OXALIC, would take the British forces through the German minefields, and would establish a 'bridgehead' for the deployment of armor on the German side of the minefield. On the extreme corps left 4th Indian Infantry Division was to execute diversionary attacks. The 2nd New Zealand Division had the 9th Armored Brigade attached (36 Sherman, 37 Grant, and 49 Crusader tanks operational). The 9th Australian, 51st Highland, and 1st South African divisions each had a regiment (battalion in US parlance) of Valentine tanks from the 23rd Armored Brigade[19] (169 Valentines total) attached, a fourth regiment remained under brigade command in corps reserve. In addition, the 2nd New Zealand Division had a Cavalry Regiment with 29 Stuart tanks, as did the 9th Australian Division with 4 Stuart and 15 Crusader tanks.

A secondary effort was to be made to the south by 13 Corps, with 44th British Infantry Division (only a single infantry brigade was initially committed), 7th British Armored Division

[17] Neil Orpen and H. J. Martin**.** *South African Forces World War II, Volume 8: Salute the Sappers, Part 1* (Johannesburg: Sappers Association, ND) p. 418.

[18] That British planning badly miscalculated the actual depth of the mine belts may be inferred from various remarks in *Landmine and Countermine Warfare, North Africa, Appendices*, p. K-5 and *seriatim*.

[19] The 9th Armored Brigade was an organic part of the 10th Armored Division. The 2nd New Zealand Division only had two infantry brigades at this time – the third brigade was converting to armor. The 23rd Armored Brigade was technically an organic element of 8th Armored Division. However, it had been thrown into the Battle of First Alamein under command of the 1st Armored Division straight from arriving in Egypt. Before the Battle of Second Alamein the 8th Armored Division was broken up and it was never used in action as a complete formation. See Duncan Crow, "British Armoured Units and Armoured Formations (1940-1946)" in *Armoured Fighting Vehicles of the World, Volume 3*, p. 243.

(68 Grant, 55 Crusader, and 83 Stuart tanks operational), and the reinforced Free French Infantry Brigade (16 Crusader tanks operational). Diversionary attacks, also under the command of 13 Corps, were to be executed in the center by the 50th British Infantry Division and the 4th Indian Division.

It was expected that at 0200 on 24 October the 10th Corps would begin passage of the minefields, executing its own breaching operations. The corps had two divisions under command, 1st (92 Sherman, 1 Grant, 76 Crusader tanks in 2nd Armored Brigade) and 10th Armored (124 Sherman, 59 Grant, 103 Crusader tanks in 8th and 24th Armored brigades).[20] It was planned that the two divisions would be completely deployed into the OXALIC bridgehead by dawn 24 October. From there, the corps would exploit to an objective line west of OXALIC, code-named PIERSON, and then to it's final objective, code-named SKINFLINT, straddling the main Axis lateral communications route. It was believed that this would force the Axis mobile forces to attack, and that they would be destroyed by the overwhelming British preponderance of strength.[21]

Kursk

While the image has been created in popular literature that the German forces at Kursk trained extensively in the months building up to the battle, and rehearsed on mock-terrain of the fortified area, the actual events are somewhat different.

Eyewitness claims have been made that particular emphasis was placed on teaching the break-through of fortified positions, breaching antitank ditches and defeating antitank strong points. They claim that exercises were held under active service conditions, and included field exercises with live ammunition and combined exercises with the Luftwaffe. Mine clearing was supposedly taught in special courses.[22]

However, it does not appear that this training was applied consistently to all 16 attacking divisions. Most of the training for the infantry divisions was more limited since they remained in the line before the battle. Two of the armored divisions moved into the area just before the offensive. Of the other seven armored divisions, a number of veterans from them in fact report the reverse, that they really had no idea of the extent and nature of the Soviet defenses. For example:

Private Karl Stark[23] of the *Grossdeutschland* Engineer Battalion recounted that:

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[20] Technically the 24th Armored Brigade – also an organic element of the 8th Armored Division – was only attached to the 10th Armored Division. However, as was previously noted, the 8th Armored Division was never employed as a complete formation.

[21] The British outnumbered the Axis in every category of strength except antiaircraft guns and light artillery (75mm field guns or smaller). Some of the numbers were (British – Axis):

Manpower	220,476	105,223
Medium Tanks	740	563
Light Tanks	324	50
Field Artillery	908	388
Light Artillery	0	173
Antitank Guns	1,451	586
Antiaircraft Guns	584	585

See Hero *Report Number 92* as corrected in *The Dupuy Institute* DuWar Database.

[22] See Friedrich Wilhelm von Mellenthin, *Panzer Battles* (Norman, OK: University of Oklahoma Press, 1956).

[23] Karl A. Stark was born on 20 April 1924, and was conscripted in 1942. After basic training he joined the engineer battalion of the *Grossdeutschland* Division in 1943, serving as a combat engineer (*pionier*). Kursk was his first battle. This and the following material are derived from personal interviews conducted with the veterans by Major General (Rtd.) Dieter Brand in 1999.

There was some really tough training from March through June in our unit. This included general combat training together with training in assault squads. However, there were no combat exercises in conjunction with armor or armored infantry, also no live fire exercises. There was no training aimed specifically at the tasks anticipated during Operation Citadel. We only learned later on that such an operation was imminent. We had no idea of the enemy 's system of defenses having being built with such intensity until we came upon it during the actual attack. The main purpose of this training was to create strong unit cohesion.

Information on the actual works that they were to attack was also limited. In the case of the 332nd Infantry Division, Lieutenant Jung[24] stated that:

I did see aerial photographs of the Soviet fortifications in the days before the offensive. I think our artillery had those. It clearly showed the antitank ditch, but the infantry positions were difficult to make out. Next to it were surely a lot of "fake" positions, which could not be identified as such on these photographs. Minefields were not recognizable. The whole sector up to Cherkasskoye had been heavily fortified.

In the case of *Grossdeutschland* Division, there appeared to be some awareness among the troops of what they were about encounter. This certainly was true of battalion-level commanders, as was reported by Captain Bergemann,[25] commander of the III Battalion, GD Regiment:

Our situation map in the operational department displayed a comprehensive view of the enemy situation at the end of June, beginning of July 1943. Several Soviet fortification systems placed within substantial intervals towards the enemy's rear had been positively identified up to a depth of over 20 kilometers (13 miles). We had a clear picture of the size of enemy artillery and antitank forces as well as numerous expanded minefields. I realized at the time that it was pure nonsense to have our Panzer divisions target the most heavily fortified enemy positions head on and at such minimal clearance between each division. I was of the impression that many other officers of the divisional command were aware of this as well.

Below battalion-level command, information, preparation and warning of what to expect appeared to be limited. Lieutenant Buchardi[26] of the *Grossdeutschland* Artillery Regiment staff reported:

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[24] Hans-Joachim Jung was born on 27 January 1921 and volunteered on 12 January 1939. He first served with the 8th Antitank Battalion, then with the 102nd Infantry Division, and since October 1942, with the 332nd Division. He was a company commander in the divisional antitank battalion.

[25] Alfred Bergemann was born on 10 October 1915 and joined the army on 1 April 1935. He first served with the 3rd Panzer Division, then temporarily in the Luftwaffe as an observer before joining the *Grossdeutschland* Division in April 1942. He began the battle as part of the divisional leadership reserve (intended as immediate replacements for officers lost in battle). While in reserve status he was assigned to the divisional Ia (operations officer) where he participated in much of the planning prior to the battle. He assumed command of the III Battalion on the third day of the battle.

[26] Joachim Buchardi was born on 10 May 1917 and was conscripted in October 1937, serving as an artillery officer since June 1940. During the Battle of Kursk he was O1 (S-3) of the *Grossdeutschland* Artillery Regiment.

My comrades and I had no idea at the time, that we were set to attack a system of fortifications staggered in the enemy's depth and branched out over a wide area, which the enemy had been preparing in for weeks on end and which featured deep ditches, earthen bunkers, fixed flame throwers, dug-in tanks and countless mine obstacles, as we later found out during the attack. We did not receive this intelligence about the enemy at that time.

Overall, although the German forces were trained and knowledgeable in a general sense of what they were facing, and in many cases were knowledgeable of the specifics of what they were facing, they did not have the detailed, carefully laid plans that characterized the British operations at El Alamein. In fact, the general approach was to initiate the plan of attack, and as difficulties were encountered, to improvise within the plan. This improvisation included aborting the attack of two divisions on the first day of the offensive, shifting their advance to follow other more successful divisions. Significant parts of *Grossdeutschland* Division were also rerouted away from areas that were heavily obstructed (the effectiveness of the obstacles was magnified by the wet weather, see Appendix V). The evidence is that this operation was not distinguished by a significant amount of time spent planning and preparing to deal with mines and obstacles. It certainly was addressed in the German operational order, but with nowhere near the degree of preparation done at El Alamein.

The mix of antipersonnel and antitank mines seems to have played no role in increasing planning or preparation time. **In fact, the difference in the planning and preparation times between the British at El Alamein and the Germans at Kursk was almost entirely driven by doctrinal differences and the intent of senior commanders, not by the threat or mix of weapons.**

BREACHING TIME

Second El Alamein

At El Alamein the most extensive minefields were concentrated into two major minefield belts. Individual minefields varied in shape, size, and density, as did their arraignment in the overall scheme of the minefield belts. The overall depth from front the front of the first mine belt to the rear of the second mine belt varied between two and as many as eight kilometers. And, depending on the angle at which the breaching parties struck them, the actual minefields (or in most cases the series of minefields) to be breached could be as much as 1,600 meters in depth.

However, in most cases where the British mine detachments were able to work they were able to breach the minefields through the depth of both minefield belts in less than 12 hours. Most of the breaching parties began working on the forward edge of the first belt between 2200 and midnight on 23 October, depending on the distance between the British front line and the forward edge of the minefield belt. By the following morning most of the mine detachments had achieved an initial breach, even if they had not completed their corridors.

In both of the cases where we know the specific times that the main breaches were begun and when they ended, less than eight hours were required. In the zone of the 9th Australian Division work began at 2245 and the final breach was completed at about 0500. In the 2nd New Zealand Division zone gapping began at 2223 and was completed by 0630. In the other cases specific times were not given, but it appears that – with a few exceptions—about the same time was required.

Only in operations of the XIII Corps to the south could it be said that the breaching operation was a failure. And in that case, it was more a factor attributable to the Axis holding the critical high ground, which allowed almost unlimited observation of the British breaches, rather than an actual problem in clearing the breaches that was responsible for the failure.

Kursk

As at El Alamein the most significant minefields at Kursk were in the first two defensive belts. Work on breaching the first belt was begun on the afternoon and evening of 4 July and major portions were breached by the 5th. The German breached parts of the second defensive belt by the afternoon of 6 July and the morning of 7th. By the afternoon of 7 July most of the attacking German armored forces were through the first two defensive belts and encounters with mines were sporadic thereafter.

We have not found any specific times required for clearing mines in these operations. The German records did not indicate the beginning and end times for clearing operations, although we have a general awareness of when action occurred throughout any particular day. However, the veteran interview we have access to provide some idea of the mine clearing time on 4 July:

Sergeant Ivanchuk,[27] Squad Commander, Separate Reconnaissance Company, 375th Rifle Division, recalled:

On 2 July I received the order from the company commander (Senior Lieutenant Kobzev) to get a prisoner from the area to west of the village of Shopino. During the entire day, I, along with

[27] Zahar Danilovich Ivanchuk served with the reconnaissance troops from late 1942 at Stalingrad to the end of the war at Berlin. The interview was conducted by Major General Nessonov on 20 November 1998.

two sappers, who were supposed to clear both our mines and German mines, and also a mortar platoon commander, were observing the area.

About 700 meters from our front line we saw with binoculars a trench, probably a Germans ammunition storage trench. We decided that on the night of 3 July we would get a captive. Nights were short, so as soon as soon as it got dark, we went to our front line. The Germans conducted sporadic gun and mortar fire and often fired star shells into the air. As usual, I divided the group into two, a capturing group and a fire group. Each soldier had a machine gun and grenades. Our mortars, one at a time, started infrequent fire at the front line. During the noise of the explosions, our sappers crawled ahead to clear mines. I and three soldiers behind me were following them. We were moving one behind the other, and stopping during star shells' flashes. It was scary. The path through the minefield was very narrow. Sometimes it seemed to us that German bullets were going right as us, not to say their mortars. We decided that our actions should be a surprise for the Germans. It was about one in the morning when most soldiers are very tired. We crawled to within 30 meters of the German trench.

Lt. Buchardi said that:

I observed the advance attack on the hillcrest between Gertsovka and Butovo on July 4th from our regiment command post. It began with a Stuka attack at 14:50 hours. At 15:00 the infantry attacked in pouring down rain.

Our Panzer Grenadiers and Fusiliers immediately found themselves under heavy artillery fire, and enemy ground attack planes also entered the fray. After surmounting at times heavy resistance and extensive minefields, the objective of the attack is accomplished by nightfall.

As Captain Wackernagel[28] recounted the battle:

On July 4 in the afternoon, the 3rd Battalion of the Fusilier Regiment attacked enemy securing posts along the crest of a hill range approximately two miles westward of Butovo. One battalion of the Grenadier Regiment advanced right next to it. A heavy fire barrage had preceded the attack by the artillery as well as by the deployment of Stukas.

This attack encountered strong resistance beyond expectation. The 3rd Battalion suffered the first losses among their leaders. The expansive mine fields the battalion had to cross were a particularly formidable obstacle. We had never seen mine fields of such an expanse before, they were the first great surprise.

I moved my battalion towards the hillcrest to the west of Butovo on the evening of July 4. We spent the night in the Russian positions that had been taken by our 3rd Battalion.

[28] Commander of the I Battalion, Fusilier Regiment, *Grossdeutschland*.

Lieutenant Walther Schaefer-Kehnert[29] described the afternoon and evening of 4 July in a letter written from the front on the 13 July 1943:

We assembled on the afternoon of 4 July. Stuka and artillery made their usual fireworks, assault guns and tanks rolled towards us with the battalions moving forward. The afternoon had been chosen, because the first day's task was merely to move forward and close in on the enemy's main line of resistance situated further back. This went according to plan and after taking the heavily mined village of Butovo we stood before the enemy's anti-tank ditch at dusk. The situation was not all that wonderful, as the Russian artillery had done their ranging exactly to this point and the enemy was able to prepare for the next day. Soaked by a thundershower and chilled, we hunched down in our foxholes and hardly found any sleep due to the restless bomber activity at night. Countless parachute flares hung in the sky and the flashes from detonating bombs illuminated the darkness.

These interviews – and the German ones all cover the crucial breaching of the first defensive line on 4 July – indicate that the crossing of minefields was something that was accomplished in hours, rather than days. The analysis of operations for 5 and 6 July show that the defended defensive belts were usually penetrated in a half-day (effectively about four hours) in the main area of attack. A chronology of the subsequent days of attack and discussion of armor losses during these breaching operations is provided in Appendix V. Overall, it does not appear that the time spent clearing mines was particularly lengthy in the mixed antitank and antipersonnel minefields at Kursk.

[29] Commander of the 4th Battery, II Battalion, 119th Artillery Regiment.

LOSSES

Second El Alamein
Personnel Losses

Daily battle casualty data is available for most of the Commonwealth Army units engaged in the Battle of Second El Alamein and may be found in Appendix II for those units discussed in this study. Most were recorded as of 0600 and represent the estimated casualties of the previous 24 hours.[31] Note that these were estimates, based upon the best knowledge available while the units were engaged in combat, and should not be considered to be either precise or definitive. It is often found that daily casualty reports are neither perfectly correct nor even reasonably complete. However, they do provide an excellent and timely reflection of the assumed status and capability of the units. These figures may be checked against a later summary, which does not given casualties by unit but rather by arm and nationality.[32] These yield the following comparisons:

Nationality	Cumulative Total From Above	Summary of Battle Casualties
South African	809	903
Australian	3,084	2,794
New Zealand	2,306	1,712

It is difficult to explain these discrepancies except to note that the first is from a 12-day and the second a 13-day sample, which could only explain the shortfall in the South African figures. However, the Australian and New Zealand figures given in the daily reports may be subject to interpretation. For instance, it appears that the Australian casualty estimate for 060030 - 060031 October 1942 was overly pessimistic. And in general, many of those counted as missing probably later rejoined, and in fact many that were captured by the Axis were released later in the battle and may never have been counted as a casualty in the final summary.[33] Also, it is uncertain whether or not the New Zealand casualties later in the battle included the attached brigades from the 44th, 50th, and 51st Divisions. Although it cannot be said that the daily accounting of casualties is the most accurate, there is little evidence that it does not give a reasonably accurate overall picture of the day to day battle as it was experienced. That is, there is no reason to believe that the actual casualties varied from the assumed casualties on only a single day. If that surmise is accepted, then the total casualties per day for the units of 10 and 30 Corps during the battle were[34]:

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[31] PRO WO 201/440, Eighth Army Daily Battle Casualties. Note that the first record in this serial, dated 25/10/42 appears to incorporate casualties from the start of the battle on the evening of 23 October. No record has been found for 24 or 28 October. However, 28 October is reconstructed from the cumulative totals given on 29 October.

[32] PRO WO 201/2834 'Summary of Battle Casualties (Excluding Sick) For Major Operations in Egypt, Libya & Tunisia: 23rd October to 4th November 1942 (13 Days), Second Battle of El Alamein.'

[33] The category of MIA is most subject to problems in reporting and interpretation. Personnel reported MIA may later report to duty, may be counted as wounded or killed, or may remain until the end of the war as MIA. It is not uncommon to find records where daily MIA losses are reported even though cumulative MIA losses decrease.

[34] Since the 13 Corps operations were so distinctly separate – and quickly terminated – they are addressed seperately in Appendix IV.

23 – 24 October	1,995
25 October	1,109
26 October	1,056
27 October	1,655
28 October	480
29 October	1,559
30 October	773
31 October	265
1 November	1,244
2 November	852
3 November	1,326

Note that the average daily casualties for the last ten days of the offensive (effectively after the minefields had been breached) were 1,032. Since the casualties for 23 – 24 October were 1,995, it could be assumed that the additional 963 casualties on the first day were a result of the Axis minefields. On the other hand it does not explain why the second highest casualty day was 27 October, after the minefields were mostly cleared (or at least were adequately gapped). A glance at the battle narrative shows that 27 October was the day of Rommel's major counterattack in which most British forces stood on the defensive rather than maneuvered. Furthermore, in a battle that featured much fighting at night, the casualties for 23 – 24 October include two nights of intense combat. Thus it could be speculated that the primary cause for the higher casualties on that day was simply more intense fighting over a longer period of time.

An examination of the casualties inflicted within individual divisions is also not illuminating. On 23-24 October, arguably during some of the most intense fighting by the infantry and when the minefields had probably the greatest effect, there does not appear to be any connection between the division casualties and the minefield sectors they encountered. For instance, the highest casualties suffered – by a wide margin – on 23-24 October were in the 51st Highland Division. It suffered 856 casualties, 607 more than its average of 249 on the following 10 days.[35] And yet, the linear density of antipersonnel mines in Mine Sector 'L' in the 51st Division zone was the second lowest encountered that night while the square density was the lowest. The highest antipersonnel mine densities found – again for both linear and square kilometer— was in the sector between 'J' and 'L' in the zone of the 9th Australian Division. And it was the 9th Australian Division, which suffered the lowest casualties of the night. In fact it suffered only 264 casualties, 18 less than its 282 casualty 10-day average. Of course this sample is from only four divisions. A more extensive analysis from a larger number of cases would be required to draw firmer conclusions.

Tank Losses

British tank strength for Second El Alamein is well documented and a daily record for those units examined in this study may be found in Appendix III.[36] However, losses, particularly

[35] It should also be noted that on the morning of 27 October the cumulative total of missing-in-action in the 51st Division was reduced by 290 – evidently men who had returned to duty.

[36] PRO WO 169/3861 and 201/440 'A.F.V. State (Eighth Army). Time is given as 0700. Another series of reports, 'Tank State – Egypt' is also available, with time given as 1200. The first is used except for 25 and 26 October, which are missing in the first set.

as to cause, are less well documented. The AFV State (Eighth Army) only records 'casualties to date' and 'unaccounted for' beginning with 27 October and only for the army as a whole, rather than for individual units. The Tank State – Egypt only gives cumulative army totals for 'unfit with units,' 'in bde [brigade] workshops,' 'in army workshops,' and 'under evacuation from fwd [forward] area,' figures which are also totals for the entire army, rather than for units. It may be taken that these include all battle damaged and mechanical losses recovered by formations, with the last being those so badly damaged as to require evacuation to the base workshops found in Egypt proper.

A total of 38 losses can be definitely attributed to mines, with another 15 as possible mine casualties. At least 118 may be attributed to tank gunfire. Initially, at least 746 tanks were fit for action with the units studied. By the end of the battle, 353 were left, including the 92 of the 22nd Armored Brigade. Thus, of the initial units involved in the battle, 261 were left. That would indicate that at least 485 were lost.

Further illumination may be gained by studying the losses of tanks in the Eighth Army as a whole. On 23 October the army had a total of 1,038 tanks serviceable with units, 157 serviceable in replacement units and in transit to the front from depots, 26 serviceable with training units, and 209 unserviceable in unit or army workshops. These totaled 1,430 serviceable and unserviceable. In addition, there were 1,240 serviceable and unserviceable in the Middle East Command, not assigned to the Eighth Army. Of these, 156 were in schools and units in training, 1,016 were in base workshops awaiting repair or modification (many were obsolescent types), 13 were in preparation for issue, 37 were unaccounted for (but not casualties), and 18 were being evacuated from the front. Thus, 2,670 serviceable and unserviceable tanks were in the Middle East.

By 4 November the army was reduced to 525 tanks serviceable with units, 87 serviceable in replacement units and in transit, and 15 serviceable in training units. Unserviceable included 133 under repair, 78 awaiting recovery from the battlefield, 41 in process of evacuation, and 416 unaccounted for. It was also noted that the unserviceable categories included "some casualties" but were "known to be incomplete." In addition, 165 were now in Middle East Command schools and units in training, 1,032 were in base workshops (apparently many of them were the same vehicles that were reported on 23 October), and 11 were being prepared for issue. Thus, by this time there were only 2,503 tanks in the Middle East, which would imply that at least 167 – the difference between the 23 October and 4 November total – had been 'written off' as destroyed.

Further evidence for the number of tanks lost may be gleaned from two reports filed later in November. In the first, dated 10 November, the losses are given as:

'Up to the evening 27th Oct'	100
'Slogging period, 31/10 and 1/11'	66
'9th Armd Bde Losses 2/11'	85
'Losses by other formations from 2/11 to 6/11'	81
'Total Casualties up to 6/11'	332

It was also noted that "not included in the above are 100 tanks unaccounted for in the forward area. Doubtless some of these are casualties." It is unclear whether or not these include the units of 13th Corps, which are not considered in this analysis. In any case it appears that at

least 232 apply almost exclusively to the breakout battle in the north after 27 October (there was little or no activity on the 13th Corps front after that time). A separate report on the same day estimated that 50 Sherman and 30 Grant tanks were 'written off' and that a further 75 Shermans and 60 Grants had been recovered and were repairable. The last report that addresses this subject is dated 22 November 1942. It is probably the most accurate, since it was from the Royal Electrical and Mechanical Engineers (REME), which was responsible for the repair, maintenance and recovery of tanks and other vehicles. That report gives the total number of tanks 'written off' as of 19 November as 128, of which only 22 were Grants and 23 were Shermans.

Overall, from these data the following assumptions may be made:

1. Eighth Army as a whole lost between 128 and 167 tanks destroyed between 23 October and 4 November.
2. Eighth Army lost about 449 were damaged or broke down between 23 October and 4 November (the difference between the unserviceable and unaccounted for on those dates).
3. The 10th and 30th Corps lost between 332 and 485 tanks.
4. The 10th and 30th Corps lost at least 38 tanks to mines and probably at least 53.
5. The 10th and 30th Corps lost at least 118 tanks to antitank or tank gunfire.
6. If the overall proportion of tanks lost to mines and gunfire – 38 (or 53) versus 118 – were maintained throughout the sample of 332 to 485 tanks assumed lost, then 107 – at minimum – and 218 – at maximum – were lost to mines. Of course this methodology posits the insupportable assumption that all of the tanks were lost to mines or gunfire and that none were lost to mechanical breakdown or other non-battle causes.
7. Twenty-one of the 38 tanks identified as lost to mines were lost by the morning of 25 October. That is, roughly within 33 hours of the beginning of the British attack.
8. The second largest incident, 6 known mine losses and 15 suspected mine losses, occurred during the 28 October Australian attack on a previously unbreached mine sector. In effect, it was a return to the night of 23-24 October, with apparently similar results.

Kursk

Before the main defensive minefield belts were penetrated, total German tank losses for 5 July were 249, including an estimated 131 that were lost due to mines. Total German personnel losses on 5 July were 6,478. Total German tank losses on 6 July were 278 with an estimated 69 that were due to mines. Total German personnel losses on 6 July were 4,118.

After the main defensive minefield belts were penetrated, total German losses on 7 July were 197 tanks and personnel losses were 3,252. The average German loss for 8 to 11 July was 100 tanks and 2,621 men per day.

Personnel Losses

There is no clear indication that the losses on 5 and 6 July that were in excess of the average loss between 7 through 11 July were due to mines. Still, these "excess losses" on the first two day of battle do provide some idea of the degree of loss suffered as a result of the fortified belts. These belts included not only antitank and antipersonnel mines, but also trenches, bunkers, pillboxes,

antitank ditches, barbed wire, cleared fields of fire, pre-registered artillery points, and so on. In effect, the excess casualty difference is the total contribution caused by the defensive works **and their defenders.** Mines make up an undetermined portion of that total.

Appendix VI contains an estimate of "excess losses" suffered on 5, 6, and 7 July. The “excess losses” were calculated as the difference between the daily loss on 5, 6, and 7 July, and the average daily loss for the days after each of those days. In other words, the average loss for 6 to 11 July was subtracted from the loss of 5 July, the average losses for 7 to 11 July from the loss of 6 July, and so on. This approach was justified because almost all of the Soviet mines were placed in the forward and first defensive line, while the major German attack forces were through that line by the end of the day on 5 July. The second defensive line was penetrated on 6 July in those areas where the Germans attempted to penetrate it (four of the nine German armored divisions did not attack the second defensive belt).

To summarize what may be concluded from Appendix VI:

1. "Excess" losses due to the Soviet prepared positions (including mines), natural defenses, and all other factors (air, pre-planned fire, force mix, and so on) for 5 July is 3,500 to 4,000 men (or more). Most of these losses are from just two infantry divisions.
2. "Excess" losses due to the second defensive belt (including losses from units still in the first defensive belt) for 6 July is 1,500 to 1,600 men.
3. "Excess" losses for the second defensive belt (including losses from units still in the first defensive belt) for 7 July is around 900, and was more likely due to other factors than the defensive works.

We then compared the mixture of antitank and antipersonnel mines in the defensive belts to the loss of the forces attacking through them. Detailed data on the composition of the minefield belts was only available for the Sixth and Seventh Guards Army, so the losses of the two German infantry divisions opposite the Fortieth Army (the 57th ID and the 255th ID) were not included in the analysis. Neither of those divisions had significantly higher losses in the first three days of the attack compared to their losses in the following four days.

The mix of mines in the Soviet first and second defense echelon was (see Appendix VII for details):

	AT	**AP**	**Percent AP mines**
6th Guards Army			
First Echelon	68,987	54,346	44.06
Second Echelon	19,274	8,978	31.78
7th Guards Army			
First Echelon	58,146	81,429	58.34
Second Echelon	8,668	3,711	29.29

Note that:

1. The ratio of antipersonnel to antitank mines declines in the second echelon when compared to the first.
2. The number of mines of any type is considerably smaller in the second echelon than in the first (4 to 11 times less).

3. The mix of antitank versus antipersonnel mines in the first echelon differs between the Sixth and Seventh Guards Army.

The first point – that the ratio of antipersonnel to antitank mines declined from the first to the second echelon – is probably not causing any significant difference in the casualty results. Many other factors were at play and the most likely was that the actual number of mines dropped so precipitously. Still, there might be some useful insight gained if it could be shown that there was a decline in armor losses that was similar to the decline found in personnel losses (about one-half). This analysis was done, but armor losses on 6 July were actually higher than they were on 5 July. This was due to significant defending armor forces (five armored corps) being committed by the Soviets on 6 and 7 July. As a result there is no way to establish such a relationship without further, in depth analysis of the losses in individual engagements.

The second point – that the number of mines in the first echelon was considerably greater than in the second – does allow one, with some gross assumptions, to measure the combat effectiveness of mines. If one assumes that the entire casualty difference between 5 July and 6 July was because they were longer fighting in the dense minefields of 5 July, then one could postulate that the much denser minefields of 5 July directly or indirectly resulted in 2,000 to 2,500 additional losses. This conclusion relies upon a series of gross assumptions, and certainly represents the most extreme conclusion derived from the data. The increased loss on 5 July could also be justified by the other defensive works, the presence of Soviet air, the presence of pre-planned artillery fires, and so on. Still, there is no question that the dense minefields on 5 July was responsible – at least indirectly – for some additional German losses, which could have been as many as 2,000 men

The third point – that the mixture between antitank and antipersonnel mines in the first echelon of the two Guards Armies is different – is worth exploring further. Facing the Sixth Guards Army (and its reinforcing troops) were six German armored divisions and two infantry divisions, while facing the Seventh Guards Army were three German armored divisions and three infantry divisions. The same analysis of daily losses as was done for the entire army was done separately for those troops facing the Sixth Guards Army and those facing Seventh Guards Army. However, the infantry corps (Corps *Raus*) facing Seventh Guards Army in particular had unusually high losses. This was for a number of reasons, including attacking without air support, the defender having armor while the attacker had limited antitank capability, the defender having considerable artillery, the normal problems associated with river crossing operations, and others. On the first day of the attack each of the two divisions in the corps suffered more than twice the casualties suffered by any of the other 15 German divisions on that or any other day of the battle. This was definitely true from 4 to 18 July and almost certainly held true until at least as late 3 August. As such, it is probably an exceptional case that had a lot more to do with factors other than minefields. Therefore, the data for units facing the Seventh Guards Army defenses is presented both with and without the casualties of Corps *Raus*. The specific breakdown of losses by corps is presented in Appendix VIII. To summarize:

July	"Excess" losses: 5	6	7	Total	Percent Mines are AP[37]	Minefield Density[38]
XLVIII Pz Corps	393	0	232	625	38.01	1,681
SS Pz Corps	778	580	0	1,358	39.86	2,327
III Pz Corps	280	331	173	784	56.87	3,391
Corps Raus	2,490	668	611	3,769	57.71	1,407

Any way one examines the data, there does not appear to be any clear pattern. To summarize the results:

1. If Corps *Raus* is excluded, then the result of the defensive belts was that an additional 2,767 casualties were inflicted on the three armored corps (12 divisions). These "excess losses" were caused by a variety of reasons, of which defensive mine works is only one.
2. There appears to be no clear and direct relationship between defensive minefield density and attacker losses.
3. There appears to be no clear and direct relationship between the mixture of antitank versus antipersonnel mines in defensive minefields and attacker losses.

A more in-depth analysis is possible, by dividing each day into its component division-level engagement (about 120 daily engagements) and comparing those fought in minefields to those where the force mix and ratios were similar, but where they were not fought in minefields. However, this is a much more complex task that is well beyond the available time and budget of this contract.

The Dupuy Institute has already divided the operations of two of the German corps into 49 separate daily division-level engagements. We suspect that an even more detailed analysis will certainly provide more reliable measures of the value of fortifications in combat, but it will probably still not completely address the issues of mine density or the mix of mine types.

Tank Losses

Recently *The Dupuy Institute* analyzed the loss of tanks at the Battle of Kursk and developed an estimate of the number that may have been lost to antitank mines. The methodology for the estimate may be found in the TDI report entitled *The Military Consequences of a Complete Landmine Ban,* and is repeated in Appendix V of this report. However, that report did not attempt to resolve the question of whether or not different densities of antitank mines resulted in higher or lower numbers of tanks lost to mines. It also made no attempt to compare and contrast or develop relationships between tank losses and personnel casualties. We will attempt to derive at least a 'first order' resolution of these questions in this report.

[37] For the XLVIII Pz Corps, it is calculated from the totals for the 71st Gds RD, 67th Gds RD and 90th Gds RD. For the SS Pz Corps, it is calculated from the totals for the 67th Gds RD, 375th RD and 51st Gds RD. For the III Pz Corps, it is calculated from the total for the 81st Gds RD, 78th Gds RD and 73rd Gds RD. For Corps Raus, it is calculated from the totals for the 72nd Gds RD and the 213th RD.

[38] Linear density is only calculated for the divisions (see previous note) in the first echelon. If there is more than one division, it is a simple average.

The "excess loss" estimation methodology used earlier with personnel casualties relies upon a certain degree of consistency in the opposition. By that we mean that the defenders force that is faced each day by an attacker is about the same as it is on any other day. In this way, one may compare total losses on a given day to average losses on other days and calculate from the difference an "excess loss." There are many weaknesses in this methodology, but it is about the limit of what may be done – at least partly due to the limitations of the data – without a far more extensive analysis.

Unfortunately, in the case of armor losses this methodology fails to provide any meaningful result. Since most of the Soviet armor did not see action until 6 and 7 July, the armor losses on the 5th were often less than the average losses for the subsequent days. Thus, for all the attacking armored units (except the Panther Regiment) on 5 July there were 56 "excess losses" (see Appendix IX). This is considerably less than our earlier estimate of 131 tanks lost on that day to mines. "Excess losses" for 5 and 6 July total 169 tanks, meaning that twice as many tanks – 113 – were "excess losses" on the 6th as there were on the 5th. This is contrary to the personnel "excess loss" data, the density of the minefields and antitank mines (which decrease proportionately through the depth of the position), and the sense of the narrative found in the record of the operations. This anomaly continues in the following days. We estimated that about 69 tanks were lost to mines on 6 July. The "excess losses" calculated for 5 to 7 July is 256 tanks, meaning that again there were more "excess losses" on 7 July than on 5 July.

The inconsistencies in the data were certainly caused by the commitment of large Soviet armored formations and the resulting tank battles that occurred on 6 and 7 July. As a result, this methodology cannot be used to estimate the additional tank loss caused by the presence of fortifications at Kursk. Instead we are left with the estimate of losses to mines on developed in the *Military Consequences of a Complete Landmine Ban*. This also leaves us with the unenviable position of trying to compare data derived from two entirely different methodologies. Still, for the sake of completing the analysis, we did do this. Finally, this also shows one of the major weaknesses of the "excess loss" methodology. It is distinctly possible that the numbers estimated for "excess" personnel losses are in fact lower than they actually were.

Comparison of Tank to Personnel Losses:

We also examined the ratio of tank to personnel losses to see if we could discern a pattern. However, little can be discerned from a direct comparison of total losses. One does note that the number of personal casualties per tank loss was very high on 5 July, implying that there may have been one or two thousand additional personnel casualties on that day (as a result of the fortified defensive positions). Still, one notes a similar ratio on 8 July, when tank losses were fairly low. The worst ratio (lowest number of casualties per tank loss) was on 6, 7 and 9 July. Overall, no pattern could be discerned, other than to confirm that infantry losses seemed very high on 5 July. A breakdown of this data by corps does not provide any further insights. See Appendix X for the details of this analysis.

Another comparison, which is to examine the total estimated tanks lost to mines versus casualties can only be done for 5 and 6 July, which are the only days we have estimates for tank losses due to mines. This data was inconclusive and is not reliable, so no conclusions were drawn from it. See Appendix XI for a detailed discussion.

THE FOLLOW-ON BATTLE

Second El Alamein

At Second El Alamein it may be fair to say that the British forces – at least in the northern sector of the battle – had effectively breached the main Axis minefield belts by the late morning of 24 October, some 10 to 12 hours after beginning their assault. The gaps were not as numerous nor always as wide as had been planned, and many were not completely 'mine proofed', but nevertheless, British forces had penetrated them. Curiously though, unlike Kursk (see the discussion that follows), there was no immediate breakthrough or exploitation phase following the penetration. Instead, the British armor suffered heavy losses attempting to breakout of the lodgment that they had made on the Axis side of the barrier.

What followed was a week of battle of varying intensity, as the Commonwealth Army slowly expanded its lodgment, repelled Axis counterattacks, and slowly eroded the defender's capacity to resist. In an effort to bolster the defense, Axis engineers emplaced additional mines, but with little apparent effect. Eventually, the Axis Army, with their reserves gone and with little capability of resisting, retreated. But, throughout this period it does not appear that mines had any direct effect on British losses or the course of the battle, except when the British attempted to assault previously unbreached sections of the original Axis defense line.

During the initial pursuit phase mines had little direct effect. However, the fluke combination of a drenching desert thunderstorm, untouched minefields, and a dummy minefield caused the Commonwealth pursuit to fail. This curious chain of events resulted because the British penetration had been directed south of the main coastal road. This coastal road was vital to Axis communications and was vulnerable to assault from the sea. As a result, the coastline adjacent to the road was mined, especially around the port town of Mersa Matruh, to a much greater depth than the rest of the Alamein position. So, as the Axis forces withdrew along the coast road, it was a relatively simple task to block the road. And, as the heavy rains made cross-country movement impossible, the coast road became a bottleneck for the British pursuers. Finally, the only slight chance of cutting off the Axis retreat before the Germans and Italians could take full advantage of those circumstances was thwarted – ironically – by a dummy minefield emplaced by the British months before the battle.

Kursk

When the Germans attacked and penetrated the first Soviet defensive belt, they engaged seven Soviet rifle divisions, which were supported by some tank regiments. After they penetrated this first defensive belt and approached the second belt on 6 July, the Germans were quickly entangled with five to 6 more rifle divisions, which were reinforced by 7 July with five Soviet armored corps. As the German attack developed, additional Soviet forces poured into the battle area. As such, the rate of advance of the attacking German forces slowed as the battle developed. This is shown in Appendix XII. The fastest rates of advance were on the second and third day of the battle, after the first defensive belt was penetrated. The advance rate on 5 July often exceeded the advance rates on subsequent days, when few mines or defensive works were encountered. However, after clearing the two defensive belts, the German rate of advance began to decline, until it effectively came to a halt on 12 and 13 July, when the Soviets counterattacked.

The effects of the defensive belt may be clearly shown when comparing the average opposed advance rate by corps from 5 to 6 July. On 6 July the XLVIII Panzer Corps advanced 2 kilometers more, the SS Panzer Corps advanced 2.2 kilometers more, the III Panzer Corps advanced 3.2 kilometers more, and Corps Raus (consisting of two infantry Divisions) advanced 3.9 kilometers more, than they did on 5 July. In the case of the XLVIII Panzer Corps and the SS Panzer Corps, the increase in the advance rate was entirely due to one division in each Corps achieving an advance of over 10 kilometers for the day. In both corps, two of the four divisions advanced less on 6 July than on 7 July.

For the other two corps (III Panzer Corps and Corps Raus), they also consistently advanced further on 6 July. These were the two units that were fighting through the Seventh Guards Army minefields that consisted of roughly 40 percent antitank and 60 percent antipersonnel mines. The two corps both showed a slower rate of advance on 5 July than did the others and thus a greater difference in their advance on 6 July. One could postulate that this was because of the mixture of mines in the defenses, but this is reaching well beyond the available data and is probably not the major cause. These two corps also had to conduct a time consuming opposed river-crossing operation. Their forces were limited to a small number of bridges that were available to cross armor and other supporting heavy weapons, which certainly slowed the advance on the first day of battle. Also, the two did not have any air support on 5 July. Finally, the opposing Soviet forces were deployed with a distinct forward bias and were able to defend with more men per kilometer of front than the Sixth Guards Army. The forward divisions of the Seventh Guards Army were deployed in two echelons (effectively with two regiments in the first and one in the second echelon). In the Sixth Guards Army divisions were deployed with all three regiments in a single echelon, due to the greater width of front they were defending. Finally, the Seventh Guards Army had more extensive and effective artillery and air support than the Sixth Guards Army did. As such, the low rate of advance for the Germans facing the Seventh Guards Army was due to a large number of reasons, of which the mixture of the mines was probably insignificant.

There is not much that may be concluded from the rate of advance after 6 July. There is clearly no simple correlation between the opposed rate of advance and the minefields. In fact in some cases the data shows a reverse correlation. That is, the illogical relationship that the more extensive the minefields, then the faster the Germans advance. A more sophisticated analysis, looking at terrain, force ratios and other factors, would be required to develop more meaningful results. However, it does appear that the first defensive belt as a whole (mines as well as fortifications) was responsible for slowing the German advance by an average of about two kilometers per day on the first day.

FINDINGS

Second El Alamein

1. The British made extensive preparations before the battle to account for the extensive German minefields. Planning and training of engineer troops was both specialized and intensive. Between six weeks and three months (depending on the unit) were spent in practicing minefield breaching. Minefields were a major factor in the planning stages of the battle.
2. The time required to breach each of the minefield belts varied considerably, but appears to have been about 4 hours for each. Minefields where the covering fortified positions were quickly seized were cleared relatively quickly. However, in those cases where the defended positions held out against the British assaults, then the breaching operations in the adjacent minefields were either severely retarded, only partly completed, or were abandoned completely.
3. Casualties due to mines in the first 32 hours of the attack may have been significant. After the initial attack casualties remained remarkably consistent with the intensity of operations. However, there is no indication that the casualties caused by the minefields hindered the breakout, rather it appears that the secondary affects of the minefields – traffic congestion, restricted maneuver, constricted logistical communications were a greater factor in limiting the early British success.
4. The presence of the minefields had a definite impact in reducing the success of the initial British attack. However, the later failure by the British to achieve significant advances appears to be more due to an unwillingness to accept the casualties that might have ensued from an all-out attack, rather than to any effect of the presence of mines on the battlefield.

Overall, at Second El Alamein, the defensive works prepared by the Axis had a significant role in slowing the British attack. However, ultimately the Axis lost not because the minefields and other defenses were quickly or easily breached, but rather because the Axis forces had insufficient strength to accept the attrition that was inflicted on them by the British attack.

Kursk

1. The Germans did not make any unusual preparations before the battle to account for the presence of the minefields. Planning and training were neither specialized nor intensive. Since they had three months to prepare for the attack, the Germans did conduct a considerable number of training and planning exercises, but mostly they were focused on general combat proficiency rather than on specific means of dealing with the Soviet defenses. The extensive defensive minefields did not pose a particular burden or delay to the planning and neither did the mix of mines.
2. The time required to breach the mined, fortified, defended positions was often around one-half day (4 hours). Undefended minefields clearly were breached at a much faster rate. This is also reflected in the reduced rates of advance for 5 July, about two kilometers per day less than on 6 July. As such, the fortified positions certainly slowed the German advance and delayed the attack, but not significantly. Minefields were part of that delay, in addition to other obstacles, defensive works, and opposing forces. There is no clear indication that minefields with a mixture of more antipersonnel than antitank mines caused a greater delay than minefields where the ratio was 50:50.

3. Casualties due to mines were significant. The fortified belt was certainly responsible for 2,000 or more additional personnel casualties (total German force strength was initially 337,705 in 16 divisions and total German battle casualties for the 17 participating divisions from 4 to 18 July was 34,354). Certainly a significant percentage of the loss were actually mine casualties. Over the first two days of battle, the minefields probably caused the loss of 200 tanks (although most were temporary) of a total of 1,525 lost to all causes, out of a total of 1,538 tanks committed. As such, one can conclude that the defensive works, which included minefields, caused increased attrition to the attackers. Certainly the opposed river crossing and defensive works were devastating for two German infantry divisions, which both lost about 10 percent of their strength in one day. Still, no pattern could be seen to indicate that the mixture of mines (antitank to antipersonnel) had a role in increasing or decreasing such losses.
4. The defensive works certainly slowed the German advance on the first day of battle. After 6 July, the measurable impact of mines on advance rates appears to have been limited.

Overall, at the battle of Kursk, the defensive works were helpful, but were insignificant in slowing the German attack or inflicting attrition on the attackers. The minefields clearly played a role as part of those defensive works. After the first two days of battle, the role of defensive works was much more limited. Ultimately the German attack was defeated, not by the presence of mines or by fortifications, but rather to a combination of factors, including the unfavorable force ratio and an especially stubborn resistance by the Soviet forces.

Comparing Second El Alamein to Kursk

A comparison of the results of the Second Battle of El Alamein to the Battle of Kursk still does not seem to answer the question of how the mixture of antipersonnel and antitank mines effects combat results.

	El Alamein	**Kursk**
Percent of Mines that are AP	6%	49%
Duration of Operations	15 days	14 days
Time to penetrate main mine belts	2 days	2 days
Initial Attacker Strength	220,476	337,705
Total Attacker Battle Casualties	12,604	33,697[39]
Losses, first day of attack	< 1,995	6,334
Losses, second day of attack	1,109	3,973
"Excess Losses"	934 ?	2,000 ?
Losses to mines	unknown	500-2,000 ??
Initial Attacker Tank Strength	746	1,538
Total Attacker Tanks Lost	485 ?	1,525
Estimated Tanks Lost to Mines	53 ?	200 ?

One could argue, from a quick glance at this comparison, that what was effectively a 50:50 mix of antipersonnel and antitank mines at Kursk resulted in 2,000 or more additional casualties and

[39] There were 657 casualties on 4 July, the day before the main attack. They are excluded from this figure.

is a testament to the effectiveness of mixed mine systems. However, this does not actually appear to be the case.

For one thing, the level of combat intensity at Kursk was higher. Total casualties at Kursk were 9.98 percent of the initial strength. At El Alamein casualties were 5.72 percent of initial strength. This was for forces of similar size, strength and composition, and a battle of similar duration. On the first day of battle, total losses at Kursk were 1.88 percent of initial strength, while at El Alamein they were 0.91 percent. The second day shows a similar pattern (1.18 percent at Kursk versus 0.50 percent at El Alamein). Overall, it appears that personnel losses at El Alamein were one-half the rate of Kursk. Casualties after the first two days at Kursk were 23,390, while at El Alamein they were 9,500. This results in losses of 6.93 percent of the initial strength at Kursk and 4.31 percent of the initial strength at El Alamein. It appears that the intensity of combat at Kursk was fairly constant at twice that of El Alamein, both while penetrating the mine belts and in the fighting afterwards. Added to that, the German forces at Kursk were 50 percent larger (1.53 to 1) than the British forces at El Alamein. When these two factors are considered (combat intensity and force size), then the casualties in penetrating the minefields in the first two days show no major differences. In other words, the 1,995 British losses on the first day multiplied by two and then 1.5 equals 5,985, which is not far from the German loss of 6,334. British losses on the first two days of combat account for 24.63 percent of their loss in the battle, while for the Germans the first two days account for 30.59 percent of their loss. Furthermore, nearly 3,000 German casualties were lost on that first day in two infantry divisions conducting a river crossing. If those are excluded from the first two days, then 22.06 percent of the German casualties were lost on the first two days. Therefore, when different intensity of combat, size of the attacking forces, and the unusually heavy losses suffered by two poorly supported infantry divisions are taken into account, there appears to be no evidence that the mixture of mines caused a major difference in losses.

The tank data shows the same pattern. The size of the tank forces differed by a factor of almost two (2.06 to 1). The losses varied by a factor of over three (3.14 to 1) and the mine loss varied by a factor of almost four (3.77 to 1). In both cases, mines appear to have been responsible for about 10 to 13 percent of the tank losses (10.93 percent for the British and 13.11 percent for the Germans). The British lost 7.10 percent of the tanks committed to mines, while the German loss of 13.00 percent at Kursk also reflects the higher intensity level there. Again, combat at Kursk appears to be twice as intense, but there does not appear to be much difference in casualties to mines, once that difference is accounted for.

Overall, it appears that the primary difference between El Alamein and Kursk is the intensity of combat. Once that and the size differences between the two forces are accounted for, then the losses, loss patterns and loss rates are very similar. This argues against the mixture of mines being a major factor in affecting casualties.

With this analysis, we have reached the absolute limit of what can be discerned from a "top-down" examination of the data and by comparing the Battle of Kursk to the Battle of Second El Alamein. However, further work can be done to produce a more precise measure of the effectiveness of fortifications and how effective the mines were as part of those fortifications. As a result of such a measurement, it may also be possible to produce a more rigorous measure of the combat effectiveness of mixed antitank and antipersonnel minefields.

To do such an analysis would require use of the DuWar Data Bases, in particular the Division-Level Engagement DataBase (DLEDB). *The Dupuy Institute* would analyze about 120 Kursk engagements (49 already exist) and about 60 North African engagements. The analysis would compare those engagements where there was heavy use of mines to those where there was no

heavy use of mines, and engagements where there were similar force mixtures, force ratios, terrain, and so forth. It would then compare losses, advance rates and outcomes from engagements in which fortifications were a major factor to those without extensive fortification.

This analysis would likely produce a definitive "force multiplier" value for field fortifications that could have statistical significance. *The Dupuy Institute* would then compare those operations in field fortifications that incorporated extensive minefields (measured by linear density) to those without minefields. Conveniently this occurs at Kursk, where the first defensive line was well mined, while the second and third defensive lines were not, while the first two defensive lines had similar numbers of other defensive works (pillboxes, trenches, ditches, and so on).

By measuring the result (casualties, advance rates and outcomes) of those engagements that occur where fortified works with different degrees of mines are present, one should be able to obtain a "force multiplier" value for the mines themselves. In addition some notion as to what portion of the "force multiplier" caused by field fortifications consists of the added value of mines should be obtainable. The final analytical step for such work would be to determine if this more refined data would provide us with a measure of the value of different minefield mixes on combat.

Such a study would take considerably greater effort than was expended in this study. At this point, without such a study, there is probably little more that can be determined from real-world data about the overall value of fortifications, mines, or minefield mixtures. In effect, we have reached the limitations of what can be done regarding the issue of mines within the constraints of low-budget studies that require quick turn-around.

CONCLUSIONS

The conclusions drawn by *The Dupuy Institute*, although based upon an extensive collection of historical data, is still limited by the depth of analysis possible under this contract. More work is required if more definite results are to be obtained. Thus, our conclusions are tentative. Still, they are based upon what is probably the most extensive analysis of the available real-world data that has ever been done on the subject. As such, although tentative, these conclusions are valid.

1. **The mixture of antitank and antipersonnel mines in the minefields was not a significant factor in determining casualties.** *The Dupuy Institute* is uncertain to what extent it was a minor factor in determining casualties. This was true for both personnel and tank losses. While logic dictates that a minefield with some antipersonnel mines present would be of more value than a purely antitank minefield, the *Institute* suspects that even the most rigorous analysis will not determine what the value of adding them would be. However, the added value of mixed fields is probably very low.
2. **Minefield density (measured as mines per kilometer) was not a significant factor in determining casualties.** While mines certainly caused casualties, the actual density of the fields did not demonstrate any measurable relationship to the number of casualties that were inflicted. While the *Institute* does not doubt that minefield density is a factor in determining casualties, no measurable relationship could be established between them. The *Institute* concludes that there were many other factors that were more important in determining casualties.
3. **Minefields have greater attrition effect against armor than against personnel.** While minefields accounted for a noticeable percentage of the armor loss – even though most were only lightly damaged – they accounted for a much lower percent of the total personnel losses. As such, it would appear that antitank mines are more effective than antipersonnel mines against their respective intended targets.
4. **Minefields have greater value in delaying armor than in delaying infantry.** In many cases (especially at Second El Alamein), the infantry passed through the minefields ahead of the armor. The ability of infantry to observe and avoid marked mines enabled them to pass through minefields without completing clearing – that is removing, disabling, or destroying – the mines. Armor on the other hand, required engineer or infantry support to pass through minefields. Thus, it would appear that antitank mines are a more effective as a barrier to tanks than antipersonnel mines are as a barrier to infantry.
5. **Minefields are primarily barriers.** It is important to fully understand this. The use of mines in conventional combat is not **primarily** to cause casualties (although they do cause casualties). Thus, for most purposes an effective substitute for them may be another barrier and not another casualty causing agent. Without performing a more lengthy and sophisticated analysis the *Institute* could not determine whether mines were a more effective barrier than tank ditches, barbed wire, and such, although tank ditches and marshy creeks seem to have been particularly effective at Kursk.
6. **Minefields did not appear to be a decisive determinant of the outcome of the engagements.**
7. **Minefields did not guarantee that casualties would be inflicted on the attacker.**
8. **Minefields that were undefended or undefended sections of minefields were an annoyance but had little impact on combat.**

9. **Defended minefields that were a surprise to the attacker could be particularly disruptive.**
10. **Preparation and special equipment results in fewer losses.**
11. **A more aggressive attack resulted in increased casualties and shorter breaching times.** The minefield was a barrier that forced the attacker to choose between losing time or casualties. This relationship can probably be measured with a more rigorous analysis. Therefore, if an attacker is willing or plans to take the time (like at El Alamein) they will have relatively lower losses in personnel and potentially in tanks. If they attempt to push through minefields in one-half day or less (as at Kursk) they will have higher losses. This is best expressed by three corollaries:
    A. **If the attacker is willing to accept casualties, the capability of the mines to act as a barrier and delay the attacker is reduced.**
    B. **If the attacker is unwilling to accept casualties, the result is an increase in breaching time.**
    C. **Minefields force the attacker to make a trade-off between time and casualties.**

APPENDIX I: Course of Operations, Second El Alamein

We will not attempt another narrative of the Battle of Second El Alamein. Rather, this narrative will trace those events of the battle that appear directly attributable to the German mine fields. We will also not attempt to cover the entire battle – in effect the operations of 13 Corps on the British left encountered so many difficulties that they were for all intents and purposes halted after the night of 25-26 October. Rather, we will concentrate on 10th and 30th Corps, in operation LIGHTFOOT and SUPERCHARGE.[40]

Night, 23-24 October 1942

The attack began promptly as planned at 2140, with intense counter-battery fires on known and suspected Axis artillery positions that lasted until about 2200. Wellington medium bombers added to the preparation, dropping 125 tons of bombs on suspected artillery positions and troop concentrations. The artillery then switched over (except for some units that remained dedicated to the counter-battery program) to direct support of the infantry assault, firing pre-planned concentrations on identified Axis positions and barrages to cover the advancing infantry. Overall, the pre-planned artillery program lasted about five and one-half hours.

On the corps right, 9th Australian Division, with two brigades, advanced through the depth of the Axis position, despite intense resistance. The right boundary of the division zone was close to the northern edge of Mine Sector 'J' and the left boundary included all but the southern tip of the mine sector between 'J' and 'L'. The division gapping detachments on the extreme right began operations as early as 2245. After 35 minutes work two 8-yard gaps had been cleared through the first minefield, but ten minutes later a second field was met. However, by 0050 (two hours and five minutes after starting) the first belt, 'January,' had been gapped. On the left, more antipersonnel mines were encountered, but by 0030 at least one lane had been cleared through 'January.' During these clearing operations, two of the three 'Scorpions' assigned to the Australians broke down and apparently the last was knocked out – possibly by an antitank gun. At about 0345, to quote from the official Australian history, [41]

It had been expected that the main minefield to be traversed in the first phase of the corps attack would be 250 yards deep and the plan allowed for this (and more) to have been cleared before the second phase attack began. However, the route to the start-line [of the second phase attack] *of the 2/13th* [Australian infantry battalion] *and 40th R.T.R.* [Royal Tank Regiment, the attached tank battalion from 23rd Armored Brigade] *was traversed by many secondary minefields so that mines had to be cleared for almost 1,600 yards. The lanes could not be made ready for the tanks despite Herculean efforts…*

[40] This narrative relies on three major sources: Playfair, *et al*; Michael Carver, *El Alamein* (New York: The Macmillan Company, 1962); and the Historical Evaluation and Research Organization (HERO*) Report Number 92, Modern Artillery Experience in Combat, Phase II Final Report, Volume I* (Dunn Loring, VA: HERO, 1983). Tank strengths are derived from PRO WO 201/440, A.F.V. State (Eighth Army) (as of 1200) and WO 169/3861, which give daily operational strengths (as of 0700) by unit and totals unserviceable and in reserve.

[41] Details on the mine clearing activities are from the extensive extracts of the relevant Commonwealth unit histories found in *Landmine and Countermine Warfare, North Africa,* and *Appendices*, and particularly in the separate volume of appendices.

However, just before dawn at 0500, the leading squadron (company) of 40th RTR managed to clear the minefields and linked up with the infantry. The tanks assisted in the capture of a few more strongpoints and then withdrew about 800 yards to sheltered positions. It may be said that the Australians had accomplished their objective, the right-hand brigade had reached OXALIC on schedule, but the left brigade was held up some 900 meters short of its objective as dawn broke.

The 51st Highland Division, next on the left, met considerable resistance and was halted short of OXALIC all along its front except on the extreme left, where the extreme northwestern slope of the crucial Meteirya Ridge was seized. The division zone included almost all of Mine Sector 'L'. The same problems that had met the Australians – scattered minefields and fields of greater than expected depth and density – had slowed the Highlander advance, as had their lack of experience.[42] The tanks of 50th RTR, the attached battalion from 23rd Armored Brigade, had a particularly frustrating night. The gapping detachments clearing the way for the advance of the tanks ran into one difficulty after another,

> *Scorpions failed to turn up, there were no mine detectors and the sappers, reduced to trying to clear a gap through 150 yards of minefield with nothing but bayonet-prodding, had a number of casualties. 'C' Squadron* [50th RTR] *were told to find their way to the 7th Argylls* [infantry battalion], *which as we have seen they eventually did. The gap was clear by half past two, but another field was found…*[43]

Three tanks of 50th RTR were lost to antitank fire as they approached their final objective.

The 2nd New Zealand Division, next in line, reached all of its objectives on the extension to the southeast of Meteirya Ridge, except on the extreme left, where part of the ridge remained in Axis hands. The division zone included about one-half of Mine Sector 'K'. Beginning at 2223, the two gaps for the right-hand brigade were opened by four sections (platoons) of engineers. One section quickly cleared the first minefield in the northernmost lane and a second section then passed through them, clearing two more belts of mines and finishing before dawn just behind the foremost troops. About 400 meters to the south, the second gap was opened with the assistance of 'Scorpions.'

> [Lt. Foster, commanding the engineer section] *went back for them. He found there were only two of the original three that had started out that night. The second one got off centre a bit and blew off a track but the third on made up for everything…the auxiliary motor finally seized up just short of the objective – Miteirya Ridge, but the tanks and supporting weapons were through before daylight*.[44]

The engineers completed both gaps by 0530 and antitank guns and other heavy weapons had reached the forward infantry positions and were being dug in. However, it was discovered that there was an additional minefield that partly covered the crest of the ridge and extended to

[42] The 51st Highland Division at El Alamein was actually the second one created by the British Army in World War II – the 'first' 51st Division having been captured in France in 1940. El Alamein was the 'second' 51st Division's first battle.
[43] Carver, p. 112.
[44] *Landmine and Countermine Warfare, North Africa*, p. 88.

the west, it was not finally cleared until 0630. By dawn the right-hand brigade had secured all of its objectives and was established well west of Meteirya Ridge.

The two gaps in the left-hand brigade sector were also begun at about 2230. Clearing the northern lane began well, and the first minefield was quickly cleared. However, the section clearing the lane then met disaster when it tripped a 500-pound British bomb that killed the NCO in command and three enlisted, and wounded 12 more men. Another section relieved them, and it then encountered an extensive antipersonnel minefield at the foot of Meteirya Ridge. The lane was finally completed at 0500 and the engineers were preparing to extend it to the forward slope of the ridge when daylight broke. The southern lane also ran into difficulties and was badly delayed. A 'Scorpion' troop (platoon) was brought up to speed the advance, but evidently all quickly broke down or bogged down in soft sand.

By dawn the engineers had cleared gaps all the way up to Meteirya Ridge, but "the field on and beyond the ridge was not breached by dawn."[45] However, the tanks of 9th Armored Brigade had begun to move forward at 0300, and at dawn were well closed up behind Meteirya Ridge. But when two regiments (battalions) attempted to push on they ran into more minefields. The Wiltshire Yeomanry lost nine tanks and the Warwickshire Yeomanry six tanks to mines. The rest then withdrew again behind the ridge.

The 1st South African Division, on the far left, met strong resistance and suffered heavy casualties and disorganization in its right-hand brigade, which was stopped about 700 yards from OXALIC, except on the far right where it adjoined with the New Zealander left. However, its left-hand brigade suffered only minor casualties and achieved all its objectives. The division zone included the southern one-half of Mine Sector 'K'. It does not appear that any of the four mine gaps were completed before dawn and the tanks of 8th RTR (attached from 23rd Armored Brigade) remained in divisional reserve.

At dawn on 24 October, 30th Corps had achieved about 80 percent of its objectives. However, the price of the achievement was that many of the Axis strongpoints had been bypassed rather than reduced. Worse, it appears that the small number (in relative rather than absolute terms) of antipersonnel mines used had an unintended consequence. Because the antipersonnel mines were concentrated along the edges of the antitank mine fields and around the major strongpoints, the British infantry advance proved to be relatively easy. But, the clearance of the antitank mines, necessary for the passage of the British armor and infantry heavy weapons remained a daunting task.

Worse, the failure of the left-hand Australian brigade to reach its final objective, and the similar failure by the right-hand brigade of 51st Highland Division adjacent to it, meant that the route of the 1st Armored Division corridor was badly obstructed. This corridor ran directly through the center of the mine sector between 'J' and 'L'. The bypassed strongpoints became critical, their fire harassed and disrupted the British mine clearing efforts and further delayed the entry of 1st Armored Division into the battle.

At 0200 the two divisions began their approach march. The 1st Division mine task force began gapping operations at 0020. One 16-yard gap though the first mine belt was opened by 0100, the second belt was breached by 0200, and a third minefield was gapped by 0500, opening a route forward to the Australian positions. However, the other two routes immediately ran into problems. On the next route the first minefield had to be cleared by prodding since the mine detectors refused to function, one that was cleared further progress was halted by one of the Axis

[45] Playfair, p. 38.

outposts that was still holding out. The outpost didn't fall until 0900, whereupon the second field was gapped, but another outpost blocked the clearing of the third minefield until midday. The third route had similar problems, the first field was gapped at 0200, but only an 8-yard gap was through the second by 0430. Axis resistance then prevented widening of the gap in the second minefield and work on the third until midday. The 1st Division leading units reached the former German front line a little after 0400 and began a slow and torturous advance through the single corridor that had been cleared through the minefields. The 2nd Armored Brigade leading the advance of 1st Division was repeatedly delayed by scattered mines, three Sherman tanks being disabled, and at daybreak was still well short of the forward Australian and Highlander positions, some five kilometers from its objective, PIERSON. Worse, the 2nd Armored Brigade was badly exposed to long-range German antitank and artillery fire. As it grew brighter, harassing fire on the tanks trapped in the confines of the corridor began. Apparently no tanks were lost, but the situation was steadily deteriorating.

To the south the 10th Armored Division mine task force benefited from a lack of enemy resistance and opened four corridors, one at 0200, one at 0430, one at 0515, and the last shortly thereafter. The corridors ran through the northern one-half of Mine Sector 'K'. The 8th Armored Brigade was thus able to close up on the left of 9th Armored Brigade on Miteirya Ridge by dawn, but lost 18 tanks to antitank fire when it attempted to push over the ridge. The trailing 24th Armored Brigade of 10th Division was unable to begin its approach march until 0430 – the rear areas were becoming badly congested – and did not reach the minefields until near dawn. As day broke it was only beginning passage of the corridors.

The movement of the armored divisions through the corridors failed in it's ultimate objective, the seizure of the OXALIC line before daylight. As the sun rose, the narrow, 16-yard wide corridors were teeming with vehicles, armored and otherwise, and the area on the eastern slope of Miteirya Ridge was becoming packed with troops, tanks, and guns. In the words of one participant it, "looked like a badly organised car park at an immense race meeting held in a dust bowl."[46]

Day, 24 October 1942

As the sun rose on 24 October, it rapidly became obvious to General Montgomery that the planned breakthrough had gone badly awry. Nowhere had the PIERSON line been reached and only one-half of the armored brigades (8th and 9th) planned for could be said to have cleared the main mine belts, and even they were still confronted with scattered mines and small minefields to their front. In the north, the 1st Armored Division was caught astride the minefields, with 2nd Armored Brigade badly exposed. To the south, the 10th Armored Division was in a better overall situation as regards the minefields, but any advance west over the Miteirya Ridge was badly exposed to the well established – and now very alert – antitank gun defenses.

After discussing the situation with his corps commanders and staff, General Montgomery decided to adhere to the original plan. During the day, 1st Armored Division and 51st Highland Division were to complete closing up to the OXALIC line and were to clear out the Axis positions to their rear that were holding up the mine clearing. The Royal Air Force, with support from the US Army Air Force, would strike German reserve and artillery positions. Meanwhile, the 10th Armored Division would improve positions along Miteirya Ridge and attempt to clear the mines to it's front in preparation for an advance to the PIERSON line that night.

[46] Carver, p. 123.

The 1st Armored Division was mostly successful during the day, eliminating two major defensive positions blocking the mine gaps. However, as the day advanced they became heavily engaged with Axis armored and antitank units. Most of the division losses suffered that day appear to have been to these causes. In the 2nd Armored Brigade, one regiment (battalion) lost four tanks to antitank and tank guns, another lost three to mines, supporting an attack on 'Kidney' Ridge – part of the OXALIC line, and the third lost six, all to antitank and tank fire. At least seven more were lost to other causes.

Further south the 9th Armored Brigade suffered heavily attempting to cover mine-clearing detachments on the forward slope of Miteirya Ridge. One regiment (battalion) was reduced to just four tanks by mid day, and was withdrawn to reorganize.

Finally, at dark, the 10th Armored Division attempted to breakout to the PIERSON line. The 24th Armored Brigade immediately ran into problems with mines. Apparently four gaps were planned, but gapping did not begin until 2245, an hour after they were to be completed. Finally, all resources were concentrated in a single corridor, in an effort to speed up operations. The 8th Armored Brigade also ran into mines and attempted to clear at least three gaps. Work began at 2000, and by 2230 two were open, but one was covered by heavy fire and was abandoned. Misfortune then struck when a random bombing attack hit some of the brigades' logistic vehicles, setting fuel and ammunition on fire. The fires attracted Axis artillery and the brigade was ordered to disperse to reduce casualties. By 0100 on 25 October the confusion was so great that the brigade commander recommended that the attempt be abandoned. However, at 0500 the 24th Armored Brigade succeeded in penetrating the minefield and began to advance on its objective.

25 October 1942

The confusion continued as day broke. The 8th Armored Brigade lost six tanks to antitank or tank guns and the brigade commander decided to withdraw behind Miteirya Ridge. By 0700 they were back at their starting line. Meanwhile, the 24th Armored Brigade had finally cleared a gap and threaded its way forward just before dawn. However, they lost two tanks while establishing that, despite their success, they were nowhere near PIERSON, having only advanced some 1,000 meters past the ridge. The 9th Armored Brigade was in a similar situation further south, dueling with Axis guns on the ridgeline 1,000 meters to their west that was their objective. Further north, the 2nd Armored Brigade also tried to push forward, but lost at least 20 tanks, 6 of them to antitank and tank guns.

Finally, at about 1130, Montgomery realized that the attempt to breakout to PIERSON had failed. He confirmed orders to withdraw 10th Armored Division and 9th Armored Brigade to the protection of the ridgeline, and later decided to withdraw the 10th entirely and reorganize them. The 30th Corps was to hold the Miteirya Ridge with the 2nd New Zealand and 1st South African Divisions. The 9th Australian Division was to begin 'crumbling' attacks to the northwest, supported by the 51st Highland Division and 1st Armored Division. The 24th Armored Brigade was reassigned from the 10th to the 1st Armored Division.

This plan was followed with some success. The 9th Australian Division advanced about 1,600 meters and took 173 Germans and 67 Italians prisoner. However, the 1st Armored Division supporting operation did not do as well, losing at least 16 more tanks in a renewed attempt to seize Kidney Ridge. The 51st Highland Division continued to push on and seized more of its original objectives along the OXALIC line.

26 October 1942

The efforts to push on to PIERSON in the 9th Australian Division zone had met with some success. However, overall it appeared that the Axis defenses had stiffened. They had successfully maintained an antitank gun line, roughly along PIERSON, that had restricted the maneuver of the British armor. The Axis reported a total of 1,700 Germans and 1,955 Italians killed, wounded, and missing to 26 October.[47] The British reported that, to date, a total of 628 German and 1,534 Italian prisoners had been captured – an unimpressive total given the resources the British had deployed in the attacks. On the other hand, Commonwealth losses had been fairly heavy, about 6,140 killed, wounded, and missing were estimated by Eighth Army – 4,640 in 30th Corps, 1,040 in 13th Corps, and 460 in 10th Corps. The estimates were that 300 British tanks had been put out of action, but that many were repairable (10th Corps had 93 actually under repair).[48]

The actions of this day remain confused for both sides. The Germans executed a number of attacks on the Australian positions around Kidney Ridge, and reported fierce fighting and heavy casualties. However, for their part the Australians reported 'threatening' Axis movements by groups of up to 100 tanks, but little actual combat. However, that was not to remain true on the following day.

27 October 1942

On 26 October Rommel had attempted to concentrate his mobile reserves in a strike to destroy the Australian penetration that centered on Kidney Ridge. However, miscommunications plagued the Axis forces and what had resulted were the desultory displays of force that the Australians had remarked on. But, by the morning of 27 October he had managed to assemble a fairly powerful striking force. Elements of the 15th Panzer Division, the Italian Littorio Armored Division, the German 90th Light Africa Division, and the Panzer Army Battle Staff had assembled northwest and southwest of Kidney Ridge.

At the same time that the Axis massed around Kidney Ridge, the 24th Armored Brigade prepared to pass through the defenders and continue the breakout attack. Instead, the British tankers encountered the Axis armor moving forward, 17 British tanks were quickly lost and the Brigade withdrew. But then the Axis tanks ran onto the British antitank guns on Kidney Ridge and, after suffering heavy losses, withdrew themselves.

Rommel then further reinforced his striking force with elements of 21st Panzer Division and the Italian Ariete Armored Division from further south and at about 1600, attacked again. This attack also ran into fierce resistance from British antitank guns and was unsuccessful. By the evening of 27 October, Rommel's major attempt to counterattack had failed, with heavy losses. The 15th Panzer Division had lost at least 17 tanks destroyed or damaged, it appears that Littorio had lost about 30, and the elements of 21st Panzer Division had lost about eight. At least 309 personnel casualties had been inflicted on the Axis forces as well.[49]

However, by the morning of 28 October, General Montgomery had decided to adjust his plans again.

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[47] *Tagesberichte, Pz-Armee Afrika Ia, 26 Okt 1942* (Daily Report of the Operations Officer, Panzer Army Africa), NARA Microfilm, T-313, Roll 470.
[48] Playfair, *et al*, p. 52.
[49] *Pz-Armee Afrika Ia*, 27 Oct, NARA T-313, Roll 470.

28 October 1942

Montgomery in fact decided to abandon attempts to breakout west from the Kidney Ridge position. Instead, the 1st Armored Division was to be withdrawn to reorganize. The new main thrust was to be executed by a heavily reinforced 2nd New Zealand Division, possibly as early as the night of 29-30 October.

Meanwhile, the 9th Australian Division continued operations, but reoriented from attacking to the northwest to attacking almost due north and northeast. The initial attacks by one brigade, supported by 40th RTR went well, but the other attacking brigade's armor support, 46th RTR, ran into minefields on the way in and lost six tanks. Then, in the dust and confusion the tanks became separated from the infantry and the 46th RTR was reduced to just 12 operational tanks. At least 21 had been lost, most of them evidently to mines, but all were recovered. In any case, these tank losses did not halt the Australian attack. Although all the objectives had not been attained, it had punched a new hole in the Axis line and threatened the envelopment and isolation of the Axis defenses that extended north and east to the coast. The Australians would continue to grind away at these defenses for the next two days, while preparing for another major set-piece attack on the night of 30-31 October (see below).

29-31 October, Preparing for Operation SUPERCHARGE

During 29 October the British Army was for the most part engaged in reorganizing and preparing for Montgomery's planned breakthrough attack, which had been code-named Operation SUPERCHARGE. The Germans made some minor attacks, attempting to re-establish contact with troops cut off by the Australian advance of the previous night. However, no major British attacks were made.

The 2nd New Zealand Division was reinforced with the 152nd Infantry Brigade of 51st Highland and the 151st Brigade of 50th Division (which had been only scantily engaged to the south). Later, the 131st Brigade of the 44th Division (13th Corps) would also join it. The attached 9th Armored Brigade was given a priority on tank replacements and was brought back up to strength of 72 Sherman and 49 Crusader tanks. The 1st Armored Division was also reinforced. The 24th Armored Brigade of 10th Division, badly hit, turned over its remaining tanks to the 2nd Armored Brigade and withdrew for refitting. Finally, the 7th Armored Division – leaving the 4th Light Armored Brigade behind – would also move north from 13th Corps and join the attack as 10th Corps reserve.[50]

It was expected that the minefield obstacles would consist only of scattered minefields and hastily emplaced individual mines. The remaining 'Scorpions' – 18 remained with the SAEC as of 1200 on 1 November – were all assigned to the operation to facilitate the rapid breaching of these scattered mines. However, the standard mine gapping tactics that had been developed were not ignored. The 2nd New Zealand Division Engineers prepared to open five corridors, two for each attacking brigade and one at the intra-brigade boundary.

Originally, the plan was that SUPERCHARGE would begin the night of 31 October-1 November. However, General Freyburg, commanding the new Zealand Division realized that the troops were exhausted, and that problems in re-deploying the mass of reinforcements, withdrawing the redundant elements of 10th Armored Division, and supporting the ongoing attacks of the 9th Australian Division, were insuperable. He requested a further delay in the

[50] The 7th Armored Division attack had made virtually no progress on 23 and 24 October and its attack had been called off by 25 October.

attack, to the night of 1-2 November. On the morning of 31 October, Montgomery reluctantly agreed.

Night of 30-31 October 1942, Attacks by 9th Australian Division

These attacks continued the success begun two nights before and were aimed at completing the isolation of the northernmost part of the Axis main line of defense that straddled the coastal road and highway that ran along the coast. During the attack two more tanks of 40th RTR were lost to mines, and at least two were lost to tank gunfire. The Australian attack did succeed in cutting off more Axis forces along the coastal highway and railroad at the strong-point known as Thompson's Post. German counterattacks attempting to seal the threatening breakthrough continued through 1 November. That evening, just before SUPERCHARGE began, the Germans succeeded in withdrawing their garrison at Thompson's Post.

Night of 1-2 November 1942, SUPERCHARGE

At 0105, 2 November, Operation SUPERCHARGE began. The two leading infantry brigades, the attached 151st and 152nd Infantry, supported by tanks of 8th and 50th RTR, reached their objectives by dawn, but with heavy casualties. Mines did not prove to be a major problem. By one account a 'Scorpion' operating in a suspected minefield exploded only a single mine. However, mines continued to have some unexpected effect. The 9th Armored brigade lost 29 tanks, at least six of them to mines, in the approach march before it reached its line of departure.

2 November 1942

Then, at about 0615 on 2 November, the 9th Armored Brigade executed its attack. One regiment (battalion) was quickly thrown into disorder when a mine disabled the commanders' tank. More were lost to antitank and tank gunfire. By 1040, the brigade was reduced to 17 operational tanks, and a total of at least 85 had been lost to enemy action (accounts of the number they began with vary, but it appears to have been between 133 and 140). But only 7 of the 114 lost can be reliably attributed to mines.

At about the same time, the 2nd Armored Brigade was passed through to continue the attack. However, it encountered a German counterattack, which stopped it short of the Rahman Track. The Rahman track was the critical lateral communication route that had been the ultimate objective of the original LIGHTFOOT plan. The British had been striving for over a week to achieve it. The 8th Armored Brigade was then inserted on their left, but also made no progress. By the end of the day the 8th Armored Brigade had lost six tanks. On their left a New Zealand Brigade, supported by 50th RTR extended the attack even more. Four tanks were lost, two of them to mines, but 160 Italian prisoners were taken and the attackers suffered virtually no infantry casualties.

Although the carnage inflicted on the 9th Armored Brigade was sobering, and it did not appear at first that the Axis defenses were weakening, in fact by the evening of 2 November Rommel had decided upon a withdrawal. German forces had been reduced to fewer than 35 tanks. There were still 143 Italian tanks left, but they were only marginally capable against the British tanks. Finally, personnel losses, especially in the infantry, were climbing. German missing in action had climbed to 2,161 and incomplete reports indicated that at least another 1,481 killed and wounded had been lost. Italian personnel losses were also growing, reports indicated that 1,660 were missing and 1,299 were killed and wounded.

Interestingly, it does not appear as if the scattered minefields encountered by the attack had any appreciable effect. There does not appear to have been any noteworthy cases where the attack suffered significant losses to mines, except in the case of those lost by the 9th Armored Brigade, six out of seven of which were lost in the approach march prior to the attack. That is, it appears likely that at least six of the losses were to scattered mines encountered in the 'cleared' gaps, rather than to deliberate mine barriers. Perhaps significantly, the number of operational 'Scorpion' remained constant at 18 until 1200 on 4 November when it fell to eight, indicating that few of them were lost to any cause during the actual attack.

3 November 1942

However, on 3 November orders from Adolf Hitler arrived, forbidding withdrawal. Some Axis units reluctantly returned to positions they had just abandoned. In the afternoon a new British attack struck the weakened Axis lines. The 8th Armored Brigade lost 20 tanks, all to antitank guns. However, the relatively fresh 22nd Armored Brigade of 7th Armored Division, attacking further south, met little resistance and rapidly outflanked the new German line. British and South African armored car regiments (battalions) pushed into the slowly widening gap, threatening the Axis rear. Pushing on into the morning of 4 November, the British finally began to crack the obstinate defense. The Panzer Army Africa Battle Headquarters was overrun near noon, and the commander of the Afrika Korps, General Ritter von Thoma was captured, a few members of the staff escaped and rejoined Rommel at the Army main headquarters. By then, the entire position had begun to collapse and the Axis forces were in full retreat.

Aftermath

The British pursuit of the Axis army suffered from confusion, hesitance, exhaustion, and lack of fuel. Montgomery decided to execute the pursuit with 10th Corps (1st and 7th Armored and 2nd New Zealand Divisions), while 30th Corps reorganized along the coast and 13th Corps mopped up the battlefield. During the night of 4-5 November, the 8th Armored Brigade attempted to push on, but became disoriented in the unfamiliar desert. The brigadier decided to halt and wait for daylight. The two brigades of 7th Armored Division, 4th Light and 22nd Armored ran short of fuel during the night and were forced to halt. At dawn on 5 November the pursuit began in earnest, 54 German and Italian tanks were destroyed or captured and the 8th Armored Brigade took over 1,000 prisoners. But by this time the remnants of the Axis army had effectively broken contact and were rapidly streaming west on the coast road.

A dummy minefield held up the 7th Armored Division cross-country advance for two hours late in the evening. Worse, fuel shortages continued to plague the armored brigades. Curiously, this eventually proved to have been a dummy minefield installed by the British during the withdrawal earlier in July.

The 1st Armored Division was forced to halt until dawn of 6 November while its fuel trucks attempted to move forward through the traffic congestion in the original battlefield area. Finally, heavy rains began at mid day on 6 November, turning the desert into a quagmire. The cross-country pursuit ended, effectively ending the Second Battle of El Alamein. The next major stand by the Axis forces was about 1,500 kilometers to the west, at El Agheila on 14 December.

APPENDIX II: Daily Personnel Casualties for Selected Eighth Army Units

Date	KIA	WIA	MIA	Total
220023 - 060025 October 1942				
1st Armored Division	13	31	2	46
10th Armored Division	4	66	8	78
51st Highland Division	156	200	500	856
1st South African Division	91	309	9	409
2nd New Zealand Division	68	194	74	336
9th Australian Division	32	173	59	264
23rd Armored Brigade	2	4	0	6
060025 - 060026 October 1942				
1st Armored Division	28	125	1	154
10th Armored Division	24	101	65	190
51st Highland Division	66	116	59	241
1st South African Division	5	26	4	35
2nd New Zealand Division	30	89	50	169
9th Australian Division	49	230	14	293
23rd Armored Brigade	10	17	0	27
060026 - 060027 October 1942				
1st Armored Division	24	71	6	101
10th Armored Division	8	67	40	115
51st Highland Division	141	254	-290	395
1st South African Division	10	61	1	72
2nd New Zealand Division	43	160	25	228
9th Australian Division	25	95	16	136
23rd Armored Brigade	0	9	9	9
060027 - 060028 October 1942				
1st Armored Division				106
10th Armored Division				346
51st Highland Division				16
1st South African Division				155
2nd New Zealand Division				556
9th Australian Division				476
23rd Armored Brigade				0
060028 - 060029 October 1942				
1st Armored Division	41	107	41	189
10th Armored Division	19	54	33	106
51st Highland Division	15	87	33	135
1st South African Division	1	9	4	14
2nd New Zealand Division	2	6	0	8
9th Australian Division	2	18	1	21
23rd Armored Brigade	1	5	1	7
060029 - 060030 October 1942				
1st Armored Division	24	89	6	119
10th Armored Division	26	115	463	604
51st Highland Division	17	74	5	96
1st South African Division	12	63	2	77
2nd New Zealand Division	1	16	2	19
9th Australian Division	44	388	130	562
23rd Armored Brigade	8	32	42	82

060030 - 060031 October 1942				
1st Armored Division	8	39	41	88
10th Armored Division	13	10	23	46
51st Highland Division	12	38	6	56
1st South African Division	0	0	0	0
2nd New Zealand Division	1	4	0	5
9th Australian Division	58	217	299	574
23rd Armored Brigade	3	1	0	4
060031 October - 060001 November 1942				
1st Armored Division	2	5	1	8
10th Armored Division	8	20	3	31
51st Highland Division	13	51	1	65
1st South African Division	2	3	2	7
2nd New Zealand Division	3	17	0	20
9th Australian Division	14	68	17	99
23rd Armored Brigade	4	22	9	35
060001 - 060002 November 1942				
1st Armored Division	0	0	0	0
10th Armored Division	34	78	2	114
51st Highland Division	70	130	137	337
1st South African Division	1	5	3	9
2nd New Zealand Division	46	187	0	233
9th Australian Division	75	234	206	525
23rd Armored Brigade	6	18	2	26
060002 – 060003 November 1942				
1st Armored Division	27	87	1	115
10th Armored Division	0	5	0	5
51st Highland Division	77	136	8	221
1st South African Division	1	15	0	16
2nd New Zealand Division	72	231	78	381
9th Australian Division	12	64	31	107
23rd Armored Brigade	1	5	1	7
060003 - 060004 November 1942				
1st Armored Division	13	63	120	196
10th Armored Division	17	72	6	95
51st Highland Division	185	199	251	635
1st South African Division	1	14	0	15
2nd New Zealand Division	36	161	154	351
9th Australian Division	14	13	0	27
23rd Armored Brigade	1	6	0	7

APPENDIX III: Daily Tanks Reported Fit and Lost for Selected Eighth Army Units

070023 October 1942	Total Fit	Lost in the previous 24 hours
2nd Armored Brigade	169	
24th Armored Brigade	146	
8th Armored Brigade	140	
23rd Armored Brigade	169	
9th Armored Brigade	122	
Total	746	

070024 October 1942		
2nd Armored Brigade	171	3 - mines
24th Armored Brigade	126	
8th Armored Brigade	160	18 – AT guns
23rd Armored Brigade	193	3 – AT guns
9th Armored Brigade	127	15 - mines
Total	777	

Comments: In this 24-hour period these units moved up to the front and began the attack. Curiously, it appears that by the end of the period the overall strength of the units had increased. However, upon close examination it appears that the report for the 23rd Brigade may have included a transcription error and that it is likely that the brigade only had 163 rather than 193 tanks. This would jibe with reports that the 23rd brigade lost 3 tanks to AT gunfire.

120025 October 1942		
2nd Armored Brigade	149	10 – AT guns, 3 – mines, 7 – unknown
24th Armored Brigade	145	2 – unknown
8th Armored Brigade	167	6 – AT guns
23rd Armored Brigade	135	
9th Armored Brigade	92	
Total	688	

Comments: It appears that this report actually begins to 'catch up' with the losses to date. The decrease of 58 tanks from the 070023 October report still appears short, since the reported cases total 67 in the previous two days. However, it is likely that some of those were repaired and returned to the units.

120026 October 1942		
2nd Armored Brigade	122	6 – AT guns, 14 – unknown
24th Armored Brigade	104	16 – unknown
8th Armored Brigade	114	
23rd Armored Brigade	154	
9th Armored Brigade	80	
Total	574	

070027 October 1942		
2nd Armored Brigade	131	
24th Armored Brigade	104 (as of 1200)	17 – AT guns
8th Armored Brigade	97 (as of 1200)	
23rd Armored Brigade	160	
9th Armored Brigade	65	
Total	557	

070028 October 1942	
2nd Armored Brigade	143
24th Armored Brigade	} Total for both
8th Armored Brigade	} 191
23rd Armored Brigade	149
9th Armored Brigade	81
Total	564

070029 October 1942		
2nd Armored Brigade	119	
24th Armored Brigade	} Total for both	
8th Armored Brigade	} 167	
23rd Armored Brigade	153	6 – mines, 15 – unknown (possibly mines)
9th Armored Brigade	121	
Total	560	
070030 October 1942		
2nd Armored Brigade	114	
24th Armored Brigade	72	
8th Armored Brigade	67	
23rd Armored Brigade	142	
9th Armored Brigade	102	
Total	497	
070031 October 1942		
2nd Armored Brigade	164	
22nd Armored Brigade	108	
8th Armored Brigade	76	
23rd Armored Brigade	144	2 – mines, 2 – AT guns
9th Armored Brigade	114	
Total	606	
070001 November 1942		
2nd Armored Brigade	139	
22nd Armored Brigade	108	
8th Armored Brigade	91	
23rd Armored Brigade	111	
9th Armored Brigade	140	
Total	589	
070002 November 1942		
2nd Armored Brigade	163	
22nd Armored Brigade	111	
8th Armored Brigade	131	
23rd Armored Brigade	116	
9th Armored Brigade	164	
Total	685	
070003 November 1942		
2nd Armored Brigade	110	
22nd Armored Brigade	89	
8th Armored Brigade	79	6 – AT guns
23rd Armored Brigade	79	2 – mines, 2 – unknown
9th Armored Brigade	45	7 – mines, 40 – AT guns, 23 – unknown
Total	402	
070004 November 1942		
2nd Armored Brigade	94	
22nd Armored Brigade	92	
8th Armored Brigade	75	20 – AT guns
23rd Armored Brigade	57	
9th Armored Brigade	35	
Total	353	

APPENDIX IV: 13 Corps Operations at Second El Alamein

The operations of the British 13 Corps on the far southern flank of the Eighth Army constitutes a distinctly separate part of the Battle of Second El Alamein. The battle in the south was complicated for the British by the Axis possession of Qaret el Himeimat. Himeimat was a high hill that formed the easternmost extremity of the El Taqa Plateau. The El Taqa Plateau in turn formed the northern rim of the impassable Qattara Depression that acted as an anchor for the Axis right (and British left) flank. From the height of Himeimat it was possible for Axis observers to view every movement in the broken ground north and east of the hill, forcing the British front line to be held back almost 10 kilometers from the Axis front in the south.

Plan of Operations

As a consequence, the British 7th Armored Division was forced to make a 16 kilometer long approach march from its assembly area to the battle area. And, in the interest of speed and coordinating the 13 Corps attack with that of 30 Corps in the north, it was decided that the four gaps planned for the 7th Armored Division would be executed primarily by 'Scorpions.' A total of seven 'Scorpions' were assigned to the division, one to each gap with four in reserve. However, it was planned that the supporting attack by an infantry brigade of the 44th Division, 300 meters north of the 7th Armored Division corridors, would be executed manually, with engineers on foot prodding for mines after the first was encountered. The method for detecting the edge of the minefield was the same as in 30 Corps, a heavily sandbagged truck was slowly driven backwards at the head of the column until it exploded a mine. About 300 meters further north, the 131st Brigade of the 44th Division was to use similar methods, without the 'Scorpions,' to clear two additional lanes in support of the attack.

Himeimat was to be seized by a bold flanking maneuver by a Free French Brigade, with two infantry battalions. The battalions – without armored or heavy weapons support – were to execute a deep envelopment to the south, skirting the edge of the Qattara Depression, and seize the southwestern side of Himeimat, cutting it off from the Axis line. Then, it was hoped that sufficient time would remain for antitank guns to be brought up in support before an Axis armored counterattack could eject the French from the heights.

Night of 23-24 October

Unfortunately, neither of the supporting operations for the 7th Armored Division main attack had much success. To the north the 131st Brigade attack fell into confusion almost immediately. The single battalion assigned to seize strongpoints covering the planned lanes suffered heavy casualties – including their commander who was killed – and fell back to their start line.[51] The Free French attack had little more success. The two battalions seized their objective by 0230. However, the supporting antitank guns were unable to move up through the harsh terrain (mines were not mentioned as a cause for the delay) and the expected German counterattack swiftly pushed the French off the high ground. In the ensuing withdrawal at least 200 casualties were incurred and the French commander was also killed, demoralizing the

[51] A measure of the confusion in the 131st Brigade was that initially casualties were reported as 8 KIA, 23 WIA, and 723 MIA up to 0600 on 26 October. One day later, the MIA was reduced by 632, to 91. See the casualty addendum that follows.

remnants of the two battalions.[52] Himeimat was to remain firmly in Axis hands until the end of the battle and Axis observation of the 13 Corps movements was to be unobstructed.

When the gapping parties of the 7th Armored Division began advancing at 2200 hours, the first mine they encountered was about 900 meters east of 'January.' This random chance – one British history called it "a chance in a million," since no other single mines were discovered more than 300 meters from 'January'[53] – caused the gapping parties to begin mine clearing operations with the 'Scorpions.' The immense plumes of dust that were raised by them immediately attracted the attention (even in the darkness) of the Axis defenders, who began harassing the engineers with artillery and mortar fire. The delay meant that clearing of 'January' did not begin until after 2130 hours, well over an hour late. Worse, the pointless mine clearing effort had severely stressed the 'Scorpions," which quickly began to suffer repeated breakdowns, further slowing their progress. One was lost, evidently to a mine, in the fourth, southernmost corridor at 1230. A second was lost to a combination of antitank gunfire and mines in the second corridor from the north at 0140. A third, in the third corridor, was lost to breakdown at 0215. And the fourth was lost at 0430 to unknown causes (probably breakdown) in the first corridor. The gapping of 'January' continued by hand and by 0230 the two southernmost lanes were open. By 0400, three gaps (only one was 24 meters wide – the other two were barely three meters wide) were open and a bridgehead was formed, west of "January.'

However, with daylight breaking, and Himeimat still in Axis hands, it proved impossible for operations to breach 'February' to continue. It was decided to put off further breaching until the night of 24-25 October, when the three 'Scorpions' in reserve could be brought up.

Night of 24-25 October

The plan of operations for the night of 24-25 October was to complete the breaching of 'February,' allowing the two armored brigades of the 7th Armored Division to force their way through the minefields. The 131st Brigade (minus one badly disorganized battalion) was to push through "February,' covering the opening of two lanes for the armor. No attempt was made to seize Himeimat this time.

The attack began in a muddle, as the two attacking battalions of 131st Brigade were delayed getting to the start line (in fairness to them, one battalion had a 5.5 kilometer-long and the other a 8 kilometer-long approach march to the start line). However, despite being delayed twice, the attack began at 2030 and the 131st Brigade made initial good initial progress and penetrated beyond 'February.' After that though, it was a repetition of the previous night. Both battalions were pinned down by intense machine gun, mortar, and artillery fire and suffered heavily – one of the battalions lost its commander, second-in-command, and two company commanders – probably 200 casualties were lost and the attack stalled.

Despite the setback, by 0230 the two remaining 'Scorpions' (the third had broken down en route) had opened two lanes. However, the fire was so intense that the northern route could not be marked by the engineers. Unfortunately, this was the route assigned to the 4th County of London Yeomanry, leading the 22nd Armored Brigade. The Yeomanry attempted to push

[52] As in the 131st Brigade, French casualties were very exaggerated. Initially, 38 officers and 700 men were reported lost. However, on 29 October the loss was reduced to "about 200" officers and men. See WO 201/441 "Daily Strengths and Casualties – Libya."

[53] *Landmine and Countermine Warfare, North Africa, 1940-1943, Vol. 1*, p. 139.

through, but lost four Grant and 22 Crusader tanks to the mines and to antitank guns that enfiladed the gap. The 1st Royal Tank Regiment attempted the southern gap (which had been marked) and succeeded with light losses. The divisional commander then decided to postpone further attempts to push the armor through until daylight when observed artillery fire could deal with the antitank guns and the engineers could proof and mark the gaps again. The divisional engineer – convinced that the gaps were already open and that it would be impossible to clear the northern gap in daylight – protested the order. He was then ordered to see to the northern gap personally, which resulted in the loss of another tank and confirmation that the intense antitank and small arms fire directed at the gap would prevent any further lifting of mines by hand.

As a result, just before daybreak, the divisional commander decided to abandon any further attempts at getting the tanks forward through 'February.' The 13 Corps commander concurred with the decision, and, at noon on 26 October, General Montgomery ordered that the attack in the south be canceled. The 7th Armored Division was withdrawn with little further loss and later shifted north to reinforce 10 and 30 Corps.

Conclusions

It was unlikely from the start that the secondary operation of 13 Corps would have any real chance of success. Given the nature of the terrain, the entire operation was predicated on the Free French seizing Hemeimat, which was – at best – a gamble. Mines played no part in the repulse of the French, the terrain was a sufficient obstacle in this case. More interestingly, mines did play a part in the eventual failure of the 7th Armored Division. However, the initial setback to the 7th Armored Division attack was a result of random chance, rather than the deliberate plan of the Axis defenders. It appears possible that without the additional delay imparted by the explosion of that single mine, the 7th Armored Division might have had enough time to open lanes in 'February' before sunrise on 24 October. However, it also appears that the most likely consequence resulting from that would have been that the mass of the 7th Armored Division tanks would have been exposed, west of 'February' to the untouched antitank guns of the Axis defenders. It is difficult to see how the result would have been any different than that found by the tanks of 10 and 30 Corps to the north, a repulse with heavy tank losses.

Given that most of the losses to the infantry of the 131st Brigade were to direct and indirect fire, rather than to mines, it is also difficult to imagine how the presence of more antipersonnel mines could have affected the outcome. In fact, it may be concluded from the exaggerated casualties reported, that confusion, darkness, and disorganization was more responsible for the British repulse than were mines.

Even in the second attempt at penetrating 'February,' it does not appear that mines were of great consequence, except as a barrier to armored movement. The 131st Brigade attack again collapsed in the face of direct and indirect fire, little mention is made of mines affecting their advance (that the advance was halted *after* they passed through 'February' appears conclusive). Adding additional antipersonnel mines into the mix would not have changed the result.

Overall, the mines facing the British could not be identified as the cause of any of the personnel losses and could only be identified as the sole cause of loss for a single tank (excluding the 'Scorpions'). They may have contributed to the loss of 26 other tanks on the night of 24-25 October and – less likely – perhaps 14 more tanks later on.

Personnel Casualties

220023 – 060025 October	KIA	WIA	MIA	Cumulative Total
7th AD	222	186	187	595
44th ID	5	7	295	307
Free French				738
060025 – 060026 October				
7th AD	72	153	93	913
44th ID	3	16	428	754
Free French				738?
060026 – 060027 October				
7th AD	-69	-63	-9	772
44th ID	1	27	-604	178
Free French				738?
060027 – 060028 October				
7th AD				739
44th ID				362
Free French				738?
060028 – 060029 October				
7th AD	4	25	2	770
44th ID	3	26	3	394
Free French	-225	-150	-175	188
060029 – 060030 October				
7th AD	0	14	11	834
44th ID	4	28	2	428
Free French				188

Tank Losses

060023 October	206 operational
060024 October	219 operational} A total of 27 reported lost to mines and
060025 October	191 operational} antitank guns during the night of 24-25 Oct
060026 October	177 operational
060027 October	168 operational
060028 October	155 operational
060029 October	170 operational
060030 October	175 operational
060031 October	177 operational
060001 November	186 operational

That the operational strength climbs by 13 between 23 and 24 October would imply that none were lost in that period. The fall then to 191 on 25 October closely matches the reported loss of that night. However, the continued decline in strength after that date does not match with any reports of combat or losses, and by noon on 26 October the armored brigades had been withdrawn from the front. Thus, it is just possible that 14 more were lost up to 26 October. However, it appears more likely that the continued decline in strength was due to mechanical breakdown rather than to enemy action. A major reason for this viewpoint is that the continued decline in strength was almost exclusively in the category of Crusader tanks, a type well known for their mechanical unreliability. The continued decrease to a nadir of 155 on 28 October can only be explained as mechanical losses.

APPENDIX V: Narrative and Estimate of Losses Due to Mines at Kursk

4 July

During the late afternoon and evening of 4 July, infantry of six German armored divisions and two infantry divisions moved forward to clear the Soviet forward outpost line. The outposts were composed of platoon, company and (in at least one case) battalion-size defensive positions. In the sector of the *Grossdeutschland* division, extensive minefields were reported, including at the village of Butovo – the battalion-size defensive position. Still the attack objectives were all achieved by later that night. No German armor was either committed or lost in combat. One battalion commander of *Grossdeutschland* stepped on a mine and lost his leg.

5 July

The main attack began at dawn on the first defense line. All nine armored and five infantry divisions were committed. The corps operations and the effect that antitank mines had on the operations during the first days of the offensive follow.

XLVIII Panzer Corps (5 July)

The XLVVIII Panzer Corps attack began at dawn with three armored and two supporting infantry divisions. Around noon, the 332nd Infantry Division commander was lost to wounds inflicted by mine fragments. He was one of two German division commanders who were casualties during the two-week offensive.

Extensive minefields, antitank ditches, and other defensive works in the area delayed all units of XLVIII Panzer Corps. The biggest problem was an area where a creek had flooded a ravine in the path of the advance. The soggy area was also mined and further obstructed by a deep antitank ditch. The attack went forward in the morning, but the armor was held up until the obstacles were breached. By noon, the German attack had broken through the first defensive line at several points along the front, but most of the armor wasn't across the swollen creek until late in the afternoon and some did not cross until after midnight. According to a veteran of the 3rd Panzer Division, the extensive minefield greatly limited their mobility and speed. Engineers worked round-the-clock in order to clear lanes for the tanks. Usually manpower was insufficient so the tank crews had to pitch in. The 3rd Panzer Division reported losing six tanks damaged to mines. One other was destroyed, and while the records do not explicitly so state, our assumption is that this one was also lost to mines.

Grossdeutschland Division seemed to suffer the worst as their attack went directly across the defended swampy Berezovyii creek. The Fusilier Regiment *Grossdeutschland* and its supporting armor suffered heavy losses when they were held up in a previously undetected minefield and were shelled by artillery. A veteran of the 3rd Battalion claimed that 50 men were killed or wounded. They were forced to bring forward the engineers to clear the mines and to assist the supporting tanks mired in the swampy creek. Engineers also had to construct a second crossing place after mid morning when a heavy tank became mired, blocking the first crossing place. Meanwhile German armor was backed up on the road and came under Soviet air attack.

In the early afternoon, a route bypassing the ravine was reconnoitered but was also found to be heavily mined. Engineers were then sent to clear this route. By late afternoon, armor had crossed to the other side of the ravine and the division began to advance on its next objective (which it was

supposed to have taken that morning). They then brought up the engineers to clear mines from the road in preparation for the next day's advance.

The division later reported substantial casualties and stated they were caused by having to make the attack without armor support because of the unfavorable terrain, and by encountering unexpected minefields, many of them more than 100 meters in depth. The "substantial casualties" totaled 401 men (64 killed, 332 wounded, and 5 missing), including 7 officers killed and 11 wounded. The Panzer Regiment *Grossdeutschland* reported that it had lost 5 assault guns and about 20 tanks to mines. This armor loss to mines is the worst suffered by any of the divisions.

The 11th Panzer Division also had considerable problems with the heavily mined areas around Butovo, and had to request the entire corps engineer reserve (two companies) to help clear the mines. Still 11th Panzer and the neighboring 167th Infantry Division jumped off on schedule in the morning. By mid morning they had penetrated the Soviet positions and were advancing on further objectives. Most problems were reportedly caused by antitank ditches, clogged roads, a late afternoon rain, and Soviet antitank guns, mortar and artillery fire. The 11th Panzer Division, thanks to a Soviet deserter, also located a road free of mines (the Soviets needed a clear road for supply). They allowed part of *Grossdeutschland* to use this road to break the logjam at Berezovyii Creek. Once past the first defensive line, the 11th Panzer Division does not appear to have encountered any more major problems with mines. At least four tanks were disabled during an engagement with the Soviet 245th Tank Regiment. The 245th Tank Regiment also reported losing four tanks in one company to mines (the company reported a total of 6 tanks lost), which were almost certainly Soviet laid (another instance of fratricidal losses to mines). The 245th Tank Regiment appears to have lost 33 tanks on 5 July, thus at least 12.12 percent of the loss was due to friendly mines. The 11th Panzer Division reported losing 8 tanks on 5 July. It is unclear, but it appears that all of these were also lost to mines.[54]

Mines clearly were a hindrance to the three armored and the two infantry division of XLVIII Panzer Corps on the morning of 5 July. By mid day, the minefields had been crossed by two of the armored divisions, only *Grossdeutschland* had become tangled up with and had suffered serious damage from Soviet mines and supporting artillery and air. Overall, mines accounted for 25 tanks in *Grossdeutschland* and probably a 15 more from the other two divisions. The minefields had delayed the operation by about one-half day.

The SS Panzer Corps (5 July)

The SS Panzer Corps faced much the same opposition as the XLVIII Panzer Corps. However, the terrain was more favorable for the SS. The SS Panzer Corps lost 54 tanks on 5 July, which is not far from the total lost by the XLVIII Panzer Corps if Panthers are not counted (52 tanks and perhaps 79 Panthers).

The SS Panzer Corps attack was delayed first by rain, and then by antitank ditches and mines. Because of the weather, the infantry regiments executed the initial attack on Berezov. The assault gun of one veteran interviewed hit a mine at Berezov while moving in a lane which engineers had supposedly cleared. He was unhurt and was reassigned three days later to another tank. Overall, from the accounts, it appears that the SS Panzer Corps was also held up for about a

[54] This report is part of a tabular listing of losses that includes those of the 3rd Panzer Division and *Grossdeutschland*. A note made to the tabulation indicates that all were lost to mines, but it is unclear that the note was intended to apply to all three divisions. See NARA Microfilm T313, R368, *Anlagen zum K.T.B. Pz.A.O.K. 4, Juli 1943* (Attachments to the Fourth Panzer Army War Diary, July 1943), morning entry for 6 July.

half day, with the weather, antitank ditches and mines all playing a role. The SS unit reports and post-war interviews are not as extensive as those found for the XLVIII Panzer Corps,

The *Adolf Hitler* SS Division reported losing 20 tanks on 5 July, including six heavy Tiger tanks. The *Totenkopf* SS Division lost 12 tanks, including five Tigers. The record notes that these were "mostly from mines." This analysis assumes that all were in fact lost to mines. The *Das Reich* SS Division reported 12 tanks lost, including two Tigers. It was in the center leading the attack on Berezov. They do not report the cause of loss, but it is also assumed that most were from mines.

III Panzer Corps (5 July)

There are few reports of mine losses in III Panzer Corps, although there certainly were some. The one division (6th Panzer Division), which had a foothold on the opposite bank of the river had its attack stall out. The attack does not appear to have been pushed forward with much aggressiveness. The other two armored divisions and the two supporting infantry divisions had to execute an opposed river crossing. The biggest problem encountered appears to have been in the sector of the 7th Panzer Division where the crossing site at Solomino was reached only by crossing a German minefield that hadn't been cleared by the unit responsible for it. This fratricidal incident caused "significant problems" according to the unit reports. By the end of the morning, despite heavy Soviet air attacks bombing the assault units, the bridgehead was firmly established and leading elements had advanced.

South of III Panzer Corps, there was another river crossing with two infantry divisions that suffered very heavy casualties.

Summary (5 July)

Overall, the six attacking armored divisions of the Fourth Panzer Army lost as many as 84 tanks to mines on the first day of the offensive, including one of which was destroyed. Although it is not explicitly stated, it does appear that most of the tanks reported lost on 5 July were all lost to mines. However, it does not appear that this report includes all of the tanks lost on that day. If the actual number of tanks ready for action on the evening of 4 July is compared with that of the evening of 5 July, it will be found that the total losses were probably 106.

Calculated Losses of XXXXVIII Panzer Corps and SS Panzer Corps

	Calculated loss (total losses) 5 July	**Reported loss (mine loss) 5 July**	**Mine loss as a percent of total losses**
XLVIII Panzer Corps			
3rd PzD	10	7	70%
GD PzGrD	30	25	83%
11th PzD	12	8	67%
SS Panzer Corps			
AH SS PzGrD	20	20	100%
DR SS PzGrD	19	12	63%
T SS PzGrD	15	12	80%
	---	---	---
	106	84	79%

Using the same methodology, the III Panzer Corps and the various tank and assault gun units attached to it and Corps Raus show a decline of 64 tanks on 5 July. Assuming that the same percentage was lost to mines, then another 51 tanks were lost to them. As is discussed in Appendix VI, no clear report of losses due to mines on 5 and 6 July for the 39th Panzer Regiment has been found. It has been estimated as 38 tanks, with 19 on each day. Therefore, on 5 July it is estimated that the attacking Germans lost 154 tanks to mines, out of 249 recorded as damaged and destroyed on that day. That amounts to 78.64 percent of the tanks lost on that day and account for 10.09 percent of the total German tanks lost between 4 and 18 July. Of the 154, only one or two, including one Panther, were clearly destroyed by mines.

Most of the tanks lost to mines were damaged without loss to the crew. In many cases the tanks were repaired and put back into action within a few days. One division – 6th Panzer – was halted by what appears to have been a particularly strong Soviet defensive effort. One division – *Grossdeutschland* – had a difficult day caused by minefields, antitank ditches and a swollen creek. One, 7th Panzer Division, was delayed by its own minefield. The other divisions apparently got through the 100-meter deep minefields without significant problems and were able to continue the attack.

6 July

Having broken through the first defensive line, the Germans then attacked and broke the second defensive line. Over one-third of the German armor losses during the 14-day offensive occurred on 5 and 6 July while breaking through these two defensive belts.

XLVIII Panzer Corps (6 July)

The advance of *Grossdeutschland* Division on this day depended on clearing mines from a road northeast of Butovo. The clearing was done from both directions at once, since the 11th Panzer Division was already well advanced. Some Soviet units, which had moved into nearby woods, hampered the clearing effort, but still it appears that this minefield was relatively undefended. As a result, the German tanks were able to move forward as the field was being completed. The mine clearing was complete by 0715 hours, and the German advance was able to proceed.

That morning the Germans moved up to attack the second defense line, which was also mined. During that advance, the *Grossdeutschland* Armor Regiment was held up by a minefield, causing the trailing 39th Panzer Regiment to halt and wait as well. While the 39th was waiting, it came under heavy artillery fire, which resulted in some tank losses (at least three Panthers). In the early afternoon, the XLVIII Panzer Corps encountered the Soviet second defensive line, which was also well supported by minefields. The engineers were deployed to clear the minefields, and the afternoon was spent fighting significant Soviet forces opposing them. By late afternoon, the main elements of the 11th Panzer Division had broken through the minefields and emplacements of the Soviet second defense zone and were advancing towards Dubrova. An hour later, the *Grossdeutschland* Division confirmed that it too, having overcome very dense minefields, barbed wire entanglements and antitank ditches, was also attacking Dubrova. The Germans were finally able to penetrate this well defended line by dawn the next day.

Overall, the Germans suffered casualties from a mixture of artillery, mines, antitank and tank gunfire, in addition to a large number of Panthers lost due to mechanical breakdown. The minefields seemed to particularly haunt the *Grossdeutschland* Division, which lost 40 tanks on this day. The attached 39th Panzer Regiment lost an estimated 79 tanks, 19 of which are calculated to

have been lost to mines.[55] The 11th Panzer Division had fewer problems, with 4 tanks lost this day. The 3rd Panzer Division halted its attack on a very strongly held position and only lost 7 tanks.

The SS Panzer Corps (6 July)

The SS Panzer Corps began to attack around 0730 hours, at 0945 units reported penetrating the strongly fortified, mined and barbed wired positions. Fighting hard to take each trench section, by early afternoon they had reached their local objectives. The SS Panzer Corps lost 79 tanks breaking the second defense line and in battles with Soviet armor. The record of these actions is sparse, and the number of tanks lost to mines is unknown.

The III Panzer Corps (6 July)

The III Panzer Corps spent the day exploiting the success of its river crossing. It did advance to the Soviet second defense line, but instead of attacking, the corps turned north and skirted the line. In the early morning, the armor group of the 19th Panzer Division came to an abrupt halt when it ran into a wide and deep minefield. Fourteen tanks were lost to mines and four more were knocked out by direct fire. It was unable to resume the attack until 1430 after a lane had been cleared through the minefield. By late afternoon, the division was again able to pursue its local objectives.

Summary (6 July)

Soviet mine placement was biased heavily to the first defensive belt. In the case of the Sixth Guards Army, opposite the German XLVIII Panzer Corps and SS Panzer Corps, there initially were 68,987 antitank mines in the first belt and 19,274 in the second. Thus, 78.16 percent of the antitank mines were in the first belt (with 85.82 percent of the antipersonnel mines laid by the Sixth Guards Army). The linear density of antitank mines in the first belt was 1,042 per kilometer, while in the second belt it was only 292 per kilometer.

The Seventh Guard Army, opposite the III Panzer Corps and the assault gun units of Corps *Raus*, had an even greater forward bias, with 58,146 antitank mines in the first belt and only 8,668 in the second. The first belt contained 87.03 percent of the antitank mines and 95.64 percent of the antipersonnel mines laid. The liner density of antitank mines in the first belt was 1,057 per kilometer, in the second belt it was only 100 per kilometer.

There were some mines laid further to the rear, and some mines were laid during the course of the battle, but it appears that these two forward defense belts accounted for at least 90 percent of the mines in the area of the battle.

While we have a fairly good estimate of German tanks lost to mines on 5 July, when they were penetrating the first belt, we have poor accounts for 6 July, when they were primarily engaged with the second belt and intermediate positions. As we have had to develop an estimate of losses for 6 July based upon the percent of losses suffered to mines on 5 July, then the relative density of the first and second belts provide a basis for such an estimate.

In the case of the Germans facing the Sixth Guards Army, the liner density of the second belt was 28.02 percent of that of the first belt. This figure was not used as is, because it is understood that there is not a linear relationship between number of weapon systems and opposing force losses. Quite simply, the mines tend to be concentrated on the major axis of advance.

55. The remaining tanks lost were mostly due to mechanical failures.

Therefore, a figure one-half (50 percent) of the loss rate for 5 July was used to estimate losses for 6 July in this sector.

For the Germans facing the Seventh Guards Army, the linear density of the second belt was 9.46 percent of that of the first belt. Unlike the two armored corps further north, on 6 July the III Panzer Corps had not cleanly penetrated the first defensive line. In fact, the 19th Panzer Division was still fighting on this line (when it recorded losing 14 tanks to minefields). The 7th Panzer Division had penetrated the first defensive line with the 6th Panzer Division following behind it. Thus, a figure 25 percent of that for the III Panzer Corps on 6 July was used for those tanks where a cause of loss was not recorded (the cause of loss for 18 of the 24 tanks lost by the 19th Panzer Division, including 14 to mines, is known).

Since the XLVIII Panzer Corps lost 51 tanks (not including Panthers) then approximately 20 tanks were lost to mines. For the SS Panzer Corps, resistance in the second defense line was certainly less than that faced by the XLVIII Panzer Corps. The XLVIII Panzer Corps was facing tanks from the bulk of two Soviet armored corps (divisions) in strong defensive positions. The SS Panzer Corps faced only two tank brigades detached from one of the armored corps and infantry, some of whom had just retreated the previous day after suffering heavy losses to the German attack. So, even though the strength of defensive works and minefields was probably about the same for both corps, the overall strength of the defense the SS encountered was less. Still, the SS Panzer Corps lost 79 tanks, partly while engaged in intense armor battles. If the same methodology is used, then 31 of them may have been lost to mines. For the III Panzer Corps and Corps *Raus*, 69 tanks were lost, of which 18 have been accounted for. Therefore – by again using the same methodology for the 51 where no cause is known – it is estimated that 10 tanks may have been lost to mines. Adding the estimated total of 61 to the 14 known in the 19th Panzer Division and 19 in the 39th Panzer Regiment results in an estimated total of 94 tanks lost to mines. That is 33.81 percent of the total of 278 lost on 7 July or 6.16 percent of the overall tank loss from 4 to 18 July. The attack of one XLVIII Panzer Corps division was delayed, but not halted by extensive minefields. Minefields delayed the SS Corps by two or more hours. Mines halted an armored task force from one division of III Panzer Corps for the better part of a day.

7 July

Since the second defensive line was clearly broken through in the SS Panzer Corps sector, and was being skirted in the III Panzer Corps sector, most of the problems caused by mines occurred in the XLVIII Panzer Corps sector again. This was because many of its units were still tangled in the works of the second defensive line, especially when the division attempted a close envelopment with the Panther regiment.

XLVIII Panzer Corps (7 July)

In the XLVIII Panzer Corps area, the *Grossdeutschland* Division continued to push forward, but still reported considerable delays and problems caused by mines. The crossing of the Pena River was further delayed because heavy Soviet resistance and air attacks coupled with extensive minefields prevented construction of a bridge over the Pena. The Fusilier Regiment *Grossdeutschland*, which had already suffered on 5 July from the minefields at Berezovyii Creek, found itself again tangled up in minefields around the Pena River ravine. This attack was pushed forward against the wish of the 1st Battalion commander, who wanted to conduct a careful reconnaissance because of the mines. A mine then wounded him.

The 52nd Panzer Battalion (Panthers) was also halted in its attack on the 7 July when it ran into yet another minefield and came under fire from dug-in Soviet tanks, antitank guns and artillery. One veteran interviewed estimated that in a brief moment they lost 30 tanks due to Soviet fire, forcing them to withdraw. They then were able to then turn the Soviet flank and take the position, but this was a serious loss. The *Grossdeutschland* Division also reported problems with extensive minefields in the afternoon. While the division did achieve its local objectives by the end of the day, it was a slow advance with heavy losses.

The 11th Panzer Division reported minefields during its advance in the morning, but appeared to have had no real problem crossing them. The are no reports form the SS Panzer Corps, but at this point, the primary threat to it was from Soviet armor. In the III Panzer Corps sector, the 19th Panzer Division also reported continued problems with minefields. It had to clear lanes through them so as to be able to continue the attack. The 6th Panzer Division actually passed through a minefield in column, but apparently did so without a major delay. It does not appear that these minefields were properly covered by fire.

Subsequent Days

There are sporadic reports of minefields later in the fighting. In most cases they seemed to have caused a halt of a few of hours, then they were breached and the attack continued. There were no cases where a major attack halted, nor were there any reports of major losses like those of 5 to 7 July. The 3rd Panzer Division did report losing two tanks to mines on 13 July and this minefield prevented them from closing a gap in their lines.

There was one more incident of fratricide during the fighting from the 8-11 July, when the Soviet 86th Tank Brigade reported losing 9 tanks to aircraft, 19 to artillery and one (3.45 percent of the tank losses) to what was almost certainly a Soviet mine.

German Tanks Lost to Mines at Kursk

It would appear that in a worst case estimate, the Germans lost 154 tanks to mines on 5 July and 94 tanks to mines on 6 July. This amounts to 47.06 percent of the armor loss for those two days and 16.26 percent of the total armor loss for 4 to 18 July. Losses to mines after those two days certainly decreased by an order of magnitude, and there were only two more losses to mines reported after 6 July.

It is likely that these estimates are high. The original records refer to “most” of the tank losses being a result of mine damage. If one assumes that "most" means only 75 percent lost to mines, then the figures are less. The XLVIII Panzer Corps loss to mines would remain at 40. The SS Panzer Corps loss to mines would lower to 33, the 39th Panzer Regiment to 14, and the III Panzer Corps and Corps *Raus* to 44, for a total of 131 on 5 July. For 6 July, the XLVIII Panzer Corps loss would lower to 18, the SS Panzer Corps to 27, the III Panzer Corps and Corps *Raus* to 18. Adding 14 for the 39th Panzer Regiment and 14 for the 19th Panzer Division would result in a total of 91 on 6 July. This is 42.13 percent of the armor loss for the two days and 14.56 percent of the total armor loss for 4 to 18 July.

After 5 July, only the XLVIII Panzer Corps was trying to break through heavily defended defensive works. Opposing the SS Panzer Corps were either poorly supported infantry or counterattacking Soviet armor. As a result, it is likely that the percent loss to mines was probably not as high as on the first day. In the case of the III Panzer Corps and Corps *Raus*, after breaking the first line, armor was not sent against the second line, but was instead turned north where it mostly encountered weaker blocking positions. As a result, they really did not become engaged on the

second line on 6 July and their loss was probably not the same order of magnitude as on the first day. If "most" is assumed to mean 75 percent, and if it is also assumed that on 6 July the SS Panzer Corps, III Panzer Corps, and Corps *Raus* loss was one-half the rate of the XLVIII Panzer Corps (except for the 14 reported by the 19th Panzer Division), then a total of 131 tanks were lost to mines on 5 July and 69 on 6 July. This is 37.95 percent of the armor loss for those two days and 13.11 percent of total armor loss for 4 to 18 July.

For many reasons, this last set of figures is considered to be the most reasonable. From them, one can conclude that the Germans suffered about 40 percent their total armor loss in the first two days of battle while breaking through the Soviet mine fields. After that, the percentage lost to mines declined to perhaps 5 percent or less for the subsequent days. Overall, mines probably caused around 15 to 20 percent of the German tank loss during the course of the battle.

Other losses to artillery and direct fire, where minefields or mines were a contributing factor in the loss, account for some 36 additional tanks. There were certainly more. In most cases, the minefields were integrated with other barriers (antitank ditches were a significant barrier), so it is difficult to measure the value of the barriers without mines. There was one German and five Soviet tanks reported lost to friendly mines. Certainly there were other similar cases not reported. Two Soviet tanks were reported lost to German mines.

If the number of antitank mines employed (291,797) is divided by the number of tanks lost (200), then it appears that about 1,459 mines were required to inflict damage on a tank. In most cases, it was track damage, usually without crew loss, and could be repaired within a few days.

There were three clear cases of tank loss to mines during the battle that may be taken as worst cases. First was *Grossdeutschland* on 5 July, when they lost 25 of 177 tanks or 14.12 percent of strength to mines. Second was the 19th Panzer Division on 6 July, which lost 18 of 87 tanks or 20.69 percent of strength, with 14 lost to mines and 4 lost to direct fire weapons covering the minefield. The third case was the 39th Panzer Regiment at Dubrova on 7 July, when they lost 30 of 43 tanks, mostly to direct fire, 69.77 percent of strength, because of being halted by a minefield in front of dug-in tanks and other antitank weapons.

There is no question that the defensive belts, including the minefields, delayed the attacking German forces for a half-day or more both on 5 and 6 July. There appears to have been two attacks stopped cold by minefields, the 19th Panzer Division attack on the 6 July and the Panther attack on 7 July. Both of these caused significant losses and clearly hindered operations.

APPENDIX VI: An Analysis of German Losses in the First Seven Days of the Offensive

	Losses 5 July	Losses 6 July	Losses 7 July	Losses 8 - 11 July
57th ID	13	12	12	53
255th ID	6	163	115	380
332nd ID	439	439	438	1,129
3rd PzD	179	81	81	328
GD PzGrD	401	175	224	1,240
11th PzD	184	98	141	484
167th ID	343	120	49	214
AH SS PzGrD	611	530	199	727
DR SS PzGrD	340	280	141	835
T SS PzGrD	170	305	175	1,115
168th ID	120	671	97	661
6th PzD	78	111	160	589
19th PzD	505	113	385	852
7th PzD	104	141	361	773
106th ID	1,183	280	428	509
320th ID	1,668	557	187	205
Other units	134	42	59	388
Total	6,478	4,118	3,252	10,482

	Losses on 5 July	Average daily Losses on 6 - 11 July	"Excess" losses 5 July
57th ID	13	13	0
255th ID	6	110	0 (-104)
332nd ID	439	334	105
3rd PzD	179	82	97
GD PzGrD	401	273	128
11th PzD	184	121	63
167th ID	343	64	279
AH SS PzGrD	611	243	368
DR SS PzGrD	340	209	131
T SS PzGrD	170	266	0 (-96)
168th ID	120	238	0 (-118)
6th PzD	78	143	0 (-65)
19th PzD	505	225	280
7th PzD	104	213	0 (-109)
106th ID	1,183	203	980
320th ID	1,668	158	1,510
Other units	134	82	52

			3,993 (-492)
Total	6,478	2,975	3,503

	Average daily Losses on 5 July	Losses on 6 July	Losses on 7 - 11 July	"Excess" losses on 5 & 6 July
57th ID	13	12	13	0
255th ID	6	163	99	0 (-29)
332nd ID	439	439	313	252
3rd PzD	179	81	82	96
GD PzGrD	401	175	293	0 (-10)
11th PzD	184	98	125	32
167th ID	343	120	53	357
AH SS PzGrD	611	530	185	771
DR SS PzGrD	340	280	195	230
T SS PzGrD	170	305	258	0 (-41)
168th ID	120	671	152	487
6th PzD	78	111	150	0 (-111)
19th PzD	505	113	247	124
7th PzD	104	141	227	0 (-209)
106th ID	1,183	280	187	1,089
320th ID	1,668	557	78	2,069
Other units	134	42	89	0 (-2)

				5,507 (-402)
Total	6,478	4,118	2,747	5,102

	Average Daily Losses on 5 July	Losses on 6 July	Losses on 7 July	Losses on 8 - 11 July	"Excess" Losses on 5, 6, & 7 July
57th ID	13	12	12	13	0 (-2)
255th ID	6	163	115	95	0 (-1)
332nd ID	439	439	438	282	470
3rd PzD	179	81	81	82	95
GD PzGrD	401	175	224	310	0 (-130)
11th PzD	184	98	141	121	60
167th ID	343	120	49	54	350
AH SS PzGrD	611	530	199	182	794
DR SS PzGrD	340	280	141	209	134
T SS PzGrD	170	305	175	279	0 (-187)
168th ID	120	671	97	165	393
6th PzD	78	111	160	147	0 (-92)
19th PzD	505	113	385	213	364
7th PzD	104	141	361	193	27
106th ID	1,183	280	428	127	1,510
320th ID	1,668	557	187	51	2,259
Other units	134	42	59	97	0 (-56)

					6,456 (-468)
Total	6,478	4,118	3,252	2,621	5,985

APPENDIX VII: Mine Density by Defender

The breakdown of the mine barriers by division was as follows:

	AT	AP	Total
71st Gds RD	19,530	14,700	34,830
67th Gds RD	15,981	12,434	29,315
52nd Gds RD	16,476	14,189	33,581
375th RD	17,000	13,023	31,430
1st Echelon total	68,987	54,346	129,156
90th Gds RD	8,775	2,247	13,156
51st Gds RD	3,490	470	4,440
89th Gds RD	7,009	6,261	13,995
2nd Echelon Total	19,274	8,978	31,591
Army Total	88,261	63,324	160,747

What is interesting from this comparison is the imbalance in mine placement in the two echelons. Some 78 percent of the AT mines and 86 percent of the AP mines were in the first echelon. Four times as many mines were employed in the first echelon as in the second. This is supported by the comments in the 1944 Soviet General Staff Study. A comparison of linear density of the zones shows a similar pattern. In this case, the figure shown is the number of mines per kilometer, meaning that a linear density of "1,000" is one mine per meter of front.

Linear Density of Mines in the Sixth Guards Army Zone

	Frontage	AT	AP	Total
71st Gds RD	18.9 km	1,033	778	1,843
67th Gds RD	19.3 km	828	664	1,519
52nd Gds RD	13.5 km	1,220	1,051	2,487
375th RD	14.5 km	1,172	898	2,168
1st Echelon Total	66.2 km	1,042	821	1,951
90th Gds RD	29.9 km	293	75	440
51st Gds RD	14.4 km	242	33	308
89th Gds RD	21.7 km	323	289	645
2nd Echelon Total	66.0 km	292	136	479

In looking at the first echelon, it appears that the highest mine density was in the 52nd Guards Rifle Division sector. Considering the forces that they were facing – the SS Panzer Corps – this was logical. But, the division with the lowest mine density in the front line was the 67th Guards Rifle Division, which was facing the entire XLVIII Panzer Corps and had a large expanse of open

terrain behind it. This is counter-intuitive. The two flanking divisions were well anchored, with the 375th having the highest weight of mines.

The mine density of the second echelon was a fraction of the first echelon. Oddly enough, it was the 89th Guards RD, which was in the most defensible terrain that had the highest density. Just looking at the mine deployment, one could reach the conclusion that the Sixth Guards Army was expecting the main thrust of the attack to occur in the area of 52nd Guards RD, 375th RD and the 89th Guards RD. Another view is that they were indeed making sure they anchored their flanks and were planning to use the middle four divisions of the Army (52nd Guards, 67th Guards, 51st Guards and 90th Guards) to absorb the shock of the attack and inflict attrition on the Germans.

The Seventh Guards Army reported its mines by zone. We have been able to tentatively identify those zones with specific units as is displayed in the table below:

Mine Barriers in the Seventh Guards Army Zone

	Unit	**AT**	**AP**	**Total**
1st Zone	81st Gds RD	20,266	24,955	45,221
2ndZone	78th Gds RD	11,928	18,380	30,308
3rd Zone	72nd Gds RD	9,400	17,742	27,142
4th Zone	36th Gds RD	16,552	20,352	36,904
1st Echelon Total		58,146	81,429	139,575
5th Zone	73rd Gds RD	2,451	2,340	4,791
6th Zone	213th RD	3,873	371	4,244
7th Zone	15th Gds RD	2,344	1,000	3,344
2nd Echelon total		8,668	3,711	12,379

Again, in the case of resources assigned to the first and second echelon, the difference is striking, with 87 percent of the AT mines and 96 percent of the AP mines assigned to the first echelon. This was an even a stronger forward bias than is seen in the Sixth Guards Army. Obviously, as the Seventh Guards Army was defending behind a river, there was an opportunity to stop the German attack completely, and it appears that the fortifications were oriented to that purpose. The mine density shows a similar contrast.

Linear Density of Mines in the Seventh Guards Army Zone

	Frontage	**AT**	**AP**	**Total**
1st Zone	10.2 km	1,987	2,447	4,433
2nd Zone	12.9 km	925	1,425	2,349
3rd Zone	19.3 km	487	919	1,406
4th Zone	12.6 km	1,314	1,615	2,929
1st Echelon Total	55.0 km	1,057	1,480	2,537
5th Zone	29.4 km	83	80	163
6th Zone	28.3 km	137	13	150
7th Zone	28.9 km	81	35	116
2nd Echelon Total	87.0 km	100	43	143

The first echelon of both the Sixth Guards Army and the Seventh Guards Army had the same density of AT mines. The Seventh Guards Army had almost twice the density of AP mines. Overall, the frontage defended by the Seventh Guards Army was less than that of the Sixth Guards Army. Furthermore, one divisional sector, that of the 36th Gds RD, never really came under attack. Due to the wider frontage of the second echelon, the densities of the mines in that echelon was a fraction of that in the 6th Guards Army second echelon.

Again, the selection of which zones were supported with the greatest number of mines is interesting. In this case, again the two flanking divisions (81st Gds and 36th Gds) were well supported, while the middle of the army was weaker. The heavy support given to the 81st Gds RD, which was just east and northeast of Belgorod matches with the support given three easternmost divisions of the Sixth Guards Army. Again it appears as if the Soviet Army was taking the possibility of a thrust directly out of Belgorod very seriously.

The much reduced support, especially in AT mines given to the 72nd Guards Rifle Division, made sense given that they were not facing a major armor threat (they were opposite Corps Raus). Due to the small numbers of mines utilized, not much can be discerned from the resources provided to the second echelon.

APPENDIX VIII: An Analysis of German Losses in the First Seven Days of the Offensive, by Corps

Facing the Sixth Guards Army

	Losses on 5 July	Losses on 6 July	Losses on 7 July	Losses for 8 - 11 July
332nd ID	439	439	438	1,129
3rd PzD	179	81	81	328
GD PzGrD	401	175	224	1,240
11th PzD	184	98	141	484
167th ID	343	120	49	214
AH SS PzGrD	611	530	199	727
DR SS PzGrD	340	280	141	835
T SS PzGrD	170	305	175	1,115
Totals	2,667	2,028	1,448	6,072
Total XLVIII Pz Corps	1,203	793	885	3,181
Total SS Pz Corps	1,464	1,235	564	2,891

Facing the Seventh Guards Army

	Losses on 5 July	Losses on 6 July	Losses on 7 July	Losses for 8 - 11 July
168th ID	120	671	97	661
6th PzD	78	111	160	589
19th PzD	505	113	385	852
7th PzD	104	141	361	773
106th ID	1,183	280	428	509
320th ID	1,668	557	187	205
Totals	3,658	1,873	1,618	3,589
Less Corps *Raus*	807	1,036	1,003	2,875

* Note that for comparative purposes, the XLVIII Pz Corps is considered to consist of the 332nd ID, 3rd PzD, GD PzGrD and the 11th PzD. During this period, the 332nd ID was attached to the LII Corps from 6 to 13 July, but continued to operate on the flank of the XLVIII Pz Corps.

** Note that for comparative purposes, the SS Pz Corps is considered to consist of the 167th ID, AH SS PzGrD, DR SS PzGRD and T PzGrD. On 5 and 6 July, one regiment of the 167th ID was attached to the SS Pz Corps while the rest of the division was attached to the XLVIII Pz Corps. On 8 July, most of the 167th ID (less one regiment) was transferred to SS Pz Corps and on 9 July to direct control of the Fourth Pz Army, but it continued to operate protecting the right flank of the SS Pz Corps. One regiment remained attached to the 11th PzD (XLVIII PZ Corps) until 10 July, but was basically operating the area between the two Corps. As of 10 July, the entire 167th ID was concentrated on the right flank of the SS Pz Corps.

Facing the Sixth Guards Army

	Losses on 5 July	Average daily Losses for 6 - 11 July	"Excess" losses for 5 July
332nd ID	439	334	105
3rd PzD	179	82	97
GD PzGrD	401	273	128
11th PzD	184	121	63
167th ID	343	64	279
AH SS PzGrD	611	243	368
DR SS PzGrD	340	209	131
T SS PzGrD	170	266	0 (-96)
Total	2,667	1,592	1,171 (-96)
Total XLVIII Pz Corps	1,203	810	393
Total SS Pz Corps	1,464	782	778 (-96)

Facing the Seventh Guards Army

	Losses on 5 July	Average daily Losses for 6 - 11 July	"Excess" losses for 5 July
168th ID	120	238	0 (-118)
6th PzD	78	143	0 (-65)
19th PzD	505	225	280
7th PzD	104	213	0 (-109)
106th ID	1,183	203	980
320th ID	1,668	158	1,510
Total	3,658	1,180	2,770 (-292)
Less Corps *Raus*	807	819	280 (-292)

Facing the Sixth Guards Army

	Losses on 5 July	Losses on 6 July	Average daily Losses for 7 - 11 July	"Excess" losses for 5 & 6 July
332nd ID	439	439	313	252
3rd PzD	179	81	82	96
GD PzGrD	401	175	293	0 (-10)
11th PzD	184	98	125	32
167th ID	343	120	53	357
AH SS PzGrD	611	530	185	771
DR SS PzGrD	340	280	195	230
T SS PzGrD	170	305	258	0 (-41)
Total	2,667	2,028	1,504	1,738 (-51)
Total XLVIII Pz Corps	1,203	793	813	380 (-10)
Total SS Pz Corps	1,464	1,235	691	1,358 (-41)

Facing the Seventh Guards Army

	Losses on 5 July	Losses on 6 July	Average daily Losses for 7 - 11 July	"Excess" losses for 5 & 6 July
168th ID	120	671	152	487
6th PzD	78	111	150	0 (-111)
19th PzD	505	113	247	124
7th PzD	104	141	227	0 (-209)
106th ID	1,183	280	187	1,089
320th ID	1,668	557	78	2,069
Total	3,658	1,873	1,041	3,769 (-320)
Less Corps *Raus*	807	1,036	776	611 (-320)

Facing the Sixth Guards Army

	Losses on 5 July	Losses on 6 July	Losses on 7 July	Average Daily Losses for 8 - 11 July	"Excess" Losses 5, 6 & 7 July
332nd ID	439	439	438	282	470
3rd PzD	179	81	81	82	95
GD PzGrD	401	175	224	310	0 (-130)
11th PzD	184	98	141	121	60
167th ID	343	120	49	54	350
AH SS PzGrD	611	530	199	182	794
DR SS PzGrD	340	280	141	209	134
T SS PzGrD	170	305	175	279	0 (-187)
Total	2,667	2,028	1,448	1,519	1,903 (-317)
Total XLVIII Pz Corps	1,203	793	885	795	625 (-130)
Total SS Pz Corps	1,464	1,235	564	724	1,278 (-187)

Facing the Seventh Guards Army

	Losses on 5 July	Losses on 6 July	Losses on 7 July	Average Daily Losses for 8 - 11 July	"Excess" Losses 5, 6 & 7 July
168th ID	120	671	97	165	393
6th PzD	78	111	160	147	0 (-92)
19th PzD	505	113	385	213	364
7th PzD	104	141	361	193	27
106th ID	1,183	280	428	127	1,510
320th ID	1,668	557	187	51	2,259
Total	3,658	1,873	1,618	896	4,553 (-92)
Less Corps Raus	807	1,036	1,003	718	784 (-92)

APPENDIX IX: Analysis of Tank Losses in the First Seven Days of Combat

Daily Tank Losses

	Total Tank Losses *							
July	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
3rd PzD	10	7	6	3	13	11	11	61
GD PzGrD	30	40	4	5	0	13	3	95
39th Panzer Regiment	79	79	30	0	1	5	8	202
11th PzD	12	4	46	6	11	9	17	105
AH SS PzGrD	20	38	32	5	10	2	11	118
DR SS PzGrD	19	30	15	31	6	2	2	105
T SS PzGrD	15	11	8	11	19	0	3	67
6th PzD	13	10	10	2	43	3	0	81
19th PzD	6	24	13	3	31	3	13	93
7th PzD	20	21	21	19	3	0	23	107
503rd Tk Bn	18	8	8	0	19	0	0	53
228th AG Bn	3	3	2	0	12	0	0	20
905th AG Bn	3	3	2	3	3	0	0	14
393rd AG Btty	1	0	0	1	0	0	0	2
	---	---	---	---	---	---	---	----
	249	278	197	89	171	48	91	1123
Subtotals								
XLVIII Pz Corps	131	130	86	14	25	38	39	463
less Panthers**	52	51	56	14	24	33	31	261
SS Pz Corps	54	79	55	47	35	4	16	290
III Pz Corps	64	69	56	28	111	6	36	370

* A tank is considered to be any fully-tracked armored vehicle except German observation tanks, self-propelled artillery that were assigned to divisional artillery regiments, armored recovery vehicles, and armored ammunition carriers. The count also does include command tanks, flame thrower tanks, some assault guns, and self-propelled antitank guns.

** Panthers had a significant reliability problem, 50 to 75 percent broke down in the opening days of battle. Since total losses include mechanical failure (usually only about 10 to 20 percent), it was felt that the Panthers unusually high breakdown rate may have skewed the data. See *The Military Consequences of a Complete Landmine Ban*, a TDI report, for a more detailed explanation.

Notes: Tk Bn = Tank Battalion
AG Bn = Assault Gun Battalion
AG Btty = Assault Gun Battery

	Losses on 5July	**Average daily Losses for 6 - 11 July**	**"Excess" losses for 5 July**
3rd PzD	10	9	1
GD PzGrD	30	11	19
11th PzD	12	16	0 (-4)
AH SS PzGrD	20	16	4
DR SS PzGrD	19	14	5
T SS PzGrD	15	9	6
6th PzD	13	11	2
19th PzD	6	15	0 (-9)
7th PzD	20	15	5
503rd Tk Bn	18	6	12
228th AG Bn	3	3	0
905th AG Bn	3	2	1
393rd AG Btty	1	0	1
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	170	127	56
Subtotals			
XLVIII Pz Corps*	52	36	20
SS Pz Corps	54	39	15
III Pz Corps	64	52	21

* less Panthers (see above)

	Losses on 5 July	Losses on 6 July	Average daily Losses for 7 - 11 July	"Excess" losses for 5 & 6 July
3rd PzD	10	7	9	0 (-1)
GD PzGrD	30	40	5	60
11th PzD	12	4	18	0 (-20)
AH SS PzGrD	20	38	12	34
DR SS PzGrD	19	30	11	27
T SS PzGrD	15	11	8	10
6th PzD	13	10	12	0 (-1)
19th PzD	6	24	13	4
7th PzD	20	21	13	15
503rd Tk Bn	18	8	5	16
228th AG Bn	3	3	3	0
905th AG Bn	3	3	2	2
393rd AG Btty	1	0	0	1
	---	---	---	---
	170	199	111	169
Subtotals				
XLVIII Pz Corps*	52	51	32	60
SS Pz Corps	54	79	31	71
III Pz Corps	64	69	48	38

* less Panthers (see above)

	Losses on 5 July	Losses on 6 July	Losses on 7 July	Average daily Losses for 8 - 11 July	"Excess" losses for 5 – 7 July
3rd PzD	10	7	6	10	0 (-7)
GD PzGrD	30	40	4	5	59
11th PzD	12	4	46	11	29
AH SS PzGrD	20	38	32	7	69
DR SS PzGrD	19	30	15	10	34
T SS PzGrD	15	11	8	8	10
6th PzD	13	10	10	12	0 (-3)
19th PzD	6	24	13	13	4
7th PzD	20	21	21	11	29
503rd Tk Bn	18	8	8	5	19
228th AG Bn	3	3	2	3	0 (-1)
905th AG Bn	3	3	2	2	2
393rd AG Btty	1	0	0	0	1
	---	---	---	---	---
	170	199	167	97	256
Subtotals					
XLVIII Pz Corps*	52	51	56	26	88
SS Pz Corps	54	79	55	25	113
III Pz Corps	64	69	56	46	55

* less Panthers (see above)

APPENDIX X: Comparison of Personnel to Tank Losses

Direct Comparison

July	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Personnel Losses	6,478	4,118	3,252	3,073	2,921	2,011	2,477	24,330
Tank Losses	249	278	197	89	171	48	91	1,123
less Panthers	170	199	167	89	170	43	83	921
Ratio	26.12	14.81	16.51	34.53	17.08	41.90	27.22	21.67
less Panthers	38.11	20.69	19.47	34.53	17.18	46.77	29.84	26.42

Direct Comparison by Corps

	5 July	**6 July**	**7 July**	**8 – 11 July**
XLVIII Pz Corps	23.13	15.55	15.80	31.19
SS Pz Corps	27.11	15.63	10.25	28.34
III Pz Corps	12.61	15.01	17.91	15.88

APPENDIX XI: Comparison of Tanks Lost Due to Mines to Personnel Losses

Our estimate is that 131 tanks were lost to mines on 5 July and 69 on 6 July. This averages 49.45 personnel casualties per tank lost on 5 July and 69.80 lost per tank on 6 July. For the XLVIII Panzer Corps on 5 July, as many as 40 tanks were lost to mines (not counting the Panthers of the 39th Panzer Regiment). For the SS Panzer Corps, as many as 44 tanks were lost to mines (but we assume the more correct figure to be 33). The losses for the 39th Panzer Regiment (14 tanks) and the III Panzer Corps (44 tanks) are estimated. On 6 July it is estimated that the XLVIII Panzer Corps lost 18, the SS Panzer Corps 14, the III Panzer Corps 23, and the 39th Panzer Regiment 14. Keeping in mind the very questionable nature of these figures, a comparison to the mix of mines they were facing shows the following:

	5 July	**6 July**	**Total**	**Percent AP Mines**	**Minefield Density**
XLVIII Pz Corps				38.01	1,681
Personnel	1,203	793	1,996		
Tanks	40	18	58		
SS Pz Corps				39.86	2,328
Personnel	1,464	1,235	2,699		
Tanks	33	14	47		
III Pz Corps				56.87	3,391
Personnel	807	1,036	1,843		
Tanks	44	23	67		
Total					
Personnel	3,474	3,064	6,538		
Tanks	117	55	172		
Ratio (casualties to tank losses)					
XLVIII Pz Corps	30.01	44.06	34.41	38.01	1,681
SS Pz Corps	44.36	88.21	57.43	39.86	2,328
III Pz Corps	18.34	45.04	27.51	56.87	3,391
Total	29.69	55.71	38.01		

No recognizable pattern can be discerned in this data. The only clear pattern – the increase in personnel casualties lost per tank on 6 July – was artificially created by the original estimation methodology and human intervention in the estimation process. This analysis was simply too "back of the envelope" and was not used further in this report.

APPENDIX XII: Comparative Advance Rates

Distance Opposed Advance by Division (Kilometers)

July	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
57th ID	0	0	0	0	0	0	0	0
255th ID	0	0	0	4.8	2.2	-1.2	0	0
332nd ID	0	2.7	1.6	3.8	5.9	1.5	-2.7	3.8
3rd PzD	0	3.8	3.5	13.2	15.0	2.4	5.1	10.8
GD PzGrD	5.8	6.3	7.2	9.0	5.4	2.7	8.1	6.8
11th PzD	2.4	3.6	12.0	7.7	6.8	10.6	1.4	0
167th ID	5.4	0	7.8	0	0	0	0	0
LSSAH PzGrD	0	10.7	6.8	7.6	5.6	5.1	0	4.1
DR SS PzGrD	0	6.8	13.6	6.0	0	0	0	3.3
T SS PzGrD	0	6.7	4.9	4.9	0	0	0	6.9
168th ID	0	0	0	0	5.3	0	5.6	10.9
6th PzD	0	2.7	6.5	4.9	9.0	0	2.6	11.1
19th PzD	0	3.7	5.9	8.1	5.5	0	0	0
7th PzD	0	2.3	9.0	11.4	0	0	0	4.2
106th ID	0	4.3	10.0	2.5	1.1	0.6	1.0	0
320th ID	0	1.9	4.0	0	0	0	0	0
Average	0.9	3.5	5.8	5.2	3.9	1.4	1.3	3.9
less zeros*	4.5	4.8	7.1	7.0	6.2	3.8	4.0	6.9
Daily Peak	5.8	10.7	13.6	13.2	15.0	10.6	8.1	11.1

* All zero or negative distances are not included in the calculation

Average Opposed Advance Rate by Corps

July	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
LII Corps	0	0	0	2.4	1.1	-0.6	0	0
XLVIII Pz Corps	2.1	4.1	6.1	8.4	8.3	4.3	3.0	5.3
SS Pz Corps	1.4	6.1	8.3	4.6	1.4	1.3	0	3.6
III Pz Corps	0	2.2	5.4	6.1	5.0	0	2.1	6.6
Corps *Raus*	0	3.1	7.0	1.3	0.6	0.3	0.5	0

Maximum Opposed Advance Rate by Corps

July	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
LII Corps	0	3.2	-2.2	3.4	1.8	-2.8	3.1	3.6
XLVIII Pz Corps	5.8	6.3	12.0	13.2	15.0	10.6	8.1	10.8
SS Pz Corps	0	10.7	13.6	7.6	5.6	5.1	0	6.9
III Pz Corps	0	3.7	9	11.4	9	0	5.6	11.1
Corps Raus	0	4.3	10.0	2.5	1.1	0.6	1.0	1.7