FIVE

WORLD WAR II: THE ALLIES ATTACK, 1942–45

TANK CONFLICT REPEATEDLY PROVED SIGNIFICANT IN THE SECOND half of the war, that of Allied victory, although it often lacked the novelty and drama claimed for, and invested in, the German blitzkrieg attacks of 1939–41. Tanks also became iconic for at least some Allied successes, as with the photograph of Lieutenant-General Bernard Law Montgomery standing on a M3 Grant (the British version of the American M3 Lee) after the British victory at El Alamein in late 1942. It was also a period in which the number of tanks increased as vastly greater production outweighed losses, notably for the Americans and Soviets, while the specifications of tanks improved. Given the number of tanks required, ease of production was a key factor. So, more generally, was a problem-solving approach to capability and the linked ability to devise effective feedback mechanisms during the process of implementing the development of new weapons. The varied aspects of design and production were involved, as were related changes in tactics and doctrine, making the tank ever more part of a team with other types of tracked and/or armored vehicles.

Moreover, this process required an appreciation of the interdependencies involved in adapting to particular environments, as well as the responses of opponents.[1] The choices that were made were contextual and contingent as much as driven by any debate about doctrine. These factors, however, can be difficult to gauge and certainly require a departure from monocausal explanations. Thus, there is the view that Lieutenant-General Lesley McNair, an artillery officer who became the thoughtful head of the US Army Ground Forces from 1942 to 1944 (who was killed in a "friendly fire" incident in the Battle of Normandy by US bombers), was primarily responsible for the US army focusing on the 57 mm antitank gun and tank destroyers, rather than a stronger tank. This remains a contentious decision.

It is also a decision that relates to longstanding differences. Thus, the competition, or the challenge, between gun and armor is a key issue in the history of tanks. An instructive point is the respective cost, including of training, of a tank crew and antitank teams. Moreover, it is not clear that heavier tanks were a better answer to enemy tanks than an effective antitank arsenal. Now the infrared targeting systems directed against the tank are immediately spotted by the electronic defensive systems on the tank, which is given all the information necessary to fire, but in World War II, the situation was different. Because the targeting then was simply optical, the tank did not realize it had been spotted by an antitank gun and was destroyed before noticing what was going on.

There is also the argument that the key issue was that of producing and transporting sufficient numbers of heavy tanks to make a fundamental difference in Western Europe.[2] This was, in part, a response to the difficulties involved in transportation: more space was required in shipping, and there were more significant problems in loading and unloading. In addition, heavy tanks faced the issue of bridge capabilities, which was a particularly serious issue in northwest Europe given the number of rivers there.

Separately, in considering interdependencies and choices, there is the point that doctrine, tactics, and weaponry that worked for tanks in one area, for example, for the British in Libya, might be less appropriate in others, say Italy and, for different reasons, Normandy. Thus, the British Seventh Armoured Division did well in North Africa but not, admittedly in more difficult circumstances, as well in Normandy in 1944, notably with Operation Goodwood. The same occurs with the question of other aspects of war—for example, fire support for amphibious operations. Thus, methods employed in the Pacific proved less appropriate on Omaha Beach.[3] There was also the significance of maintenance and support doctrine and organization, which were better for the United States and Britain than for Germany, especially in Normandy in 1944.

TANK TYPES

Unlike the Germans, the Americans and Soviets concentrated on weapons that made best use of their capacity for mass production because they were simple to build, operate, and repair, such as the US Sherman M4 tank. This was the first truly universal fighting vehicle, able to fight in such different environments as Europe, the Southwest Pacific, and North Africa. The ubiquitous (in addition to the prototype, 49,234 were produced in 1942–45) and very reliable Sherman was medium weight, with moderate armor (12.7 mm) and a medium-caliber (75 mm) gun. That meant, however, that, alongside its

impressive range, the Sherman was underarmored and undergunned for much of the war. The Americans took a very pragmatic approach to tank development. In the interest of rapid development, the Sherman used a suspension system that was already employed on commercial tractors. Failure to rely on a diesel engine, however, did cause an issue: due to its gasoline-fueled engine, the Sherman burned too easily, which increased the already serious hazards of tank conflict for the crew. The armor of Shermans, indeed, was too thin to make them appropriate for close infantry support. The Sherman was also provided to allies, including the British, the Canadians, New Zealanders, Poles, French, and South Africans.

The Sherman evolved into numerous versions, all intended to increase firepower against German armor as well as to enhance protection from German guns. Thus, an up-armored version was designated the M4A3E2 Assault Tank. One of these was the first to reach the besieged US lines around Bastogne in December 1944 during the Battle of the Bulge. Producing some of the Shermans with the more capable 76 mm gun, refitting others with a 17-pounder, and using a 90 mm gun on M36 tank destroyers reflected an awareness of the need for up-gunning.

The Americans were content to ride through the war on a tank that was a product of 1930s technology: the Sherman was not a feat of advanced technology, but it was one of production.[4] So also with the Soviet T-34. The first T-34 models were very crude inside, the turret layout was difficult for the crew, and there was no significant upgrading until 1944, when a new model, with 85 mm guns and a three-man turret, was deployed. The bigger Soviet KV series, which led to the IS (Joseph Stalin; Iosif for Joseph) series, were also crude inside. Yet the T-34 offered armor, armament, and mobility, as well as poor observation and a lack of radios. The use of a diesel engine in the T-34—originally developed for aerial employment—reduced the risk of destructive fire and gave the tank a good operational range. The most cost-effective tank of the war, it was not always matched by the "human software" of command. Separately, the decision not to employ part of the production for turretless versions as armored personnel carriers, or APCs (as happened, for example, with Shermans and other tanks to produce Canadian "Kangaroos"), is possibly questionable.

In contrast to the Shermans and the T-34s, German tanks were complex pieces of equipment and, partly as a result, often broke down. Much German armor, moreover, was no better than Soviet armor or, indeed, worse. In 1941, the Soviet KV-1 and T-34 tanks proved superior to their German opponents.[5] In response, the Germans increased the armament of their tanks. Thus,

from 1942 until the end of the year, the Mark IV replaced the Mark III as the backbone of the panzer divisions: the Mark IV had a new version from 1942, the Mark IV G, which had a high-velocity 75 mm (just below 3-inch) anti-tank gun, as well as wider tracks for use in the snow and mud of Russia. The power-to-weight ratio and the ground pressure both affected performance on soft ground, and not only there; this issue led to an emphasis on wider tracks to spread the weight. Improvements, however, brought problems. Thus, although the 75 mm gun of the Mark IV was fitted with a muzzle brake to reduce recoil impact, the longer barrel of the gun added stress to the brake mechanism.[6] Moreover, although the Mark IV was fitted with what was effectively spaced armor in the form of side plates to the body of the tank, it was weaker than the T-34 in armor and mobility. In turn, the latter was inferior in one-to-one combat with the Panther and the Tiger.

Germany gave Italy permission to copy its tanks, but the Italians found it difficult to do so. They tried to follow German role models, especially the Panther, with their P-40 tank. Its 75 mm gun was very effective against Allied tanks, but the 50 mm armor was weak and only riveted, and the tank had a weak motor. Italian production, instead, turned to the production of assault guns (Semovente), which, despite serious weaknesses, especially in motorization, proved more effective than their tanks.

For long, the British and Americans had tanks that did not match their German rivals and were understood in that light, including by their opponents. The British Infantry Mark I, Matilda, Valentine, Crusader, Churchill, and Cromwell tanks suffered from inadequate armor, and the first four were undergunned. In the Tobruk campaign in North Africa in June 1942, the Crusader proved mechanically poor: the air cleaners and the water pump and engine lubrication systems were defective, and it was difficult to use the tank. On July 1, 1942, in the House of Commons, Sir John Wardlaw-Milne, moving a motion for a vote of no confidence in Churchill, attacked the quality of British tanks as one of his themes: "The bulk of the tanks with which we are fighting in Libya . . . were all designed before this war began. These tanks have been manufactured for the last two or three years, and they are being manufactured today. Many of them are very good tanks for their purpose, but they are quite unequal to those with which the Germans are now armed. . . . There is on the Tank Board no officer with recent experience of fighting with tanks in the desert."[7]

In the debate, Earl Winterton pointed out the large number of tanks out of service due to mechanical problems, especially Churchills.[8] The previous day, the *Times* had published a letter from Professor A. V. Hill MP in which

he observed that there was no scientific control of the processes of production of military equipment.

The deficiencies of British tanks in armor, firepower, speed, horsepower, and profile, and the resulting problems against German tanks and antitank weaponry, affected not only British tactics but also morale. As a result, there was a turn to US Grant and Sherman tanks. Grants gave the British a 75 mm gun, which their own tanks lacked. However, the Grant was a compromise tank, used to supply the British with what they needed as quickly as possible, and it was withdrawn as soon as the Sherman, which also had a 75 mm gun, became available. British armored capabilities and lethality improved with the use of both Grants and Shermans.

Separately, by 1943, the concentration of British tank production on fewer designs had helped lead to improvement.[9] The original Crusader had a 40 mm/2-pounder gun. In 1942, it was redesigned to take a 57 mm/6-pounder gun. Larger caliber British guns, the 3-inch (76.2 mm), were used by the British A27M Cromwells and A22/42 Churchills as well as to produce the 17-pounder antitank gun.

When Anglo-American forces invaded France in June 1944, the best German tanks were technically better in firepower and armor. The Tiger and the (faster) Panther were superior in both to the Sherman and could readily penetrate its armor at one thousand yards. Nevertheless, the unreliability, low mobility, and high maintenance requirements of the costly Tiger tank weakened it, and there were also serious problems with the reliability of the Panther.[10] In response to the Soviet tanks, and to the degree to which they were now on the defensive, the Germans had emphasized the antitank role for their armor, which had previously been a secondary consideration.

The resulting German focus on heavy tanks, however, limited mobility and also had implications for fuel needs. As a reminder of multiple causation, this limited mobility was also very much hit by the impact of greater Allied air power on the German rail system. Bridges and marshaling yards were particular targets. Germany benefited from its central position, notably in moving armor between fronts in late 1944 in preparation for the Battle of the Bulge, using the excellent and tightly controlled German railway system. Nevertheless, the pressure on this mobility was accentuated both by the need, notably from late 1943, to disperse armor on the Eastern Front in order to counter Soviet attacks and by the extent to which, in the summer of 1944, the war in Europe had become a multifront one with the Germans on the defensive on all the fronts.

The quality gap that favored the German tanks against the Anglo-American ones was closed by late 1944 and 1945 as new Allied tanks appeared. Bigger

guns came because of the need to penetrate thicker German tank armor at long ranges. The Sherman was up-gunned and up-armored to counter tanks such as the Tiger I and the Panther but was of little use against the Tiger II. Generally, the 88 mm gun of the Tiger tanks and the German antitank guns outranged the Allied tank guns. The British introduced a modified Sherman known as the Firefly, which was fitted with a 17-pounder (76.2 mm) gun firing armor-piercing capped (APC) rounds, which could penetrate German armor at longer range. For much of 1944, this was the only Allied tank that could take on the Tiger I. It was also used by the Canadians, Poles, South Africans, and New Zealanders. Up-gunning, the Americans introduced a higher-velocity 76 mm gun to some of their Shermans in mid-1944. However, the 76 mm needed new high-velocity armor-piercing (HVAP) ammunition to penetrate the front plates (100 mm thick) of Panthers and Tiger Is. This ammunition was introduced when it was found that existing ammunition would not do the job.

Guns and ammunition had to be in synergy. Armor-piercing ammunition was crucial in operating against tanks, but high-explosive ammunition was necessary for infantry support. It was, therefore, valuable to have guns that could fire both, such as the 75 mm one on the Grant.

More generally, the thickening of armor and its increased sloping, especially in German and Soviet designs (the Mark V Panther was a response to the T-34, both of which made use of glacis plates sloped at sixty degrees), led to the response of increased velocity and hitting power. As a result, discarded sabots with subcaliber rounds and armored caps were among the innovations introduced. APDS (armor-piercing discarding sabot) was a British invention for providing subcaliber projectiles (fired from the standard tank guns) with greater kinetic energy to penetrate German armor. Developed in 1941–44 at the Armaments Research Department at Fort Halstead, it was used operationally from mid-1944 with the British 6-pounder antitank gun and from September with the 17-pounder. In contrast, tungsten carbide is not only very dense but also heavy, and a conventional full-caliber shot was extremely difficult to shoot from the barrel.

A stress on effective performance in tank combat could, in part, help compensate for the earlier emphasis on tanks that were fast and maneuverable, but, in practice, there was a tendency to put aside this emphasis and to increase protection and gun power at the expense of mobility. This was very much seen with the German Tiger. Indeed, as an aspect of attritional warfare, the closing stages of the war saw the introduction of more heavily gunned tanks by all powers. However, for the Allies, these were very much tanks entering service in 1945. Major-General Jacob Devers, commander of the European Theater

of Operations for the US army from May to December 1943, had pressed that November for the production of 250 M26 Pershings, with a 90 mm gun formerly only used in the open-turret M36 tank destroyers, to confront Panthers and Tigers in the battle for Normandy. However, delayed in part as a result of a lack of support in senior military circles, notably from McNair, the Pershing only entered action in February 1945, and full production did not begin until March. Only twenty saw action in Europe, but this tank would serve well in the Korean War (1950–53). Given the production of Pershings by the end of the war, as well as the Soviet progress on the IS-3, the quality gap would definitely have closed had the European war gone into the 1945 summer campaign. Soviet concern that the Germans might try to copy the IS-2 (Joseph Stalin 2) led to instructions not to let it fall into their hands.

The British finally produced well-gunned and armored tanks, the combination proving important. The Black Prince, a prototype for a heavier Churchill tank, appeared in 1945. It was armed with an effective 76.2 mm gun but did not enter service because it was underpowered, only reaching eleven miles per hour. The Black Prince was too big and not well thought out. The Comet, which had a newly designed 77 mm gun but not full sloped armor, was a better tank but did not enter service until March 1945. With its 101 mm armor, it was considered comparable to a Panther and was the first purpose-designed British tank to be capable of taking on Panthers and Tigers on equal terms. It had a speed of twenty-nine miles per hour and was "nifty" and good to drive.[11] The Centurion had full sloped armor as well as a good gun. Developed toward the end of the war, and superior to the Pershing and the T-34/85, it was too late to see service in it.[12]

Other tanks designed to cope with German heavy armor were only produced after the war when they were configured, instead, against Soviet counterparts. Thus, the Charioteer, with an 83.4 mm, 20-pounder gun, entered service in 1947 and was seen as a rival to the IS. However, it was essentially a somewhat cumbersome up-gunned, upgraded Cromwell with a three-man crew, although a fourth had to be added to act as an external observer due to the restricted view from the turret because it was too full of gun breach. The Tortoise, with a 94 mm, 32-pounder gun, never went into production. It was ill conceived and too cumbersome. Tested in 1948, it proved difficult to transport, and that was a key consideration. This difficulty was the case by both road and rail.

In contrast, in late 1942, the Germans had begun work on a super tank, the Maus, to be 188 tons and armed with a 128 mm main gun adapted from a PaK 44 antitank field artillery piece and a coaxial 75 mm gun. Hitler approved a

wooden mock-up he inspected on May 1, 1943, and ordered the production of 150. Guderian was opposed as the tank design lacked a machine gun and therefore would be unsuitable for close combat. One was then added. Tests on this tank, which was intended to break through defenses, began in December 1943. However, the ill-conceived tank was too heavy to cross bridges, and there were also problems with producing an engine able to offer sufficient power and fit inside the tank. These were systemic issues with "super tanks." Work on the project, which had only led to two hulls and one turret being built, stopped in August 1944. The turret itself weighed fifty-five tons. Hitler was interested in size as an expression of effectiveness and thus in bigger tanks. In Germany, there are counterfactual books in which the Germans are able to build these land cruisers and defeat the Allies. They are absurd.

ANTITANK WEAPONRY

Meanwhile, in the more general process of competitive development, improvements in tank specifications during the war created problems for antitank weaponry. Thicker armor resulted in pressure for more powerful weapons. The 57 mm antitank gun was ineffective against front armor unless perilously close to the target. The thick armor of the heavier Soviet tanks deployed in 1941 was resistant to German antitank shells.[13] Difficulty in destroying the heavy tanks led to the use, instead, of anticoncrete shells designed to be employed against concrete bunkers and to the development of a tank destroyer fitted with a 90 mm gun. These tank destroyers were, in effect, self-propelled antitank guns.

The relationships among (main) gun, ammunition, armor, and targeting system are at the heart of the dynamic between tanks and antitank weaponry, although this dynamic was and still is set and molded by doctrine, tactics, and fighting quality. From World War II (although not generally before), tanks, to a great degree, were mobile antitank gun platforms rather than focused on infantry support or opposition. During the war, the German 88 mm, an antiaircraft gun used in an antitank role with armor-piercing ammunition, and the British 17-pounder (76.2 mm), the first really effective British antitank gun, were both fitted to tanks—the former adapted for the Panther and Tiger, the latter fitted in Sherman Fireflies. But, as the Americans also discovered with their 76 mm gun, the type of ammunition fired made all the difference to effectiveness and, indeed, lethality.

Armor during this war was essentially ever thicker steel. It was necessary also to counter shaped-charge antitank rounds typically fired by infantry, such as the US bazooka and the British PIAT (Projector, Infantry, Anti-Tank), which was designed in 1942 and entered service in 1943. The latter was, in

effect, an antitank grenade launcher. It was simple and inexpensive but heavy to carry and difficult to use. To counter these weapons, add-on protection was applied, notably metal plates at the side and concrete add-on armor. Tank crews also placed replacement tracks and wheels on the front and side of their vehicles to provide additional protection against handheld weapons. This protection could help lessen the impact of these weapons.

The advantage of the antitank gun was its relative cheapness in comparison to a whole tank. The Germans produced over twenty-three thousand PaK 40 antitank guns. The problem with the infantry antitank weapons, such as the bazooka and the PIAT, was how close the operator had to get to the target before firing, which was not the case with antitank guns. Closeness meant exposure to defending fire. The maximum effective range of the PIAT was less than 100 meters. The bazooka had a maximum range of 370 meters, but an effective one of 140, and was not good against the frontal armor of German tanks and tank destroyers, which from mid-1944 were generally supplemented with a concrete add-on layer. Nevertheless, there often was close-quarter fighting, as in Normandy, where PIATs inflicted damage on Mark IVs—for example, in Operation Charnwood on July 8–9 and later in 1944 at Arnhem.[14]

One huge advantage of antitank guns over tanks was their small size, which meant they could be concealed easily to ambush tanks, as the Germans did in Normandy in 1944. In dealing with these guns, combined arms doctrine was affirmed anew. Antitank guns, smaller and not leaving tracks visible from the air, were far less vulnerable than tanks to observation and air and tank attack, although air-burst artillery shells killed the crews. Moreover, antitank guns did not break down or require gasoline, at least until they had to be moved, and not even then if there was a reliance on horses. Thus, when combined with antitank ditches, an important obstacle, as used by the Soviets against the German attack at Kursk in 1943, the antitank gun could prove highly effective.

In response to stronger tanks, antitank guns improved. This led to guns with larger calibers—for example, 105 mm German guns, instead of 88 mm ones, and Soviet 100 mm guns, instead of 76 mm ones. Developments also included longer barrels and better projectiles. The last entailed alternatives to solid armor-piercing shot, which had proved limited against hardened armor. The muzzle velocity was improved by adapting the shot. Separately, HEAT (high-explosive antitank) warheads were one response, applying the principle used for the PIAT and other light antitank weapons. HEAT is a shaped-charge munition that employs the Munroe effect to penetrate armor. The shaped charge has a metal liner that, on detonation, collapses on itself and focuses the explosive energy to form a high-velocity, very hot, superplastic jet of metal that

penetrates by virtue of kinetic energy combined with the high temperature of the jet. The use of copper reflected the extent to which its fusion occurs at a relatively low temperature. After the jet entered the tank, its high temperature caused the explosion of the shells contained inside the turret and burned alive the crew so quickly and so completely that normally nothing remained of the bodies but some bones covered by the melted and burned remains of flesh.

At the same time, the circumstances of combat affected the effectiveness of antitank guns and ammunition. Thus, on the Eastern Front and in Normandy, the impact of German long-range antitank guns was lessened by the close distance of many actual engagements. Separately, HEAT warheads did not have a long range, which meant they had to be fired from near the targeted tanks.

Frequent improvement was necessary for antitank guns and infantry antitank weapons. The Americans first used the bazooka antitank rocket in 1942 but failed to upgrade it as German tanks got heavier. The Germans, however, having captured and reverse engineered bazookas, developed the design into the more powerful Panzerschreck ("tank terror") rocket grenade. They also developed the handheld Panzerfaust ("armor fist"), a single-shot, antitank rocket in use from 1943. These weapons were part of the upgrading of German infantry weaponry seen also with the MG-42 light machine gun. As an instance of production history, 6.7 million of the five Panzerfaust variants were built, mostly for use by Germany but also by its allies. Its explosive charge at thirty yards could penetrate 200 mm armor. Fear of Panzerfausts induced not only caution on the part of Allied tank commanders but also, sometimes, an understandable disinclination to lead the attack.[15]

Other weapons against tanks, such as guns and rockets, were mounted on aircraft. British Spitfires and Typhoons carried 20 mm machine cannon and US P-47s and P-51s .50 caliber machine guns but used salvoes of 5-inch (127 mm) unguided rockets to strike the weakly protected upper parts of tanks. Some aircraft, such as Hurricanes, were fitted with 30 mm cannon in underwing pods. Specialized aircraft for tank busting had an offensive range that weapons on the ground lacked. The Soviet Ilyushin Il-2 Sturmovik and the British Typhoon were the most effective aircraft, although their effectiveness against individual tanks was not high. The Soviets employed a HEAT bomblet while the British favored a sixty-pound semi-armor-piercing rocket that, however, was ballistically unstable and thus difficult to aim. But large-caliber guns were also used, such as on the British Hurricane and the German Ju-87 Stuka, while, from 1944, the Americans dropped napalm, including on tanks. In Normandy in 1944, air superiority and support helped compensate for the

Allied inferiority in tank design. Throughout, it was an important aspect of Allied combined arms operations.

The high costs of tanks encouraged some Germans to support a focus on the artillery-manned Sturmgeschütz (assault guns), notably the StuG 3, an effective tank destroyer built on the chassis of the Panzer Mark III. Its average cost was about 87,000 Reichsmark compared to 103,000 for a Mark III, 107,000 for a Mark IV, 130,000 for a Panther, and 300,000 for a Tiger. Tank destroyers were harder to destroy than tanks because they had a lower profile and in battle had a good rate of destroying enemy tanks for their own loss. The StuG 3, however, was officially under the artillery, and Guderian's attempt to bring them under his control as inspector general of armored troops failed. Nevertheless, Hitler ordered one hundred StuGs of each month's production to be turned over to the Armored Troop Command: in 1943, it received 25 percent of the production, and the Waffen-SS received 13 percent. The idea of focusing on StuGs was discussed, not least due to problems with tank production in 1942, but Guderian opposed it because, like Hitler, he preferred strong tanks. Because the panzer divisions received more and more of the total production of StuGs, the infantry formations, for which they were originally designed as antitank weapons, received fewer and were short of antitank weaponry. The StuG 3 influenced the Italian self-propelled 75/18 mm howitzer, of which 491 were manufactured.

In the United States, McNair favored turreted tank destroyers and antitank guns over heavier tanks with bigger guns, arguing that lightly armored (and thus easier to make) tank destroyers, manned by his branch, the artillery, were the best defense against German tanks and that US tanks should focus on providing armored mass for the main attack. Indeed, "the tank destroyer was the artilleryman's solution to the problem posed by a mobile, armored target."[16] Although this approach could lead to underplaying the role of the tank as, in practice, a tank destroyer, motorized tank destroyers had an impact. Effective German versions were eventually matched by US tank destroyers. The latter were also good antibunker weapons.

The initial tank destroyers used by the Americans proved ineffective. The 37 mm guns installed on the rear decks of M6 trucks were inadequate against German armor while 75 mm guns on thinly armored M3 half-tracks were both outclassed by German 88 mms and easy targets, with their slow speed and high silhouettes. Moreover, their guns could not traverse. As a consequence, there was a turn to the Sherman tank hulls and chassis used for the M10 and M36 (the M18 was based on the M3 chassis). Aside from more powerful guns, there was also more effective ammunition. The 76 mm gun on the M18

fired tungsten-carbide-cored, high-velocity, armor-piercing ammunition.[17] These tank destroyers were, in effect, lightly armored or simpler tanks fitted with powerful guns, with tank-design chassis used to this end. The M10 and M18 were fitted with antitank guns but faced problems in penetrating the armor of heavy German tanks. The M36, armed with the 90 mm antiaircraft gun later used on the Pershing (and early Patton tanks), proved more effective. The first arrived in service in France in September 1944.[18]

The Germans used a similar concept but with the cheaper turretless tanks, such as the Hetzer (Jagdpanzer 38), which was based on a light tank and built in Czechoslovakia with a Skoda A7 cannon, which provided destructive power at very long range. Produced in 1944–45, this was Germany's most common tank destroyer. It proved particularly useful as a defensive weapon against advancing Allied tanks. The low profile of the Hetzer encouraged its value for ambushes, and a version served after World War II with the Swiss army, which, fearing Soviet invasion during the Cold War, very much focused on defense against tank attacks. Tank destroyers could also serve as substitutes for tanks. Thus, on December 15, 1944, the German attack on Kesternich in the Battle of the Bulge was headed by three tank destroyers and an armored 37 mm antiaircraft half-track. Based on the chassis of the Panther tank, and therefore heavier than the Hetzer, the Jagdpanther ("Hunting Panther") entered service in 1944; only 415 were built, as opposed to the planned 150 a month. The design, which focused on a long-barreled 88 mm PaK gun, a heavy caliber gun, had been ordered in late 1942. Other forms of turretless tanks were the Soviet self-propelled antitank and direct support guns, the SU-76, SU-85, SU-100, SU-122, and SU-152, the last a self-propelled 152 mm howitzer. Turretless vehicles were less expensive to produce but, if they had open tops, made the crew vulnerable to aerial bursts.

There was an overlap of technological developments in tanks and antitank systems. In a sense, the British Firefly was a tank destroyer. In practice, there were as many variants of tank destroyers as tanks. The reason for fitting the guns to vehicles, including half-tracks and other vehicles, was mobility. The Italian self-propelled 75/18 and (later) 75/34 howitzers were a surprise to British tanks. Italy also had the 90/53 gun, which was derived from a naval gun that could penetrate tank armor. It was successfully used, especially in North Africa, on a Lancia truck. Forty-eight were converted for use on the self-propelled 90/53 heavy tank destroyer employed in Sicily against the Allies in 1943.

A very different antitank weapon was the mine, which was responsible for between 20 and 30 percent of wartime tank casualties. Given this percentage,

it is surprising that they receive so little attention. Mines were used in great numbers. In late 1942, Rommel laid half a million antitank mines, and many antipersonnel mines, in order to protect his position at El Alamein in Egypt against British attack. Such mines greatly slowed attacks and could channel them toward opposing artillery.

Mine techniques and production developed rapidly during the war. Mine-clearing units became an adjunct of tank advances, as with the British at El Alamein, and also saw developments, including the use of handheld electronic detectors and flail tanks. The last, for example, were employed by the British in the Battle of Normandy in Operation Bluecoat. In turn, there were innovations with mines, notably in producing mines that were resistant to blast-clearance devices from 1941 and nonmetallic mines to defeat mine detectors from 1943. Antilifting devices were also introduced.

ARMOR CAPABILITY

The effectiveness of antitank weaponry ensured that mixed or combined arms formations were more effective than those that focused solely on tanks. It took a while for British armor units training for the Second Front, the invasion of France, to appreciate that antitank guns were a major problem requiring infantry support. There was a need for tanks capable of firing high-explosive ammunition rather than the earlier focus on armor-piercing rounds. Commanders of armored units, in response to antitank weaponry, urged their officers to wait for support rather than charging in. In particular, this tactic was a sensible response to the German skill in defensive warfare, especially the careful siting of antitank guns to destroy advancing tanks. In July 1944, Lieutenant-General Sir Richard O'Connor (brigade major of the Experimental Brigade from 1921 to 1924 and a veteran of North African operations in 1940–41), the commander of the British Eighth Corps in Normandy, instructed the commander of an armored division to "go cautiously with your armor, making sure that any areas from which you could be shot up by Panthers [tanks] and 88s [antitank guns] are engaged. Remember what you are doing is not a risk to Paris—it is the capture of a wood by combined armor and infantry."[19]

Such advice was necessary given the heavy tank casualties suffered by the British in the Battle of Normandy at the hands of German antitank guns. Neither the vegetation, notably the readily defended hedgerows of the bocage, nor the density of forces made armored advances easy in this campaign. The situation proved very different with the successful Soviet advances of 1944–45 in easier, more open terrain in Eastern Europe and, in 1945, against the Japanese in Manchuria.

Aside from the impact of defensive firepower, the question of engineering and logistical support for tanks was a serious hindrance to mobility for the Allies and, far more, the Germans in France in 1944. Yet, by 1944–45, the effectiveness of tanks in large numbers was shown in the Soviet use of mobile tank armies for deep envelopment in maneuver-style warfare.[20] This effectiveness was seen at the expense of the Germans in Eastern Europe and in the rapid defeat of the large Japanese army in Manchuria, although it was not the sole reason for these outcomes.

The US supply of tanks to the British was an aspect of a more general movement of tanks among the Allies, which had been seen, albeit at a smaller scale, in World War I. Thus, the British supplied many tanks to the Soviet Union via the Arctic convoys, although the Soviets subsequently ignored or denigrated the help. However, Alexander Hill has drawn valuable attention to the scale of the help. Thus, one-sixth of the heavy tanks in the battle of Moscow were British supplies, while 16 percent of the Soviet tanks on July 1, 1942, were foreign, mostly British, supplied.[21]

In contrast, Germany lacked the willingness or resources to provide appropriate military assistance to its allies. This was an aspect of a broader failure of the German alliance system, one also seen in the absence of any success in transferring skills and experience through training and doctrine. The net effect was to leave large numbers of Axis forces with inadequate equipment and, therefore, unable to improve.[22] For example, the Croatian army received only about sixty German tanks and eighteen self-propelled guns, although the Germans also handed over thirty-nine tanks and thirty tankettes captured from Italian forces in 1943.

A more chronological account repeatedly demonstrates the value of tanks in many combined arms operations, but this value, understandably, was dependent in part on terrain. At the same time, the effectiveness of the use of tanks was related to experience, command skills, and doctrine, as well as weaponry and the interaction with antitank techniques.

THE EASTERN FRONT, LATE 1942

Armor played a major role in the German offensive in the Soviet Union launched on June 28, 1942. The first section of the plan was achieved in July, when, in ideal tank conditions, German forces pushed into the Don bend. Poor planning, however, ensured that the armor necessary to help clear the river crossings at the eastern end of the Don bend was in the wrong location and thus unable to help the attempt to push through to Stalingrad in late July. Soviet willingness to withdraw troops ensured the Germans were deprived of

the encirclement victory in the bend they had sought and required. Instead, the Wehrmacht provided *Luftstösse*—"blows into the air"—and Soviet losses were generally during fighting retreats and no longer from encirclements.

The German advance bifurcated, with one thrust into the northern Caucasus and the other from the River Don to the River Volga. This led to an overextension that ensured the two advances were unable to provide mutual support while flank positions were weakly held. There was also serious logistical strain. To the south, the Third and Fourth Panzer Corps made major gains in the northern Caucasus in early August, with Maikop falling to the Thirteenth Panzer Division on August 9. However, growing Soviet resistance then slowed their advance, and the situation was not helped by serious shortages of reinforcements and fuel.

On the Volga, the Germans focused on trying to capture the city of Stalingrad, which, in large part due to German bombing, was a wrecked urban terrain. Armor attacks could achieve little in the ruined city. Much of the fighting was at very close range, and the Germans could not utilize their skill at mobile warfare. German armored units took heavy casualties.[23] Both sides employed massive quantities of artillery in the battle.

This unsuccessful offensive used up German reserves, and, on November 19, 1942, in Operation Uranus, the Soviets launched a powerful counterattack, outmaneuvering and rapidly encircling the German Sixth Army, then Germany's leading field army, in and near Stalingrad. The Soviets benefited in this operation from their buildup of forces, including tanks. These advantages were magnified by the success of their planning and preparations; by surprise, which reflected a catastrophic failure of intelligence gathering on the part of the Germans; and thanks to the poor quality of German command decisions, including the allocation of what became key flank positions to weak Romanian forces. The Soviet Fifth Tank Army played the crucial role in overcoming Romanian defenses when the Stalingrad counteroffensive was launched. An inadequate German response to the Soviet breakthrough was also crucial.

In the face of strong Soviet forces, and having no operational reserves, the German relief attempt failed in December. Indeed, it was overshadowed by the further advance of Soviet forces protecting their encirclement. This led to heavy Axis casualties in the Don basin.[24] The Stalingrad pocket was driven in by Soviet attack, with the Sixth Army surrendering by February 2, 1943.

The campaign was a triumph for Soviet offensive art and was far more successful than the Soviet counteroffensive the previous winter, although, with its vulnerable and poorly held flanks, the German position at Stalingrad was far more exposed than it had been before Moscow, difficult as the latter was.

The Soviets also benefited greatly from the recovery and development of their munitions industry—for example, in tank production. The campaign was badly mishandled by the Germans, in large part due to poor direction from Hitler, who failed to respond with the necessary flexibility and exaggerated the potential impact of his determination to hold out in defensive positions. Operational failure was linked to one of strategy, the two being in a mutually causal relationship.

At the same time, outcomes were far from inevitable. In Operation Mars, from November 25 to December 14, 1942, the Soviet assault on the Rzhev salient near Moscow failed with heavy casualties, including numerous tanks. In part, this was due to the strength of the defenses and the lack of an opportunity to maneuver against them, as in Operation Uranus, launched six days earlier.[25]

EL ALAMEIN, 1942

At a very different scale, the Germans and Italians had been defeated in Egypt as well. On June 20–21, 1942, Rommel captured Tobruk, having failed to do so in 1941. This followed the battle of Gazala from May 26 to June 17, 1942, in which the resumed German attack proved successful, although the initial Axis attack had been stopped on May 29 after a major tank clash. The collapse of the British armored formations indicated problems with morale. On June 18, the *Times* reported that the German Mark IVs had "dominated the battlefield" and, five days later, that "the bulk of our tank force was made up of tanks with two-pounder guns which have again and again proved almost completely useless against the German tanks." The fall of Tobruk was partly due to the degree to which the considerable antitank obstacles in place the previous year during the long siege had not been maintained in the intervening period. Many of the antitank ditches had filled with sand. The defeat led the Americans to meet Churchill's request for an immediate supply of Shermans. Rommel, having again defeated the British at Mersa Matruh on June 26, moved on eastward, with the retreating British losing much material.

However, the German advance was checked at El Alamein, about sixty miles west of Alexandria, on July 1–4 and at Alam Halfa from August 30 through September 7. In part, this reflected the impact of a lack of fuel for any German deep flanking operation, which, for example, immobilized the Twenty-First Panzer Division on June 30 when Rommel had originally planned to attack. The British benefited from new 6-pounder antitank guns, notably when resisting attack at Deirel Shein on July 1. These were a major improvement on the 2-pounders.

In addition, British operational command and tactics had now improved. There was a readiness to engage in mobile warfare, making effective strikes in combination with holding defensive positions. This was an aspect of a more general qualitative transition in the British army as it became better prepared to take the offensive against the Germans. At the same time, Montgomery did not judge the British forces as ready for a successful offensive. Their tactical grasp of combined arms combat was limited. On July 15, the British armor did not act to protect the New Zealand troops that had seized Ruweisat Ridge only, with few antitank guns, to face German tank counterattacks. The commander of the Fifth New Zealand Infantry Brigade noted the disorientating impact of the German tank movements and the need, in response, to carry "Wrigley's grenades (sticky bombs). . . . Towards morning the tanks seemed to form up in lines on either side of the main axis of our advance . . . enabled them to use cross-fire."[26]

At Alam Halfa, later in the summer, Montgomery relied on antitank guns, a technique learned from Rommel, and inflicted serious losses on the attacking German armor. In contrast, the British tanks took defensive positions and were not launched in a follow-up attack. Earlier, attacking in Operation Splendour on July 22, the Twenty-Third Armoured Brigade had incurred heavy losses. Poor armor-infantry coordination and inadequate tanks were serious problems for the British. As a result, Montgomery refused, despite intense pressure from Churchill, to attack until the Eighth Army was ready and had built up the adequate reserve necessary for sustaining any attack.

The British launched a full-scale attack in the final battle of El Alamein from October 23 to November 4, 1942. They faced prepared positions defended by extensive minefields and well-located antitank guns and supported by armor. Increased British familiarity with combined arms tactics was important but only one of a range of factors that contributed to British success, including skillful generalship; the availability of deciphered intelligence on German moves; greater numbers of men, artillery, and tanks; better tanks; improved morale;[27] effective use of artillery; air superiority and support; and attacks on Rommel's vital fuel supplies from Italy. Rommel also deployed his artillery and reserves poorly and mishandled his Italian allies, as did most German commanders. Rommel, more generally, suffered from the understandable focus of German resources on the Eastern Front.

The shift in tank warfare was shown on November 2 when a German counterattack led to heavy German tank losses. These broke the German-Italian armor, destroying the majority of the German tanks and most of the Italian units. By November 3, Rommel had only 187 tanks left, and, of these, 155 were

small Italian ones that were relatively ineffective. At the end of an attritional struggle, one in which superior British artillery, as in 1918, had been crucial, while British infantry and tank numbers were under increasing pressure, Rommel felt obliged to order a general withdrawal, leaving the Ariete tank division in the rearguard. This Italian force was destroyed.

Although failing to recognize limitations adequately at the outset, including in the British armor, Montgomery had read the terrain ably, and, alongside his adaptability and flexibility, his sequential blows eventually succeeded, not least by forcing Rommel to commit his forces, thus facilitating the decisive British blow. As a reminder that tactics take precedence over technology, this was the method used by John Churchill, first duke of Marlborough, at the expense of the French at Blenheim in 1704. Despite changes in technology, there were constants in battle planning. Montgomery's *corps de chasse* provided the flexibility to change the main point of attack during the battle and the strength to maintain the momentum of the attack after the break with the Axis position. However, the initial progress had been slow, and Montgomery's ability to read the battlefield should not be exaggerated. Moreover, he was focused on the immediate battle and proved poor at planning for the exploitation phase of the battle, although, in part, his target was removed by the rapid flight of the Germans, combined with the traffic congestion affecting the larger British forces.[28] This was to prefigure the situation in France in 1944 after the Battle of Normandy. The British aerial interdiction of retreating German forces was not very effective. Many of the Italian troops were lost because they were in the rearguard, were short of vehicles, and were mostly in the interior and thus at a distance from the coast route.

The campaign in North Africa again indicated the significance of antitank guns and their integration with armor. For example, Günter Halm, a gunner with an antitank platoon in a *panzergrenadier* regiment in the Twenty-First Panzer Division, won the Knights Cross on July 22 in the First Battle of El Alamein for destroying fifteen British tanks at Ruweisat Ridge. His gun was one of the two captured 76 mm Soviet antitank guns that comprised the platoon.[29] The use of captured material, very much including tanks, was particularly characteristic of the German military dating back to World War I. It now reflected the range of German conquests, the extensive fronts that thereby had to be defended, and the large forces, both German and allied, that had to be supplied. At the same time, there were serious consequences. Maintenance issues became more serious when there was a range of spare parts that had to be provided.

At El Alamein, as elsewhere in North Africa, British tank operations benefited greatly from the support of the Royal Engineers. This element tends to

be ignored or underplayed in tank accounts. In practice, engineering is crucial, not least in bridge building, and sappers played a key role with mine-laying and mine-clearance activities. Tank repair was also fundamental: for the British, it was provided by the Royal Electrical and Mechanical Engineers (REME), and very necessarily so in 1942. During the month following El Alamein, REME detachments recovered and got back into action 1,200 tanks and other vehicles.

THE MANSTEIN COUNTERATTACK, 1943

In early 1943, the Germans demonstrated their continued success in mobile warfare, but this was now as part of a mobile defense, rather than an offensive that could transform the conflict. The Soviets had followed up their successes by launching new offensives in early 1943 that rapidly captured Voronezh, Kursk, and Kharkov. They were most successful against the overextended Second Hungarian Army south of Voronezh, a force that was destroyed with the loss of over one hundred thousand men. The Soviets were better equipped and, the Hungarians lacked antitank guns powerful enough to stop the Soviet tanks, despite requesting them from Germany.[30]

However, Field Marshal Erich von Manstein, the commander of the reconstituted Army Group South, proved skillful at mobile defense and thereby at stabilizing the front. The Germans counterattacked from February 21, benefiting from the extent to which the Soviet forces had been overstretched by the need to destroy the encircled Sixth Army in Stalingrad and mount an exhausting winter offensive that had caused considerable wear and tear to their tanks. The Germans were also helped by their ability to defeat their opponents in the air. The Germans, advancing on converging axes, were able to inflict heavy casualties, destroying most of the Soviet Sixth and First Guards Armies. The Soviets lacked nearby reserves to maintain the offensive, and the Germans recaptured Kharkov on March 12–14, which provided their last offensive victory on the Eastern Front.[31]

This was an operational-level victory, however, not the strategic triumph the Germans needed and had sought in 1942. While reversing some of the Soviet advance and destroying Soviet units were successes, they were compensatory ones at best, and, for the Germans, returning to the positions they had occupied at the beginning of the 1942 summer offensive was not good enough in strategic terms. Meanwhile, the Soviets had destroyed the largest German field army on the Eastern Front, the Sixth Army, while the buildup of US forces against Germany had already led to a dramatic change in North Africa and threatened to open a Second Front in Western Europe itself. As a

result, Germany had to provide more troops to protect positions in both the Mediterranean and Western Europe.

The Soviet winter offensive had indicated the incremental nature of success, contrasting with the situation in 1939–40 when the Germans had knocked opponents out. It was only possible in 1942–43 for advancing forces to achieve so much before exhaustion, losses, and supply difficulties had an impact and led first to the slackening and then the stopping of the offensive. Moreover, the Soviets failed to appreciate that offensives simultaneously mounted at great distances from one another would not automatically draw off German strength from one theater to another. Until 1945, there was to be no one-campaign end to the war as a whole or to that on the Eastern Front. This gave the conflict an attritional character and, as a consequence, led to an emphasis on resources.

TUNISIA, 1943

There was also a German riposte in North Africa. With Rommel ignoring Italian advice to take a stop on the Halfaya Pass, a natural defensive position, the retreating Germans and Italians left Egypt and Libya rapidly after El Alamein. Montgomery pursued, although the communications were extended over 1,500 miles by the time they reached Tripoli, stretching all the way back to Alexandria along a single coastal road. The difficulty of supporting forces over such long lines of communication forced Montgomery to halt at Tripoli to try to open the port. It also limited the number of divisions he could effectively deploy.

Other US (mostly) and British forces had swiftly taken Morocco and Algeria from Vichy forces in November 1942. Hitler had rapidly moved German and Italian forces to Tunisia in reply. It had also been held by Vichy French forces, but there was no effective resistance there to the German advance. Very large gliders were used to transport supplies and reinforcements, and these proved easy targets for Allied fighters. As part of the response, the Germans also swiftly occupied Vichy France. Armor, including the Tenth Panzer Division, played a role in the latter.

Tunisia, a land of mountains and valleys, was a different military terrain than Libya but had a similar interplay of positional warfare and maneuver. The emphasis in the German war making there was on mobility, to which armor and the associated doctrine contributed greatly. The doctrine also made use of this capability. The Germans sought to exploit the Axis' central position by mounting a mobile defense and attacking the Allies advancing from Algeria. In contrast, the Italians focused on the Allied forces advancing from Libya.

The Germans also benefited from the difficulty the Allies faced in matching their advance with an adequate buildup of support, a problem that was to recur in 1944.

The German offensive that led to the Battle of Kasserine Pass in mid-February 1943 reflected both the German ability to mount defensive-offensive operations and their superior generalship and fighting quality. Elements of two panzer divisions, including newly arrived Tiger tanks, were launched on February 14 against US infantry who were supported by insufficient armor. As the battle developed, the Shermans and Grants of the US First Armored Division, which had been dispersed in defensive positions, were heavily defeated by the advancing Germans. This also led to the loss of trained crew. After the campaign, the US infantry involved received the relevant training in combined operations.

However, there were important flaws in the planning and execution of the German offensive, and initial advantages were not sustained in part because Rommel did not have the necessary combat power and in part because he wanted to turn to block the simultaneous British advance from Libya into southern Tunisia. In addition, the Americans had rallied, thanks, in part, to the effective use of artillery.[32]

The second German strike in Tunisia in 1943 was launched with three panzer divisions against Montgomery's Eighth Army at Medenine on March 6. Revealed in advance by ULTRA intelligence, this strike was rapidly thwarted, with heavy losses in German tanks (fifty-two tanks), as a result of the strength of the British position, in particular in antitank weaponry. The British 57 mm/6-pounder guns inflicted heavy losses. Montgomery kept his tanks in reserve. Smaller-scale German tank attacks at El Gueltar on March 23 were stopped by US artillery and tank destroyers, although, in turn, German antitank guns halted the advance of the British First and Sixth Armoured Divisions on April 24. The British, having blocked the Germans at Medenine, attacked the Mareth Line unsuccessfully on March 19 only to succeed in outflanking it. The difficulty the Eighth Army faced in breaking through the Mareth Line—a system of concrete fortifications and antitank ditches that had been built to defend the Tunisian border against the Italians by the French before the war—and in forcing the mountainous position at Enfidaville demonstrated that tanks were still vulnerable to well-defended positions with defensive obstacles. One of the surprises of the campaign, especially to the Germans, was the ability of Churchill tanks to cope with steep mountain gradients, which resulted in a number of tactical successes for the British.

In a key element of strategic weakness, once the German assaults had been blocked, their position in Tunisia was weakened by the length of their defensive perimeter. This reduced the number of reserves and ensured that the Germans were not able adequately to respond to Allied breakthroughs when they finally occurred, although they checked the US armor-infantry advance in late March. US tanks operating with artillery in support of infantry broke through German positions in late April; the British infantry broke through for their tanks on May 6, and the tanks were able to enter Tunis the following day.

By May 13, 1943, all the Axis forces in Tunisia—possibly 180,000 troops—had surrendered: more men than at Stalingrad. Attempts to evacuate the panzer divisions failed, and over 450 Axis tanks were lost in the Tunisian campaign. The Axis losses in Tunisia were compounded by Hitler's insistence on sending additional reinforcements to the area when it was already apparent that the battle was lost. For example, the use of Tiger tanks prematurely, and in inadequate numbers to be effective, was a case in point. Far from being the Verdun of the Mediterranean, as Hitler had promised, Tunisia became "Tunisgrad,"[33] making the Axis newly vulnerable in the Mediterranean and, as a result, having major consequences for the distribution of German forces as a whole.

THE BATTLE OF KURSK

By then, the Germans were preparing what was to be their last major offensive of the war on a principal theater of the Eastern Front in an attempt to return to the campaigning of the summer and autumn of 1941. Manstein's successful counterattack in February to March of 1943 had left the Germans with a vulnerable front line they could not readily protect. As Hitler did not wish to retreat, this encouraged his support for an attack. A breakthrough of the flanks of the Soviet Kursk salient was seen as a way to achieve an encirclement triumph to match the Soviet success at Stalingrad. Hitler regarded this as a battle of annihilation. However, more mundanely, the attack entailed the elimination of a position from which the Soviets could attack the neighboring German salients in the flanks. Meanwhile, the Soviets had decided to rest on the defensive in order to wear down the Germans by capitalizing on the advantages of doing so and by using the opportunity to destroy the new German tanks. This was Marshal Georgy Zhukov's advice, and it was intended as a prelude to a successful attack. Stavka, the Soviet High Command, adopted that approach.

Had Operation Citadel succeeded, the Germans were considering a further advance to the northeast designed to outflank Moscow from the south and east and thus avoid the direct approach eastward from Army Group Centre

against strong Soviet defenses. However, such a follow-up offensive would have faced serious resource problems, not least the replacement of destroyed or damaged tanks and other mechanized vehicles and the availability of sufficient fuel. Germany's failure to sustain and expand its invasion of the Caucasus region the previous summer was significant to the fuel issue.

To prepare for the offensive, Hitler sought to strengthen the tank arm. On March 1, 1943, Guderian, who had been relieved of command on December 26, 1941, for being willing to retreat near Moscow, was appointed to the new post of inspector general of armored troops. As such, he was responsible for overseeing tank design, production, and training. In the last, Guderian sought to incorporate experience gained on the Eastern Front. He held this post until appointed chief of staff of the army on July 21, 1944.

Hitler also focused munitions production on building tanks, and most of those on the Eastern Front were deployed in the battle. To mount the attack, the Germans drew on their greatly increased production of tanks and the introduction of new types, including the Tiger and Panther tanks (although fewer than two hundred of each) and Ferdinand self-propelled guns. The last carried the 88 mm gun and was well protected by armor. However, the size and weight (sixty-five tons) of the Ferdinand ensured that the maximum speed was nineteen miles per hour, and the vehicle required a crew of six. Eighty-nine Ferdinands took part in the battle, but they had serious problems. The lack of any way to train its gun meant that the Ferdinand, a self-propelled gun, was less effective than a tank. It also suffered from a lack of machine guns. The limitations of the Ferdinand were compounded by its tactical employment in the initial stages of the battle. It was used as part of the "break-in" force, for which it was less than ideal, and it proved vulnerable to mines, obstacles, and well-placed antitank guns. When, in contrast, the Ferdinand was pulled back and used in a defensive, tank-destroyer role, it proved extremely effective.

The Soviets were ready for the German attack as they had not been before. Forewarned by accurate intelligence information, the Soviets had prepared a dense defensive system of six belts, appropriately designed to resist tank attack. These belts, which included extensive antitank defenses, field fortifications, and minefields, ensured the terrain was not open and also provided a defense in depth and artillery-support system that inflicted heavy casualties when, against Guderian's advice, the outnumbered Germans attacked on July 5, 1943. Guderian not only objected to the operation on tactical grounds but also on technical ones. As inspector general of armored troops, he knew there were technical and mechanical deficiencies with the new tank designs

before committing them to large-scale combat. Guderian also argued that tank numbers should be built up before the battle.

Attrition replaced breakthrough for the Germans. Once the German armor, including the reserves, had been weakened, notably at the hands of Soviet artillery, and the tanks fought their way through some of the defenses, more in the southern than the northern sector, the Soviets were better able to commit their tank reserves against the German pincers. The Germans had Panther and Tiger tanks, which were particularly effective at long range, but the Soviet T-34s were used en masse, which allowed enough tanks to close with the Germans, despite heavy losses, to alleviate the disadvantages. The T-34s could be employed effectively at close range, and the Soviets had more tanks and uncommitted reserves. The Germans, moreover, did not fight well. Aside from tactical flaws, there were many command mistakes. For example, in accepting battle at Prokhorovka on July 12, Lieutenant-General Hermann Hoth, the commander of the Fourth Panzer Army, knowingly gambled on the tactical skills and technical superiority of the outnumbered and unsupported divisions of the Second SS Panzer Corps because he remained committed to his view that the decisive engagement would be fought there.

Although, in a battle the course of which remains contentious, German losses were less than often claimed, and despite some poor Soviet command decisions, including at Prokhorovka, the Germans failed to break through the Soviet lines and close the pocket. Hitler cancelled the operation on July 13.[34] Both sides had benefited from ground-attack aircraft, but not decisively so. The Soviets were greatly helped by the availability of large armor reserves. Indeed, the Soviet management of supply and demand proved important both to production and battlefield capability.[35] Large reserves meant they could take greater losses at Kursk and remain operational while the German losses, although less numerically, were greater proportionately and made them less able to advance. The Germans could not afford these losses. The heavy losses of the T-34s indicated that it was, if not obsolete, certainly not cutting edge, but it continued to be used.

The Soviets, having stopped the Germans, were now in a position to counterattack. Their own forces had not been so exhausted in the defensive struggle that they could not swiftly move over to the offensive. The Soviets attacked in the direction of Belgorod and Kharkov, capturing the cities on August 3 and 23 respectively. This achievement reflected the presence of large reserve forces, a particular strength of the Soviet military, and an organizational system that was better able to meet the demands of an offensive than had been the case in the more improvised circumstances at the beginning of the year.

This ability was a matter not only of supplies and maintenance but also of new and effective unit structures.[36] Thanks to a major increase in tank production, the Soviets were able to replace the very heavy losses their tank units suffered, notably in tank-versus-tank conflict and in conflict against prepared defenses. Thus, the 107th Tank Brigade of the Second Tank Army on the northern side of the Kursk salient lost forty-six out of fifty tanks in one day.[37]

Despite their doctrinal emphasis on a delaying resistance, trading space for time while inflicting casualties and preparing for a counteroffensive, the Germans proved less effective in defense than the Soviets, which was an aspect of their more general limitations on the defense. These were apparent both in prepared positions, notably with a lack of adequate artillery support, and also with a shortage of the armor necessary to provide mobile reserves. German tank losses in the Kursk offensive had this dangerous consequence. After the war, Manstein, separately, criticized Hitler for his preference for holding positions, as in his stand-fast order of December 18, 1941, rather than turning to mobile defense. However, the latter option posed serious logistical challenges, especially for inadequate fuel supplies.[38] Moreover, both approaches underrated Soviet resilience.

SOVIET ATTACKS IN LATE 1943

The focus on German tank attacks ensures that too much of the discussion about the Eastern Front in 1943 has been devoted to the Kursk offensive. However, this concentration both fails to put the German defeat in the context of a wider Soviet success and also serves to permit an analysis of this operation's failure to offer an explanation of Germany's wider difficulties. This is misleading because Operation Citadel was a failure of the Germans on the offensive, but the wider Soviet success represented a serious failure of the Germans on the defensive.

Before the struggle around Kursk had finished, the Soviets had already launched an offensive further south, overrunning eastern Ukraine. Soviet resources, including the quantity and quality of Soviet tanks and a rate of production far greater than that of Germany, were important. In 1943, their tank production had risen to twenty-nine thousand. Soviet operational skill was also significant. Earlier theories of deep operations advanced in the 1930s were now refined in the cauldron of war. Rather than seek encirclements, the Soviets deployed their forces along broad fronts, launching a number of frontal assaults designed to smash opposing forces and maintain continual pressure, an approach that was most appropriate in logistical terms. Unlike

Britain, Germany, and the United States, the Soviet military did not try to maintain the integrity and strength of their divisions, especially their armored divisions. Instead, they would use them until they were effectively no longer operational or destroyed and replace them with new, formed units with full complements of men and equipment.

The Soviets denied the Germans the ability to recover from attacks, lessened their capacity to move units to badly threatened positions, and searched out the weakest points in their positions. This approach reduced the value of German defensive "hedgehogs," mutually supporting strongpoints that were part of a defense in depth. These "hedgehogs" were less significant in resisting broad-front attacks, especially when they could not rely on armored counteroffensives.

These Soviet successes lessened the availability of German mobile reserves necessary to oppose successfully a Second Front, the proposed Anglo-American invasion of Western Europe. On the other hand, Soviet offensives were not all successful. Thus, that into Belarus in November-December 1943 miscarried. Yet there was a cumulative and effective pressure on the Germans.[39]

THE PACIFIC, 1942–44

Tanks played a far smaller role in the war in the Pacific. Nevertheless, they were deployed, notably by the Americans on the island of Guadalcanal in the Southwestern Pacific in 1942–43, where, on January 22, 1943, a Stuart tank had some success against Japanese defensive positions, particularly destroying pillboxes. The close proximity of the fighting ensured that the tanks required protection, which was provided during that attack. Another Stuart tank, lacking infantry support, had been rushed and set on fire by Japanese troops in the US landing on nearby Tanambogo Island on August 6, 1942. There were also Japanese tanks on Guadalcanal but no tank-to-tank conflict. While very good against the Japanese, the Stuarts were outclassed by the Germans in firepower and armor. The new tank squadron of the New Zealand Third Division operated in the Solomon Islands in 1943–44.

Tanks were used by the Americans in 1944 in Kwajalein, Saipan, and Tinian in the Central Pacific. They encountered not only defensive fire, but also mines.[40] On the first, Shermans defeated Japanese Type 94 tankettes. Allied leaflets dropped on Japanese troops told them, "You Can't Fight Tanks with Bayonets."[41] The Americans also used armed amphibious tractors at least partly operated by tank crews.

ITALY, 1943–45

British and US offensives in Italy faced serious problems. Italy was poor tank country due to the mountainous terrain. Sicily was invaded on July 10, 1943. In its defense, the Italian Sixth Army had few, mostly obsolete, tanks and was not helped by the refusal of the Germans to deploy the Fourteenth Panzer Corps near the coast. When the Allies invaded, the Italian defenders, including their tanks, were overwhelmed, and the German tanks were too far away to offer initial support. Subsequently, when the Allies advanced in Sicily, they found that the Germans took advantage of the terrain, which limited the use of Allied armor.

From September 3, the Allies invaded mainland Italy. Air power was seen as the way to stop German counterattacks,[42] but air power would not ensure success in mounting offensives. In mainland Italy, the density of German forces on the relatively narrow east-west defensive lines hampered Allied advances while Allied firepower stopped German attacks on Allied landing sites at Salerno (1943) and Anzio (1944). In the first case, two German panzer divisions attacked the beachhead in a determined and well-organized attack but suffered from a shortage of fuel as well as from the Allied response, which included heavy naval gunfire and the flying in of reinforcements. At Anzio, the rapid German reaction was led by armored units. There and elsewhere, naval gunfire support, which was chiefly from 6- and 15-inch guns, had a devastating impact on tank armor.

Allied tanks were often used in a fire-support role in support of infantry attacks—in other words, as mobile artillery. Yet armor was still used in large numbers by the Allies. In Operation Diadem, the fourth and last battle of Monte Cassino, the Allies committed two thousand tanks as part of their twenty-five-division-strong force, albeit suffering seriously from German antitank guns as in the Liri Valley, where the Germans had built tank obstacles, laid minefields, and cleared lines of fire as killing lines. The static defenses included Panther turrets concreted into the ground. More Allied tanks were knocked out in taking this position on May 23, 1944, than on any other day of the Italian campaign. The action gave an indication of the sort of casualties that could be expected in Normandy when attacking determined and well-prepared defenses. The battle saw the first encounter of a Panther tank by the Western Allies.

At the same time, in Italy there was an absence of relevant Allied doctrine and effective planning. This was particularly the case after the Gustav Line was broken in May 1944. The pursuit of the Germans was insufficiently close, in

marked contrast to the Soviet style. In August, Field Marshal Sir Alan Brooke, the chief of the Imperial General Staff, wrote about General Sir Harold Alexander, the Army Group commander:

> I am rather disappointed that Alex did not make a more definite attempt to smash Kesselring's forces up whilst they were south of the Apennines. He has planned a battle on the Apennine position and seems to be deliberately driving the Germans back onto that position instead of breaking them up in the more favourable country. I cannot feel that this policy of small pushes all along the line and driving the Boche [Germans] like partridges can be right. I should have liked to see one concentrated attack, with sufficient depth to it, put in at a suitable spot with a view to breaking through and smashing up German divisions by swinging with right and left. However, it is a bit late for that now . . . very hard to get old Alex to grasp the real requirements of any strategic situation.[43]

Alongside serious US and British command flaws, notably General Mark Clark's concern with focusing on the capture of Rome, rather than fighting the German Tenth Army, there were issues with the terrain. Between Monte Cassino and Rome, the Allies had an uninterrupted chain of mountains on their right side, and many difficult hills between them and Rome. There was only one relatively good road. Moreover, the plain, near the sea, was in origin a marsh, the Paludi Pontine. It had been drained by Mussolini, but soon after the Anzio landing, the Germans had destroyed the many small dams and, thereby, rendered the ground difficult for Allied tanks. In addition, Alexander was short of resources, which were focused on the Normandy (Overlord) and Provence (Dragoon) landings.

The Germans were able to retreat to the Gothic Line, protecting northern Italy. However, near Rimini in September 1944, a combined armor-infantry operation by the Fifth Canadian Armoured Division broke through the defenses, defeating the Germans—a success the division repeated the following year as it fought its way toward Venice.

EASTERN FRONT, 1944

In 1944, the Soviets, repeatedly taking the initiative and determining where the fighting should occur, again used combined forces successfully. They proved adept at developing good cooperation among armor, artillery, and infantry, and, helped by US aid, at making the latter two mobile. At the same time, the Soviet willingness to take very heavy casualties was important.

In early 1944, the outnumbered Germans were driven from western Ukraine. The campaign was less well handled by German commanders than that of early 1943, although the different verdict also reflected an increase in Soviet

operational effectiveness and tactical skill, as well as not needing to focus on dealing with the remnants of the German Sixth Army in Stalingrad. As a consequence of Soviet strength and competence and declining German combat, command, and support effectiveness, German counterattacks were less successful than hitherto. The Soviets used their reserves well to maintain the pace of the advance and thwart counterattacks but were greatly handicapped by the difficulties of maintaining resupply. This became more serious as they advanced.[44] The Soviets aimed for synchronized blows in order to deliver a cumulative operational shock (*udar*).[45] In practice, there was less coherence than theory and planning suggested; at the same time, Soviet combined arms expertise increased with experience. However, there were failures, notably the attempts from mid-April to early June to advance across the Dniester River into Romania. In these, the Germans benefited from the logistical strain on the overextended Soviets and the problems created by the spring thaw. At the same time, the bold use of tanks in counterattacks worked in May and June.[46]

Nevertheless, the burden of operational effectiveness was now against the Germans, in particular with Operation Bagration, the attack launched on Army Group Centre on June 23, 1944. In a repeat of the German success against France in 1940, Soviet operational skill was accentuated by the command and intelligence failings of its opponents. In addition, there was striking Soviet superiority in tanks and aircraft. The need for the Germans to defend the entire front against a series of Soviet attacks left them with few resources for staging counteroffensives. Moreover, the Soviets advanced on their flanks, knocking Germany's allies, Romania, Bulgaria, and Finland, out of the war. Soviet operational skill counteracted German tactical proficiency. The latter itself was undergoing strain, both because of Soviet improvements and because the effectiveness of the German army declined as veterans were replaced by poorly trained new recruits. There was also a lack of adequate mobile reserves.

The Soviets not only enjoyed a major advantage in artillery but also continued improvement in their armor to match new German tank types. The T-34/85 was more heavily gunned than its predecessors. The IS (Josef Stalin) 2, introduced in the spring of 1944 and able to take on Tiger IIs, became the best Soviet tank of the war as it proved an effective main battle tank.[47] This was an aspect of the more general enhancement in Soviet fighting capability.

Armor was usually used to the Soviet advantage. However, a German armored counterattack, including Tiger IIs, near Debrecen in Hungary in late October 1944 inflicted heavy casualties on the Romanian Fourth Division (now fighting with the Soviets), which was encircled and forced to surrender

on October 20. The Germans remained a formidable force, or at least a potentially formidable force, even though they were losing, which was a contrast between effectiveness at the tactical (high) and strategic (low) levels of war, with the operational level drawing on elements of both.

INVASION OF NORMANDY, 1944

The Canadian attack on the Channel port of Dieppe on August 19, 1942, a raid in force, demonstrated the problems of attacking a defended coast. The planners had intended that nine Churchill Mark III tanks should land simultaneously with the infantry in order to provide close fire support. However, due to a navigational error, the tanks landed fifteen minutes late, which enabled the German defenders to recover from their surprise and put down a terrible fire against the attackers. In the event, twenty-nine Churchills eventually landed, although two were "drowned," and some became bogged down in the sand on the beach. None were able to get past the concrete obstacles blocking the way into the town. The tanks could provide fire support in the subsequent battle, but that was inadequate, and the attacking force was defeated with heavy casualties.[48] This failure indicated the challenge facing the Allies invading Normandy in 1944.

Failure at Dieppe encouraged the British to press, against Soviet demands and US wishes, for the delay of any Second Front into 1944. In the meantime, Allied strength had been built up. This was a matter of scale and quality. Large numbers of tanks were built; new units were constituted, including the US Twentieth Armored Division on March 15, 1943; and relevant training took place. The infrastructure was considerable. The British had calculated that to keep one hundred Churchill tanks going for fourteen days, it was necessary to have 150 tons of spare parts.[49]

Tank availability, dispositions, moves, and conflict played a more major role in the invasion of Normandy on June 6, 1944—D-Day—and in the subsequent conflict than in the invasion of Italy. Allied planners were greatly concerned that the German panzer divisions in France would drive in the beachheads before they could become established and supported by sufficient antitank guns and armor. The German commanders, however, were divided about where the Allied attack was likely to fall and about how best to respond to it. There was particular disagreement over whether the panzer divisions should be moved close to the coast, so the Allies could be attacked before they could consolidate their position, or massed as a strategic reserve, the latter the advice of General Geyr von Schweppenburg. Rommel wanted to defeat the invasion at the waterline. The eventual decision—made by Hitler, who had taken direct

control—was for the panzer divisions to remain inland, but their ability to act as a strategic reserve was lessened by the decision not to mass them and by Allied air power. This decision reflected the tensions and uncertainties of the German command structure. These tensions accentuated major failings in German intelligence and planning.

On the invasion day, tanks were used by the invasion force. Responding in part to the problems encountered at Dieppe, the British employed specialized tanks to attack coastal defenses, notably Sherman Crab mine-clearing tanks. There were also Centaurs—95 mm howitzer close-support tanks. The Americans were not keen on these tanks.

On Omaha Beach, there were two American battalions, the 743rd and 741st, each with forty-eight tanks. Landing with the 1st Division, the 741st lost twenty-nine of their Duplex Drive (amphibious) Sherman tanks. These were launched too far offshore—five thousand yards, or nearly four miles from Omaha Beach—in a sea with six-foot waves, and the crews therefore drowned. Only three made it ashore of the thirty-two, but the rest of the 741st landed dry-shod, as did most of the 743rd operating further west with the 29th Division. The Germans had two 88 mm guns at Omaha Beach. They were in fixed bunkers and not mobile. An American tank destroyed the emplacement on the western end of Omaha Beach. There were also mines and antitank ditches on the beach, and the latter had to be cleared by M4 tank dozers. Sixteen were scheduled to land in the early assault, but only six got ashore, and five of those were knocked out. Once the beach was cleared, tanks were able to move inland from Omaha to help clear the town of Colleville.

On Utah Beach, the German resistance was weaker, but only five of twelve expected landing craft tanks (LCTs) landed safely. The decision was made to launch from three thousand yards out, and only a few tanks drowned on the run in. However, the planners had underestimated the effect of the sea state and current on the speed of the tanks through water. As a result, they landed after the initial infantry craft, not before, as had been planned.

The Twenty-First Panzer Division, the sole German armored division in the area and a poorly commanded unit, did not counterattack until the early afternoon. German tanks then approached the Channel between Juno and Sword Beaches, but they were blocked.[50] Far from having division-sized manning and equipment, the Twenty-First had 112 Mark IVs and some old French tanks and lacked the feared Tigers and Panthers. Elements of the division that counterattacked toward the sea were unnerved by seeing follow-on glider forces landing their position and, fearing being outflanked, withdrew. The Allies, meanwhile, suffered from a shortage of LCTs, which

affected the availability of armor in the crucial early stages of the battle for Normandy.

BATTLE OF NORMANDY

It proved difficult for the Allies to exploit the success and break out of Normandy. The Allies had assumed that the Germans, unable to hold their coastal fortifications, would fall back in order to defend a line, probably that of the River Seine. Instead, the Germans chose to fight hard, both near the coast and for all the territory. This defense obliged the Allies, unexpectedly, to fight in the bocage, the local Norman countryside, with its thick hedgerows and sunken lanes. Although the Caen plain is flat, Normandy was not good tank country. The landscape greatly affected cross-country performance and assisted the defense. Allied armor, doctrine, and tactics were not well-suited to the bocage and, in particular, the opportunities it offered to the defense, although the bocage was also not suitable for the Germans, whose tanks were designed for long-range firing.

Moreover, the German challenge was enhanced not only by their experience on the defense on the Eastern Front but also by the greater strength offered their defense by antitank guns, both self-propelled and not, and by heavy tanks. Resting on the defense, the Germans enjoyed the advantage of firing first, at close range, and from a stable position. Entering open ground exposed Allied tanks to serious risk, which led them to prefer to provide indirect support and, thereby, use dead ground. This situation put a renewed emphasis on infantry-armor cooperation for the attackers, but that is easier in doctrine than in practice, and the bocage made coordination particularly difficult.

With their individual units often lacking adequate training, experience, quality equipment, command, and doctrine, the Allies faced a hard battle and fell behind the anticipated phase lines for their advance. Allied casualty rates were far higher than in the initial landings. Despite air attacks, especially on bridges, the Germans were able to reinforce their units in Normandy, although the delays forced on them both ensured that the Allies gained time to deepen their beachheads and obliged the Germans to respond in an ad hoc fashion to Allied advances, using their tanks as a defense force, rather than driving in the beachheads. When the German armor was eventually employed in bulk on June 29–30, it was stopped by Allied air attack. Another armor counterattack was defeated on July 11.

In the Battle of Normandy, the Germans learned how to adapt in the face of concentrated firepower and air attack, and also adapted well to defending the bocage, whereas the Allies, notably the British and the Canadians, found

it difficult to break through and restore maneuver.[51] The Allied tanks failed to achieve what the Americans and British (and Germans) had expected from tanks. This was more than a matter of difficult terrain: the numerous hedges and sunken lanes of the bocage that provided excellent cover for opposing tanks and antitank guns and obstructed observation, movement, and lines of fire, each individually, and even more in combination, affected the capabilities of the attacking armor. Helped by the proximity of the bocage, the Germans also used sticky bombs against tanks. Small unit actions became the norm. These tested the ability to develop new tactics. Both sides did so while having to confront a lack of the necessary experience.

There were also serious operational limitations for tank warfare, not least vulnerability to antitank guns, which had become much more powerful since 1940, and the problems of communications with infantry. The last led to radios being installed in tanks to aid coordination with air power while telephone sets were placed on the backs so infantry could communicate with the tanks. The German antitank weapons included the 88 mm dual-purpose gun, the PaK 38 and PaK 40 antitank guns, the Panzerfaust, and the Panzerschreck. The Germans, however, suffered from a relative shortage of ammunition. Moreover, the Allies had far more antitank guns.

Although the Sherman was effective against opposing infantry, it suffered in tank combat in comparison with the Panther and Tiger but was better than the Mark IV, which remained the most numerous type of German tank. To help in the bocage, some Allied tanks were fitted with steel spikes so they could drive through the hedgerows. These were known as "Rhino" tanks. Sergeant Cullin, who devised the Rhino blades, was a mechanic in civilian life. The blades were iron spikes shaped as cutting blades, fabricated from German beach defenses, and fitted in front of the tracks of Sherman tanks. They proved able to cut through the hedgerows and were quickly approved for introduction to service. It took about a day for a three-man team to make and fit the device to a tank. They were fitted to over 16 percent of the available tanks and made a massive difference, not only to tactical effectiveness but also to the morale of tank crews. The episode, a classic example of US ingenuity and improvisation, reflected the adaptability of tanks as vehicles. This adaptability was also seen in tanks being used in battle to carry infantry, notably so by the Soviets. US adaptability in the Battle of Normandy was also evident in a far more effective tank maintenance practice than that of the Germans. Maintenance by the British and Canadians was also impressive.

The Germans benefited from their fighting quality and experience, although they faced many difficulties, not least poor command decisions. In the eastern

sector, the British took heavy casualties in successive attempts to advance near Caen, including the loss of five hundred tanks with the failure of Operation Goodwood on July 18–20, an advance weakened by being from a small bridgehead over the River Orne and on a limited front. This exposed the attackers to fire from both flanks as well as limited the number of tanks that could be used. Looked at differently, the Allies' failure to break through near Caen in part, at least initially, was also a matter of thwarting the possibility of a German advance in the area most propitious for such a move.[52]

Losses led to questions about the effectiveness of the British armor, as well as about British fighting quality and Montgomery's generalship. Many of the units involved had little combat experience and displayed a formality and rigidity in tactics that left them vulnerable. O'Connor, the commander of the British Eighth Corps, which included part of the British armor, noted that British armored divisions had varied in their fighting quality, adding: "The enemy, particularly the SS divisions, have fought fantastically."[53] O'Connor himself was less successful than he had been against the Italians in 1940–41. There were strains in the morale of some armor units, notably the Seventh Armoured Division and the Fourth Canadian Armoured Division. The overuse of tanks was also a deliberate policy to minimize the continued heavy infantry losses. A lack of sufficient British and Canadian infantry ensured that the Goodwood attack began without adequate infantry support. More infantry to secure the villages that were bypassed in the initial tank advance would have made a major difference in the course of the attack.

The British armor, however, learned rapidly, and it played a greater role in the German defeat[54] than is often credited. Moreover, attacks helped divert German troops, including most of the armor, from the US front further west, which was to be the crucial breakthrough zone. Without these attacks, the Americans would not have succeeded. Thus, the last uncommitted panzer division was sucked into the Caen sector, where the Germans lost tanks and self-propelled guns they could ill afford. Therefore, Goodwood was a tactical failure but an operational success, a contrast also seen on other occasions. Furthermore, of the British tanks put out of action in Goodwood, 231 were quickly recovered and returned to sector.

As so often, it is also necessary to distinguish beyond national characteristics or stereotypes in order to investigate differences between individual units. In Goodwood, the Eleventh Armoured Division did better than the Seventh,[55] although the latter, which was more professional and moved slowly and carefully, had fewer casualties. The Eleventh was helped by being equipped with Cromwell tanks, which were significantly faster and more maneuverable than

the Shermans. The same was true of differences, later that year, among US divisions in their willingness to use tanks to support infantry.[56] This was also the case for the German army and its very varied degrees of motorization and fighting quality.

Operation Cobra, delayed by the weather but begun by the Americans on July 25, created a breach, with heavy bombing wrecking the Panzer Lehr Division. Operational flexibility played a part in the Cobra breakout.[57] Firepower and infantry attack were crucial in the initial attack, but the US Second, Third, Fourth and Sixth Armored Divisions played a key role in both the creation and then exploitation of the breakthrough. Coutances fell on July 28 and Avranches three days later.

In turn, Operation Lüttich, a German counterattack by four panzer divisions through the Mortain area, was launched, on August 7, in pursuit of Hitler's hope of wrecking the Normandy landings and, more particularly, pinching that neck of the breakthrough. However, it was thwarted by strong US resistance. Defeat at Mortain prefigured the later German failure in the Battle of the Bulge.[58] The German plan reflected their commitment to a mobile defense. Having cut off the US Third Army, the Germans, who had brought up reserves, planned to turn against the First Army. Thus, the armor was to gain a central position and then use local superiority to defeat the Americans sequentially. However, the Allies had foreknowledge of the plan due to signals interception and destroyed the promised aerial support before the offensive was launched. The Germans suffered by being outnumbered in tanks, with only 190 in their four panzer divisions (divisions in name only), while the US Third Armored had 250. Defeated by US infantry, artillery, and armor, the Germans were also weakened by attacking across the front, rather than focusing on particular points and breaking through. The Germans ended the operation after failing to break through.

Allied ground-attack aircraft also played a role in the failure of Operation Lüttich. The Allies used close air support from the Second Tactical Air Force, notably with a cab-rank system that ensured missions were handled as they arose. In the earlier pattern of the Stuka on Allied forces, the rocket-firing Typhoon had a serious impact on German morale. Germans who were captured in Normandy said the two main differences between fighting in Normandy and on the Eastern Front were, first, the lack of night operations in Normandy and, second, the ever-present threat from "Jabos": British and US ground-attack fighter-bombers. However, these aircraft inflicted less damage in practice. The accurate targeting of unguided rockets was very difficult

against tanks—indeed, against anything smaller than a train—and claims of tank kills by aircraft were greatly exaggerated.[59] At the same time, the risk from air attack meant the Germans preferred not to move their tanks by day. Instead, they were employed in defensive positions. Because of Allied air support, the ground-attack aircraft were not often bothered by German fighters, but antiaircraft fire was a serious threat.

ALLIES ADVANCE TO THE FRONTIER, 1944

The much-delayed Allied breakout was followed, from August 10 to August 21, by the battle of the Falaise Pocket, with the nearly trapped German Panzer Group West taking heavy losses to Allied artillery, tank gunnery, and aircraft, but the Allies failed to achieve a complete encirclement. As a result, although much equipment was lost, many Germans escaped and were to provide valuable experience when their divisions were resupplied. The breakout also led to a rapid US armor drive into Brittany, with the Sixth Armored Division advancing to Brest, which was surrounded, while the Fourth captured Vannes, cutting off the German forces in Brittany, on August 5 and took Nantes a week later. This was a mistaken diversion of US armor away from the core target of the German forces moving back toward Germany.[60]

The Allies advanced across France and Belgium to the German frontier. Thus, on August 16, US tanks entered Chartres; on August 24, French tanks of the Second Armored Division, which had disembarked in Normandy on August 1, reached Paris. The US Seventh Armored Division crossed the Marne River at Château-Thierry on August 28 and the Meuse River at Verdun three days later before running out of gasoline. The British Eleventh Armoured Division captured Antwerp on September 4.

However, there was no success in cutting off most of the retreating German forces. Linked to this, the Germans did not experience losses comparable to those suffered at the hands of the far-more-numerous Soviets. In part, this was because it was difficult for amphibious forces to transform themselves rapidly for fast-moving advances. The Anglo-American forces had less experience than the Soviets in large-scale maneuver battles with the Germans and in the exploitation phase of battles and, subsequently, in maintaining the advance when it encountered resistance. It was far from easy to learn how best to use armor for large-scale mobile operations, an issue that remains relevant. The Germans had been doing so since 1939 and still made many mistakes in 1944. US and British commanders had to learn, at many levels, to overcome grave logistical problems and coordinate armor, infantry, and air assets, both

before and during combat. At the same time, there were important differences in aptitude in this respect between commanders and units, as had already been shown in North Africa and Italy in 1941–43.[61]

The broad-front approach to the advance across France did not work in cutting off the retreating Germans or in forcing a breakthrough once stronger opposition was encountered. Possibly, a narrow-front approach—for example, a crossing of the Rhine from Alsace by the US Sixth Army Group[62]—would have also failed, but its potential for exploitation was not grasped. The broad-front approach, in part, reflected a "come-as-you-are" tactic, moving forward troops from existing alignments in northern and southern France where Allied forces had landed on August 15. This approach also lessened the burden on particular communication routes. More positively, a broad front was a reflection of the need to maintain superiority over the qualitatively strong German forces. At the same time, this approach represented a needless anxiety about flanks and a major diffusion of combat effectiveness. The resulting lack of concentration of force seen in 1944 was appropriate more for a follow-up advance than for a fighting one. There was no equivalent to Soviet-style "deep battle" or German-style blitzkrieg, neither of which had the same concern about flanks, and no equivalent to what the Germans were to do in the Battle of the Bulge.

Allied operations after the Battle of Normandy, in a chaotic and improvised campaign in which Allied generals failed to display the necessary cooperation, were also affected by supply difficulties, notably the absence of adequate port facilities, damage to the rail system, and a lack of sufficient trucks. In addition, the logistical system was mishandled. Nevertheless, more armor was moved forward. For example, the Twelfth Armored Division, activated on September 15, 1942, left New York on September 20, 1944, and, via England, arrived at Le Havre on November 11, moving to Alsace, where it entered conflict from December 5.

The Germans themselves were vulnerable. On September 15, Field Marshal von Rundstedt complained that Army Group B was covering a front of 250 miles, but with only eighty-four serviceable tanks, assault guns, and light tank destroyers.[63] Two days earlier, the 116th Panzer division had only twelve operational tanks.

The German defense, however, hardened as the campaign of maneuver in the West was forced to a close in the autumn of 1944, with Allied mobility reduced to positional warfare. Explanations solely in terms of Allied failure are inadequate as they fail to focus on German determination, which included an ability to keep much of the war economy going even under destructive

Anglo-American bombing.[64] This meant that more tanks and antitank weaponry were produced. Moreover, fighting for Germany helped motivate the troops, not least due to the unattractive offer of unconditional surrender, although defiance, German nationalism, and military values were all more significant. The German army did not collapse. Its units, both large and small, retained cohesion.[65]

The Germans, indeed, won a series of defensive successes. German success at Arnhem indicated the deficiencies of an airborne assault when confronted by a mobile defense. In addition, the British airborne forces landed there lacked an effective antitank gun, although the PIAT, if not as deadly as the bazooka or the Panzerschreck, did score a number of successes against Tiger tanks. The British armor advancing toward Arnhem faced terrain that was both demanding and dictating: British armor had to move along narrow roads, in a country filled with ditches, canals, and rivers, preventing any wide-front movement of tank units. Instead, they were forced to advance in column and could rarely deploy and use all their firepower.

Further south, against firm German defenses, US tank destroyers and self-propelled guns alike provided the infantry with fire support—for example, in capturing the city of Aachen in October 1944. However, the strength of such positions, protected by well-motivated troops using antitank weaponry, was a formidable challenge. Furthermore, in the hilly terrain of the Huertgen Forest, the Americans took heavy casualties from October as they let themselves get bogged down in forest fighting and failed to break through the German defenses and advance eastwards into better tank country.

In addition, Patton found it difficult to accept that his zeal for movement was stopped by conditions in Lorraine and that it would not be possible to advance speedily to the Rhine. Aside from the German resistance, there were problems with the terrain once the autumn rains had saturated the ground.[66] The infantry bore the brunt of the struggle on both sides, but armor played a role, not least in successful German counterattacks. Moreover, further south, the French Second Armored Division captured Strasbourg on November 23.

GERMAN WINTER COUNTEROFFENSIVES, 1944–45

The Wehrmacht found itself on the defensive, trapped in an attritional war it could not win.[67] German attempts to regain mobility, notably by means of the Battle of the Bulge in December, failed. The Germans had been building up a significant armored force in Germany from September, in order to attack the Americans. However, aside from the political folly of German strategy—the assumption that the United States and Britain could be forced to abandon

the war—there was not room for the maneuver warfare the Germans had earlier used so well.

In the Bulge offensive, the tactical and operational advantages of armor when launched against unprepared defenses were clear. The aggressive nature of the surprise assault was impressive, and individual units did not need to be directed from high. The German armor fought well. The strength and novelty of the massed German armor for most of the Allied troops was a problem,[68] as was the German ability to gain and use the advantage of surprise against overstretched defenders lacking adequate reserves. Moreover, the Germans benefited from the impact of bad weather on Allied air operations. A forty-five-mile-long gap was smashed in the Allied front, and, deploying eight panzer divisions, the Germans were able to advance close to the River Meuse.

At the same time, these German tactical and operational advantages were lessened by deficiencies, notably a lack of fuel and some poor training, especially on the part of infantry units, as well as the strengths of the Americans, which included impressive artillery. Initial German successes could not be sustained in part because of the swiftness with which the Americans deployed reinforcements. Once the weather improved, ground-support air attacks proved particularly important against German tanks. The Germans also suffered from supply problems, as well as from the narrowness of the front, the terrain, and the firmness, strength, and eventual success of the US resistance, notably in Bastogne and on the flanks.[69]

To obstruct the German armor advance, US engineers set up roadblocks and mined bridges, delaying the German tanks—for example, by blowing up the main bridges at Trois Ponts on December 17 and that over the River Wiltz the next day.[70] The ability of such moves to affect armor operations was an indication of the problems facing tanks, and not just at the tactical level. Moreover, defensive obstacle-making moves could be accentuated by the use of antitank guns and other antitank weaponry, stationary or mobile. This capability underlined the significance of engineering units as an integral part of armor advances. In addition, antitank mines proved effective against German tanks while US tanks were important to the defense. At St. Vith, the Seventh Armored Division mounted a successful delaying action, while the Combat Command B of the Tenth Armored fought a delaying action at Bastogne. They were also significant to the counterattack, as with the relief of Bastogne by the Fourth Armored Division.

Another German counteroffensive, Operation Nordwind, in Alsace in January 1945, was resisted in part by US tank destroyers. These destroyed many tanks, with the African Americans of the 827th Tank Destroyer Battalion with

their M18 Hellcats particularly successful. At the same time, the operation of these tank destroyers revealed serious training and organizational problems, not least in coordination with infantry. The battalion had been trained on the expectation that the gunners would fire only on the instruction of their own officers. Conversely, the infantry officers gave instructions that were suited to tanks rather than the lightly armored Hellcats.[71] As a whole, the operation saw US tank units successful on the defensive, albeit taking heavy casualties.

THE WESTERN ALLIES ADVANCE INTO GERMANY, 1945

US and British forces advancing into Germany in early 1945 took part primarily in infantry struggles, with the armor frequently involved in support, as with the use of tanks to back the US Thirty-Fifth Infantry Division on its advance from the River Poer to the Rhine in March. At the same time, the armor was also involved in tank conflict with German tanks. Moreover, there were divisional-level attacks, as with the US Fourteenth Armored Division breaking through the Siegfried Line and advancing to the Rhine.

In turn, a shortage of gasoline, and being heavily outnumbered in tanks, affected the defense of Germany after the Americans crossed the Rhine on March 7 at Remagan. After the Americans encircled the German forces in the Ruhr on April 1,[72] an operation in which the Third Armored Division played a key role, including overcoming SS panzer training units, they rapidly advanced east and southeast, overrunning much of Germany. On their left, the British, who had developed an effective fighting performance,[73] overran northwest Germany. They benefited there from fighting in far more open country than the Normandy bocage or the waterlogged Lower Rhineland.

These advances still involved much fighting. In this, there was care to keep armor, infantry, and artillery able to offer mutual support. Thus, on April 12, the US Fourteenth Armored Division found the bridge over the River Main at Lichtenfels destroyed. The rifle company accompanying the Twenty-Fifth Tank Battalion forded the river and captured the town under a supporting smoke screen laid down by the battalion's mortar battalion and backed by tanks firing across the river. Three days later, an advance reconnaissance force was cut off in the town of Creussen by a German counterattack that included thirty-five tanks. They blocked a relief force of US armor, but its infantry support was able to advance, and more tanks, supported by frequent air strikes and artillery, defeated the Germans, destroying nineteen tanks. On April 21, west of Allersberg, antitank fire destroyed a US tank and tank destroyer at what they called "88 Junction" from the rounds fired by a Tiger tank. The following day, a US infantry advance on Allersberg, supported by eight medium

tanks, two assault guns, and one tank destroyer, met resistance from two Tiger tanks whose armor held up well against bazooka rounds. US attacks were met not only by tanks but also by machine guns, and Allersberg was not taken until April 24.[74] Such campaigning, which involved tough combat until the end of the war, as captured in the film *Fury* (2014), drove home the need for combined operations.

Like the Luftwaffe, German armor was hit by the increasing lack of adequate training. In part, this was a product of the urgent need for tanks for combat, but the crisis in fuel availability was also significant. A lack of training also led to a deterioration in standards of maintenance, which became more serious due to the impact on production standards arising from Allied bombing, which inflicted direct damage, hit the movement of parts and fuel, and put serious pressure on the workforce.

THE EASTERN FRONT, 1945

The final Soviet advance on Berlin in 1945 repeatedly indicated the continued value of tank warfare to the Soviet army. Against bitter resistance, the Soviets were victorious in the Vistula-Oder offensive of January and February. Breaking out from their bridgeheads across the River Vistula, a success greatly helped by plentiful artillery, the rapidly advancing Soviet tank forces then exploited the victory, advancing across western Poland to the River Oder. As with other advances, however, there were growing problems with supplies.

The last stages of the war repeatedly demonstrated the degree to which Allied forces were not only effective but also efficient. This was seen in the continued strength of Soviet operational art, which stressed firepower but also employed mobile tank warfare. Attrition and maneuver were combined in a coordinated sequence of attacks. The Soviets used large numbers of tanks, which were able to exploit opportunities prepared by short and savage artillery attacks. The individual Soviet tank armies gained space to maneuver, and this Soviet maneuverability prevented the Germans from consolidating new defensive positions. For forces that had broken through their opponents, mobility enhanced the ability to prevent their opponents from falling back in order. Mobility replaced the sequence of new front lines seen with World War I advances. Instead, there was now the open battlefield, in which retreating opponents had to rely on defensive "hedgehog" positions that could be encircled if the momentum of the offensive could be maintained. The limit of the new advance was often that of maintaining gasoline supplies, as in the Soviet advance through Poland in early 1945.

With their pronounced tendency to mount aggressive, mobile operations,[75] the Germans themselves launched an offensive in Hungary from Lake Balaton towards Budapest—Operation Spring Awakening—on March 5. Hitler had moved the Sixth Panzer Army from the Ardennes front, but the state of the railways and the weather had delayed the attack. The offensive was expected by the Soviet commanders and fought to a halt by March 15, with the Soviets benefiting from their resources, their ability to create defensive positions hastily, and the impact of mud on the German tanks. As on the Western Front in 1944–45, the German emphasis on maneuver warfare could no longer work even at the operational level.

Deploying about six thousand tanks, including the IS-2, which was designed as a breakthrough tank intended to attack defensive positions, the Soviets used armor extensively in launching the Berlin Operation on April 16. German antitank guns inflicted heavy casualties that day, and on the next two, on Soviet tanks that had inadequate infantry support. However, the Soviets, mounting frontal attacks and showing a disregard for heavy casualties, eventually broke through; their tanks reached the major ammunition store at Jüterbog on April 20 and encircled Berlin on April 25. German relief attempts were all defeated. Although they took heavy losses, the Soviets were then successful in overcoming resistance in Berlin; the remaining troops there surrendered on May 2, followed by the Germans as a whole five days later. The campaign, however, showed a flaw in Soviet armor and, more generally, with the heavy tanks. They were unable to keep up with the T-34/85s, which hit the cohesion of the Soviet armor.

THE WAR WITH JAPAN, 1945

The war with Japan is not primarily identified with armor warfare. Indeed, from the US perspective, the principal use of tanks was by the Americans as they found the seizure of islands more difficult. This was particularly seen on Okinawa, where the Americans landed on March 26 and where resistance did not cease until June 30. As earlier on the island of Iwo Jima, the Japanese had created a dense network of underground fortifications. This not only vitiated the effects of US firepower, especially air power, but also made a fighting advance on foot difficult, not least because the network provided the Japanese with a myriad of interconnected firing positions. The Japanese had sufficient artillery, mortars, and machine guns to make their defenses deadly.

The Americans made extensive use of tank-mounted flamethrowers in order to clear positions. Although the circumstances were very different to operations elsewhere, the successful use of flamethrower and other tanks depended

on effective cooperation with infantry, which provided crucial protection for the tanks.[76] Armored bulldozers were also employed on these islands, not least to close caves that were serving as Japanese positions.

Tanks were used by the Americans in the reconquest of the Philippines in 1945—for example, in the advance on Manila. In turn, Japan employed tanks and 37 mm antitank guns to defend Bataan, although infantry and artillery played the key roles in the defense.

The British also used tanks in resisting the Japanese advance from Burma into India in 1944 and, subsequently, in their advance into Burma. In the former case, tanks and infantry operated closely together as part of the relief force for the besieged British garrison at Kohima. M3 Grants were deployed and outgunned the Japanese. The tanks were then employed in the fighting at Kohima. Bulldozers were also used against Japanese roadblocks.

In 1945, the British employed the 255th Tank Brigade as an armored column to attack the Japanese lines of communication at Meiktila in February and March. Subsequently, the tanks moved south on Rangoon but were badly impeded by heavy rain, and the city instead fell to an amphibious force.

Tanks were used in a very different context, and on a very different scale, in Manchuria that August. On August 8, the Soviet Union declared war on Japan, invading Manchuria at 4 in the morning on August 9. The Soviet forces, deploying 5,500 tanks, were better trained than the Japanese, and many had combat experience from fighting the Germans in Europe. Thanks to the resources available, the troops transferred from Europe to invade Manchuria left their tanks behind and were equipped with new ones in Siberia. This reduced transport burdens on the Trans-Siberian Railway and greatly speeded up the transfer, although there were bottlenecks at the depots because so many troops demanded tanks at once. The system also lessened the demands on the maintenance side. The old worn-out tanks did not require repair.

Aided by skillful deception techniques, the Soviets seized the initiative and advanced rapidly to envelop their opponents. Soviet armored columns concentrated on advancing through the Greater Khingan Range of mountains, where the Japanese were weakly deployed. Their campaign bridged aspects of German blitzkrieg with later Soviet Cold War plans for invasions of Western Europe. Showing an ability to master terrain, the forces of the Trans-Baikal Front crossed the Greater Khingan Range, invading Manchuria from the west. At the same time, the First Far Eastern Front invaded from the east, advancing from near Vladivostok and driving on Harbin. In contrast, the units and commanders from the Far East, who had not seen recent combat and were

deployed in the Second Far Eastern Front to the north of Manchuria, operated southward in a more cautious fashion.

Although they were weak, notably in armor, the Japanese fought tenaciously in Manchuria, including using soldiers carrying explosives who detonated them against tanks, a variant on the aerial kamikaze attacks. However, Japanese planning was completely disorientated by the speed of the Soviet advance. The Japanese had failed to appreciate the advances the Soviets had made in 1943–45 in developing and sustaining "deep operations." In particular, the Japanese underrated Soviet mobility and inaccurately assumed the Soviets would need to stop for resupply after about 250 miles, providing the Japanese with an opportunity to respond to the Soviet advance. Indeed, lacking situational awareness, the Japanese were seriously outmaneuvered.

Japanese resistance was greatly affected by the announcement, on August 14, of the Japanese surrender. The commanders in Manchuria nevertheless decided to continue fighting, but, on August 17, a direct order from the emperor ensured compliance. The increasing confusion in the Japanese response helped the Soviets make further advances. They increased the pace of their operations, using airborne detachments to seize important cities and airfields and, against weaker resistance, pushing forward their tanks, many of which were refueled by air. A tank force that had crossed the Gobi Desert joined up with Chinese Communist forces near Beijing. By the time of surrender, over eighty thousand Japanese troops had been killed, compared to fewer than nine thousand Soviets. This was a dramatic display of the effectiveness of rapidly advancing forces making ambitious and successful use of tanks.[77]

CONCLUSIONS

The course of the war amply demonstrated the value of doctrine and training in the use of tanks. Major-General Eric Dorman-Smith, chief of staff for the British Eighth Army for some of North Africa in 1942 and a critic of British performance, saw this as a crucial factor in conflict there the previous year: "In the Middle East Command, during the autumn of 1941, there arose the tactical heresy which propounded that armour alone counted in the desert battle, therefore the British . . . should discover and destroy the enemy's equivalent armour, after which decision the unarmoured infantry divisions would enter the arena to clear up what remained and hold the ground gained."

Dorman-Smith contrasted this with Rommel's Afrika Korps and its tactical preference for a "mixed formation of all arms," and he attributed British deficiencies to the sway of generals with a cavalry background: "the romantic

cavalry mystique of horsed warfare" led to "basic tactical fallacies . . . the dichotomy between the unarmoured infantry divisions and the relatively 'uninfanterised' armoured divisions."[78] In a different context, the Soviet Operation Mars, launched on the Central Front west of Moscow in November 1942, suffered from poor armor-artillery coordination and totally failed.[79] So also with the US Twelfth Armored Division in Alsace in January 1945.

In contrast, armored divisions balanced between the arms were effective, rather as the Napoleonic corps had been in the 1800s. On July 1, 1942, Major James Milner MP told the House of Commons that the British had been mistaken in Libya to rush tanks forward, only for them to be wrecked by opposing German artillery. He added: "Never should tanks alone be pitted against tanks, if that can be avoided. To do that means to have a mere slogging match which leads nowhere. All the arms should be used in combination under one command. That is quite clearly what Rommel has done. We, on the other hand, have let our artillery be in the background. . . . Tanks are a kind of cavalry, and they have very definite uses, but alone they cannot win battles, and that is what we have been trying to do with them."[80]

The British eventually adapted their doctrine and closed this capability gap, although the initial doctrine for infantry-armor operations imposed by Montgomery was flawed and required changes after the problems encountered in Normandy in 1944. Combined arms doctrine was affirmed anew. In February 1945, Montgomery argued that close cooperation with infantry was needed in order to overcome antitank guns: "I cannot emphasise too strongly that victory in battle depends not on armoured action alone, but on the intimate co-operation of all arms; the tank by itself can achieve little."[81] That left aside the additional dimension of air land battle.

The world's leading economy, that of the United States, produced eighty-six tanks in 1941–45. US armor was seriously limited at the beginning of 1940, but, on September 8, 1939, President Roosevelt had ordered a protective mobilization designed to strengthen the military. In May 1940, the National Defense Advisory Council was established, a peacetime draft followed in September, and, in March 1941, the Lend-Lease Act added the burden of helping arm Britain. An unlimited national emergency declared on May 27, was followed, after Pearl Harbor, by new production outlines and the establishment of the War Production Board. Productive capacity rose, not least as worker productivity increased, in part due to new plants and techniques.

The major increase in tank production was closely linked to the prominence of armor in the US emphasis on equipment rather than manpower. This prominence was also intimately related to the objective of movement, one also

seen in the motorization of infantry and artillery, thus providing a particular quality to US combined arms capability that offered a balanced effectiveness. Movement was intended to allow for "triangular" operations in which the opposing force was frontally engaged by one unit while another turned its flank and a third, in reserve, was poised to intervene where most helpful.

Aside from doctrine, the production of tanks reflected industrial advanced mass-production capacity in the shape, in particular, of forging, casting, cutting, milling, and grinding processes, all aspects of machine-tool work. The Americans benefited from the availability of effective machine tools. The presence of a large auto industry was significant. Thus, the Chaffee was developed by the Cadillac Division of General Motors. Moreover, about ten thousand Stuarts had been built by 1944 at the Cadillac and Massey Harris plants. The ability to fund production was crucial. As with aircraft, the United States' multiple strengths translated into battlefield capability.

US production was supported by those of its allies, notably Britain[82] and the Soviet Union. Each produced large numbers. The Soviets manufactured 98,300 tanks and self-propelled guns. The Soviets proved particularly effective, not only in turning out tanks but also in matching requirements for the necessary equation of quantity with quality. Production processes were enhanced by using newly designed efficient factories that had been carefully located and by focusing on a small number of simple designs with limited updates. Moreover, the Soviets accepted that their tanks would only have a limited life span.[83] They benefited from over fourteen thousand tanks supplied by Allied powers (Britain, Canada, and the United States), including Grants, which saw action at Kursk in 1943.

The war saw a major spread of the use of tanks, including by powers that had not hitherto done so in combat. Thus, there were Canadian, Polish, and South African armored divisions; New Zealand armored regiments; and a Rhodesian armored battalion.[84] From 1941, Romania added captured Soviet tanks and received 218 German ones. Moreover, some Soviet tanks were converted by the Romanians in 1943 into self-propelled guns, with tank destroyers following in 1944. China (the Guomindang, or Nationalist government) received six hundred US CTLS-4TAC and CTLS-4TAY light tanks after Pearl Harbor. They took part in the conflict with Japan.

Production also spread. Developed and manufactured under license from the Swedish company AB Landsverk, Hungary built 202 Toldi tanks in 1939–42. A light tank, the Toldi I, weighed 8.5 tons and had a 20 mm gun. From 1942, the Toldi IIa, which weighed 9.3 tons, was developed. It had a 40 mm gun, and eighty earlier variants were thus rearmed. The tanks saw service against

Yugoslavia in 1941 and the Soviet Union but were vulnerable in frontal engagements with T-34s. The Turán, based on a Czech design, was produced by Hungary from 1940 and weighed 18.2 tons. Initially with a 40 mm gun, it was up-gunned to a 75 mm in 1941 (but only entered service in 1943) in response to the challenge of Soviet tanks. The chassis was also used for the Zrínyi assault gun, which had a 105 mm gun.

In 1943, Australia brought the Sentinel into service. The first tank manufactured there, it used US tracks and engines, British weaponry, and a French suspension system and was built at a new factory at Chullora. However, the tanks never saw action because British and US ones ready for use arrived. In 1941, the Canadian Pacific Railway Company built 1,400 Valentines, most of which were supplied to the Soviet Union where they were popular with tank crew, not least for their maneuverability and interior layout.[85]

Neutrals also sought to develop their tank programs. Spain ordered one thousand Verdeja tanks in 1941, but the tank was not built due to a lack of resources. Instead, in 1943, Spain decided to turn to Germany in order to renew its tank force, launching the Bär Program, which was intended to involve the acquisition of 250 Mark IIIs and 100 Mark IVs. However, the military needs of Germany only allowed the supply of 20 Mark IVs. Spain considered that inadequate and, in 1944, pressed for another 100 Mark IVs and some Tiger tanks. This could, and did, not happen, and, in 1945, the Spanish tank force was largely outdated: 8 FTs, 116 T-26s, 84 Mark Is, 60 CV-33/35, and 20 Mark IVs.

The war also witnessed tank combat in new areas. Linked to this came the determination to make tanks effective that led, for example, to the production of terrain evaluation maps. These major additions to topographical maps were important for both vehicles operating off-road and infantry. German terrain evaluation maps were impressive and effective, and the use of color helped make them readily accessible. The material offered included not just ground suitability but also forest composition (type of tree) and density, slope gradients unsuitable for armored vehicles, important viewpoints with their field of view, and bridge weight limits. The Americans and British produced similar maps. In the former, "trafficability," the suitability of the terrain for cross-country movement, was the key element, and the Americans became adept at producing such material rapidly, as in January 1945 in preparation for what was to be the successful invasion of Germany. The material was made more valuable by being accompanied by charts showing, per month, the expected number of days of "trafficable ground."

The major role of tanks in the conflict on land during World War II helped ensure their greater salience in the postwar world compared to its prewar

predecessor. This was true of force structure and planning. In addition, the use of tanks in World War II dominated the public discussion of the war on land—indeed, the future of warfare on land—and helped make an impression of the experience of tank warfare and the war itself normative as an account of the past and a prospectus for the future. This process was encouraged by the very look of tanks. For example, whatever its faults, the Sherman appeared streamlined in comparison to its predecessors. More generally, the increasingly streamlined appearance of tanks and aircraft were parallel developments. Both reflected designers' increasing confidence in an ability to master physical space and technological improvements.

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NINE

INTO THE FUTURE

"IF THERE IS ONE LESSON FROM THE VOTE IT IS THAT FORCE ALONE does not work in the internet age. One knitting old lady can stop a whole line of tanks." This reflection, by a senior Spanish politician in 2017,[1] when the Spanish government sought to prevent an independence referendum in Catalonia, captured one crucial aspect of the relative effectiveness of tanks—that of the very contexts within which force operated. In practice, such issues were handled very differently in particular countries and in specific contexts. In most countries, there would be no such stop, whether in peacetime or wartime. For example, without reference to tanks, Gandhi might have been effective against the British in the 1920s and 1940s, but he certainly would not have been against the Japanese, the Germans, or the Soviets.

Focusing on the performance of the tank as a machine is not the whole story, but it is obviously significant.[2] In this respect, looking to the future, secrecy about developments is an element in assessing capability. Thus, the true effectiveness of current tank armor is, for those outside the military, a matter of speculation. Moreover, the performance of tank armor has greatly affected other specifications, such as weight and cost. Despite improvements to tank protection in the shape of better protective systems, particularly new material and better sensors,[3] there are still serious vulnerabilities. For example, the Russian T-90 has, as part of its Shtora-1 active protection system, automatically triggered infrared dazzlers to jam laser-targeting systems on missiles as well as an infrared-obscuring aerosol cloud and explosive reactive armor. Nevertheless, at least five or six were knocked out in Syria in 2016 and 2017.[4] Tanks are vulnerable to nonelectronically traceable weapons or devices, such as bazookas. Finland has prepared to resist a Russian invasion by purchasing Panzerfaust 3s, which have a simple optical targeting device and no electronics that can be jammed.

This point can be illustrated by the Israeli-designed Trophy system, which in 2019 was adopted by the Americans to improve their Abrams M1A2, equipping up to four tank brigades. A counter antitank system, it is based on four sensors covering the four sides of a tank and releasing information to the tank radar, which orders the central system to react with radar-guided weapons that fire Multiple Explosive Formed Penetrators to destroy the incoming weapon within seconds. Designed for urban warfare, this also works on open ground. This is a major tool in tank protection and effectiveness electronically, but lacks effectiveness against dull-ammunitioned antitank weaponry from the APFSDS (armor-piercing fin-stabilized discarding sabot) down to Molotov cocktails. As a result, a hull-down station remains the best kind of tank defense, which, however, itself poses issues of vulnerability.

Moreover, even if destruction can be avoided, damage, as from the outset of tank warfare, remains a central problem. The cost of replacing damaged tank tracks is formidable, let alone that of dealing with engine problems. More seriously, damage is a key issue because, due in part to cost but more to other commitments, the number of available tanks has fallen. While antitank, like antiaircraft, weaponry continues to indicate the effectiveness and importance of antiweapons, their impact is increased by the fall in the number of tanks and aircraft. The growing sophistication of armor electronic systems and cyberattacks means tank operations are likely to be part of cyberwarfare.

At the same time, the place of the tank in modern conflict has declined, a point underlined in both procurement and doctrine. Thus, Russian rearmament from the mid-2010s has focused on air, naval, and missile weaponry, especially nuclear weaponry. The army has received attention, but only within this context and one in which the Russians have been developing what the West has named "hybrid warfare," below the level of overt use of regular military units but including the use of the threat of nuclear or conventional forces, information warfare and cyberwarfare, and the actual employment of special operations forces.[5]

In 2015, in the Victory Day celebrations in Moscow, air defense missile launchers and intercontinental ballistic missiles were displayed alongside tanks, including the new T-14 Armata. This was presented by the Russians, keen to boost prestige and foreign sales, as superior to Western rivals, such as the US Abrams and the British Challenger 2. Weighing forty-eight tons, the T-14 has a speed of fifty to fifty-six miles per hour and a 125 mm gun.

However, during the rehearsal, the T-14 on display stalled for fifteen minutes. Similarly, although there was initial talk of 2,300 tanks for the army, production and fiscal issues led to a major reduction. The unit cost was estimated

at $3.7 million. Nevertheless, the T-14 was now part of the display culture of the Russian military as seen, for example, in the Victory Day celebrations in 2019, alongside 152 mm self-propelled howitzers.

Of the current leading tanks in service throughout the world, most are not at the technological cutting-edge. Two clearly representing investment in new systems are the Russian T-14 and the Japanese T-10. The latter has reduced its weight by one ton to forty tons, compared to its predecessor, by utilizing lightweight nanocrystal steel and modular ceramic composite armor. The T-10 also has a hydropneumatic suspension system, a 120 mm smoothbore gun, and a speed of forty-three miles per hour. Automatic loading enables the T-10 to operate with a crew of only three.

From 2014, Russia deployed tanks in an effort to intimidate Ukraine and, in 2017, in the Zapad-17 military exercise, to intimidate the North Atlantic Treaty Organization (NATO) in the Baltic sphere. At the same time, although the Ivan Gren–class of landing ship, tanks (LSTs) that Russia was then building was large and impressive, there were only two of them. In contrast, China, by 2011, had twenty-six LSTs of over four thousand tons. These were a threat to Taiwan, and on June 6, 2019, the Taiwanese defense ministry announced that it had asked the United States to sell it 108 M1A2 Abrams, 1,240 TOW missiles, and 409 Javelin antitank missiles as part of a two billion dollar order including 66 F-16 fighters and 250 Stinger antiaircraft missiles. The tanks, TOWs, and Javelins would all represent upgrades on existing weaponry. However, Chinese tanks posed less of a threat to Taiwan than that coming from the development of Chinese missile systems.

Given the costs, it is not surprising that many states prefer to buy tanks from low-cost producers, as with Thailand, a traditional US ally, receiving Chinese VT-4s from 2017, or seek armored vehicles, which are not only cheaper but simpler to maintain and multipurpose. Armored vehicles are also easier to manufacture, which is highly important for "offset" deals, those in which reciprocal investment plays a role, with local production proving part of the process. The more complex the system, the harder to employ a low skill base and respond to a lack of high-quality production capacity. At the same time, purchasers seek such agreements, both to lessen costs and help local defense industrialization. The particular requirements of sophisticated tanks pose a major problem to this equation.

Changing force structures were an issue for the United States, which dramatically reduced its military presence in Europe after the Cold War in part due to the redeployment to the Middle East but also as a result of the run-down in the army. The last US tank stationed in Europe departed in 2013. In turn,

in response to the Ukraine crisis beginning in 2014 and the Russian threat to the Baltic Republics (Estonia, Latvia, Lithuania), NATO built up its forces. Initially, the NATO Stabilization Force was equipped with only light vehicles and no main battle tanks, but it had an antitank capability.[6] Nevertheless, as a key element, heavy equipment was soon stockpiled in Western Europe, with the equipment to be used for units that were to be airlifted in from the United States in the event of crisis. In 2015, the United States and NATO developed plans to pre-position military vehicles, including heavy tanks, in Eastern Europe. The troops to use them were to be flown in, which was an important adjunct to the use of air power to help armor.

There is certainly a NATO vulnerability in the event of war. Russian forces suffer from undermanning, poor morale, inadequate maintenance, and the dependence of public finances on the price of oil, which contributed to a fall in military spending in 2018. The operations against Ukraine were only sustained by drawing on units from across Russia. Yet the Russian army has been configured for high-tempo attacks, which increases the threat it poses.[7] The Russian VOSTOK exercise in 2018 demonstrated that military investment over the last decade, but especially since 2015, had had a favorable impact on manning, morale, and maintenance concerns.

Moreover, the Baltic Republics, vulnerable to attack and weak in air power, lack the capacity to stop a Russian tank advance, and it is unclear that appreciable NATO forces could be rapidly deployed other than to provide a "tripwire deterrent." There has been talk, indeed, of a new "Fulda Gap" between Russia's ally Belarus and its Kaliningrad enclave on the Baltic, with the Russians thus advancing, through southern Lithuania, to cut off the Baltic Republics from reinforcement by land. The Suvalki Gap, the sixty-mile-wide Lithuanian strip of land between Belarus and the Kalingrad region, is NATO's weak spot. NATO has stationed troops there to deter a Russian attack. In 2019, NATO also decided to fund a new $260 million weapons store at an airbase close to Plowditz in central Poland to be better able to equip reinforcements that were flown in. However, the scale and speed of the necessary NATO action are both significant issues.

More generally on the world scale, tanks will have to face the greater share of the population that lives in cities and the particular military environment this focus creates. This environment brings together conventional combat with asymmetrical operations—a range also seen in other environments but with particular characteristics in cities.[8] In this setting, infantry requires protection in the form of armored personnel carriers and tanks and the assistance of armored bulldozers. If operating in the narrow streets of many cities, it will be

important to have smaller tanks. That does not mean, however, a comparable need for fleets of tanks. Separately, cities can be cut off and isolated. Siege by means of stopping power, fuel, water, and food supplies will lead to a breakdown of urban life.

At another scale, there is the question of whether the West's military dominance is coming to an end,[9] with consequences for the weapons particularly associated with it. Alternatively, to maintain that dominance, does there need to be a change in weapons and/or their use?

Although the demise of the tank has been predicted since it was invented,[10] technical responses, if not solutions, to the continuing problems of firepower, mobility, and armor suggest the tank is here to stay, at least until there is a major change in the parameters of land conflict. As with unmanned aircraft, there may be unmanned tanks, and the same for antitank weapons.

At the same time, aside from improvised explosive devices (IEDs), cut-price precision weapons using off-the-shelf components are a threat to existing tanks and their use. This is not only a possibility for nongovernmental organizations (NGOs) and others involved in asymmetrical warfare, such as terrorist organizations. Most prominently, the US Army Research Laboratory's Aeromechanics and Flight Control Group is examining the potential of what it terms the Cooperative Engagement Capability program. This rests on guiding "dumb" weapons by means of radio messages from smart munitions. Thus, a swarm of submunitions would be given a guidance system, increasing effectiveness and replacing indiscriminate fire. Precision and speed will be delivered at lower cost than at present and thus will be able to hit dispersed targets. The nature of artillery would change, and individual soldiers would have maneuvering munitions with a type of video game console. The devolution of responsibility to such combatants offers a dramatically new version of that offered by the idea of decentralized command. The latter is generally held up as a means to success, notably providing necessary flexibility.[11]

In looking to the future, the comparison with changes in naval warfare is arresting. Tanks were intended originally by the British as armored ships on land. The force structure of navies, however, from the late 1940s saw battleships replaced by aircraft carriers. In contrast, tanks remained armed with guns as their size allowed no similar transformation to that seen at sea. In contrast, drones and similar unmanned land vehicles will allow a vehicle of the scale of a modern tank to carry and control a number of those vehicles and will turn the tank into a kind of carrier, including of unmanned aerial vehicles (UAVs): unmanned little tanks.

Flexibility is certainly necessary at all levels of military activity.[12] This is particularly so with rapid troop advances. In these cases, mobile combat and uncertain supply produce both tactical and operational strain. Effective combat reconnaissance, and a willingness to reformulate goals and means and reorganize battle groups, are all important in confronting that strain.[13] However, employing an argument in favor of flexibility (and notably mobility) in order to advance the case for particular weapon systems, including the tank, is less appropriate. In part, this is a consequence of the very unpredictability of the tasks that may be confronted. Flexibility at the systemic level does not necessarily mean such flexibility at that of individual units and vice versa.

Indeed, this issue becomes more of a problem with costly items that are available in limited numbers, with their use therefore being a problem. As with aircraft, the peak numbers of World War II cannot be repeated. The rising cost per unit raises questions of obsolescence and also affects the flexibility of tanks. Sir Peter Luff, British minister of defense procurement from 2010 to 2012, has observed, "My prejudice about tanks is that they are only really valuable if they are available in mass. If you can't afford mass, stick to attack helicopters."[14]

At the same time, their capabilities and roles are different, and in missions other than the conventional high-intensity battle, tanks—protected weapons platforms with good sensors and considerable resilience—are most welcome, even if large numbers are not available. Furthermore, attack helicopters, which were initially designed to stop massed tank attacks, are costly and require more training and infinitely more logistical support and maintenance.

Another aspect of compromised flexibility arises from the complex logistical burdens posed by tanks, notably in terms of providing fuel and maintenance. Modern tanks can have a large fuel capacity. Thus, the British Challenger 2 has a fuel capacity of 350 gallons. However, tanks can use up to a gallon per mile. Moreover, resupplying their needs not only is a formidable burden involving much manpower but also requires dumps that need protection. Such issues, in particular, compromise the viability of heavy tanks.

Yet it was not only heavy tanks that faced problems as the Americans and British discovered in Iraq after their success in the 2003 invasion. British Challenger 2s took damage from IEDs. The threat to all vehicles from ambush, notably by IEDs, car bombs, and suicide bombers, is such that it is important to prevent the enemy from approaching and engaging.[15] To this end, armor can only achieve so much. Instead, surveillance, firepower, command, and tactics are all important—both by the armor and by cooperating units, including not only infantry but also aerial.

The vulnerability of vehicles to ambush, and thus the relative compromising of effectiveness, has important tactical consequences, notably so if the number of tanks is limited, as was the case in 1916–18 and is again today. Moreover, that will probably remain the case unless there is a process of miniaturization. Yet, just as the antitank gun did not make tanks obsolescent, so also with antitank missiles, IEDs, and other modern weapons. Indeed, there are remedies against the effectiveness of antitank weapons, notably electronic countermeasures, as on the new Polish PLO-01 stealth tax, a fifth-generation MBT; as there were not on behalf of cavalry against machine guns, bar transferring to tanks. Separately, there is also a greater range of armor thanks to the opportunities provided by lighter-armored vehicles, whether tracked or wheeled. These opportunities include those of cost, but they do not negate the value of main battle tanks as a component of an effective system for land fighting, especially if enhanced with new capabilities, notably autonomous systems.

These points revive some of the debates about tank use in the 1920s and 1930s, as well as underline the adaptation seen in the history of the tank. At the same time, broader questions of doctrine, usage, and the cultural dimensions involved in both, especially the latter, are highly significant in effectiveness and, thus, capability.[16]

NOTES

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TEN

CONCLUSIONS

THE SCENE OF THE BEATLES DRIVING ACROSS SALISBURY PLAIN IN a Centurion tank, in their 1965 film *Help*, is not generally regarded as part of the cultural impact of the tank, and neither is James Bond commandeering a T-55 (with some additional armor) in what purports to be St. Petersburg in *GoldenEye* (1995). Indeed, tanks are regularly portrayed as images of state power, as with the depiction of President Putin atop one. Margaret Thatcher in the turret of a Challenger 1, scarf flowing, goggles on, while visiting British troops in West Germany in 1986 was one of the most iconic pictures of her and clearly underlined the cultural connection between tanks and power in the British popular imagination. She fired a practice shell using laser targeting to hit the target (an old tank) directly. Thatcher was accompanied by West German chancellor Helmut Kohl, who also test-drove a Leopard and fired a shell. Running for the US presidency in 1988, in contrast, George Dukakis got it totally wrong when he posed, at a campaign stop at the General Dynamics Land Systems' plant in the Detroit suburb of Sterling Heights, in a M1A1 Abrams tank pretending to be something he was not.

References to tanks are widely diffused. The phrase "parking tanks on the lawn" in Britain means bringing undue influence to bear and has been used frequently since the 1960s. As Labour prime minister and then in a bitter dispute over trade union legislation, Harold Wilson, in 1969, allegedly told Hugh Scanlon, president of the powerful Amalgamated Union of Engineering Workers, to "get your tanks off my lawn."[1] The London *Times* of May 4, 2019, referred, in an article headlined "Crowing Lib Dems Park Their Tanks on Rees-Mogg's Lawn," to local council results that led to the Liberal Democrats representing, at the local level, the Conservative parliamentarian Jacob Rees-Mogg. There was no reference in the article to tanks.

And not only that phrase and image. In a comment piece in the *Sunday Times* on April 14, 2019, Niall Ferguson, a prominent historian, argued, "The present danger to free thought and speech is not Red Army tanks pouring through the Fulda Gap in Germany; it is the red army of mediocrities waging war on dissent within academia and the media."

There is always a danger in reading too much from isolated mentions and episodes and still more from a particular vision of the present character, and future trajectory, of modernity. To argue the obsolescence of the tank from the growing success of antitank weaponry, or the primacy of unarmored or less armored vehicles, is possibly to draw too much from the present situation. Separately, it is clear that it is necessary to have a broad definition of the capability not only of tanks but also of less armored military vehicles. Aside from the specifications of the weapon, it is instructive to consider the degree to which an effective industrial base is significant for their manufacture and availability and also to assess the availability of oil necessary to permit the deployment and use of this type of weaponry. Moreover, technological reliability and competence in its use are crucial to the effective utilization of any military technology. Reliability includes the provision of supplies, notably gas and oil. Tanks were not alone in this, but mechanization accentuated, as well as transformed, the logistical demands of war. A key element of the Cold War was that both sides were able to provide plentiful supplies of fuel, and this ability underpinned the gigantic tank fleets. The United States and the Soviet Union were among the world's leading oil producers.

In contrast, during World War II, the Germans were heavily reliant on horses.[2] However, for propaganda reasons, they did not wish to show this.[3] This is not emphasized by most popular historians. Instead, the theme of German quality continues to be offered by some writers—notably, in Britain, Max Hastings—who generally do not devote comparable attention to German failings.[4]

Such points are not simply "academic" but have an obvious present-day (and historical) policy relevance. This is understandable given the tendency to use military history as a building block for doctrine. Moreover, in a less focused, yet still highly influential, fashion, there is the establishment of a military culture and organizational coherence based on experience or at least on an account of the past—particularly, in terms of current weapon systems, of the recent past. The latter characteristic has been very much the case with tanks, although there is no inherent reason why a deeper history of mobile warfare should not also be relevant.

The focus on tanks has resulted in an emphasis on the experience, or rather perception, of World War II and the Arab-Israeli wars. The former led the US army from 1945, confronting the prospect of facing apparently imminent and large-scale Soviet attack in Western Europe, to consider the example of the Wehrmacht when defending itself against the Soviet Union in 1943–45, and the US military repeatedly sought advice from German generals.[5]

That was not the sole experience of significance. Indeed, some of those offered at the time of World War II remain of general relevance. The draft report of 30 Corps, part of the British Eighth Army, dated November 21, 1942, reflected on the recent victory over the Germans and Italians at El Alamein: "The operations proved the general soundness of our principles of training for war, some of which had been neglected during previous fighting in the desert. In all forms of warfare, new methods should never disregard basic principles. The operations involved a reversion, with the difference due to the developments in weapons, to the static warfare of the war of 1914–18. This reversion should not be regarded as an isolated exception unlikely to recur . . . our organisations and weapons must remain suitable both for mobile and periodical static operations."[6]

Thus, alongside their value, tanks could not transform the context or, indeed, nature of conflict. They could play a role in "static operations," notably providing firepower in the attack and offering support for defending forces, including in the shape of counterattacks. However, tanks were clearly better suited to the role of mobile operations, at the same time depending on artillery and infantry support in the latter. Indeed, on September 27, 1950, Stalin complained about failures on the part of the North Korean army and its Soviet advisers, notably, "erroneous and absolutely inadmissible tactics for tank use in combat . . . you have used tanks in combat without preliminary artillery strikes aimed at clearing the field for tank maneuvers. As a consequence, the enemy easily destroys your tanks."[7]

More generally, tanks contributed to effectiveness, rather than transforming it, and, more particularly, provided a new dimension of mobility to the notion, seen in World War I and used with great effect by the Allies in late 1918, that all maneuver was to be determined by and linked to the fire plan. A very different dimension of mobility was provided by aircraft.

At the same time, there were important general-purpose advantages in the use of tanks, notably in the shape of the force and presence in part available from the equation of force equals mass times acceleration. An observer of the unsuccessful 1944 Warsaw uprising noted the effective German use of tanks:

"The first barricades, temporary, wooden, weren't worth anything. The tanks rode right over them . . . barricades. And right away those tanks rode over them . . . the Germans were arresting people and herding them in front of the tanks against the partisans."[8]

Tanks are part of the more general synergy between resources and fighting quality. More and better weapons themselves are not sufficient to obtain victory. They can increase fighting quality, including by enhancing confidence and morale. Conversely, such weapons can also compromise this quality, notably by encouraging a misguided confidence in the weapons themselves or by leading to tactics in which there is a reluctance to close with the enemy for fear of affecting aspects of the weapons' performance. Indeed, the relationship is that, instead of more resources increasing fighting quality, better fighting quality can make a more effective use of resources. This implies that forces with superior fighting quality will benefit disproportionately from enhanced (in both quality and quantity) resources. In the absence of such resources, nevertheless, forces with superior fighting quality can use this fighting quality to lessen, indeed sometimes close, the capability gap.

Yet, whether or not there are superior resources, it is highly important to put a strong emphasis on training, for that is the crucial basis for the successful use of tactics, the implementation of doctrine, and the development of fighting quality. Thus, for the British in World War II, the training regime in 1941–44, notably on Salisbury Plain, focused on differing assumptions about tank doctrine, including that gained from combat in North Africa, and was important to subsequent performance, particularly once France was invaded in 1944.

At the same time, capability gaps owe much to tasking and to whether it was appropriate and/or viable in a context made dynamic by the strength and intentions of others, including allies as well as enemies. Thus, the state of the British army vis-à-vis Germany in 1939–40 was in part due to the British government's hesitation about confirming that land forces would be sent to the Continent until soon before the war began. In part, this hesitation reflected the highly dynamic character of British strategic commitments in this period, a dynamic character that was a consequence of a rapidly changing and unpredictable international context.

Tanks themselves have many limitations, and these remain the same ones that have existed from the outset. They face particular problems with reliability and vulnerability. In the former case, despite their cross-country capabilities, tracked vehicles tend to be less easy to operate and maintain than their wheeled counterparts and require more maintenance and fuel. Moreover, the tracks provide a ready area of vulnerability to attack. This vulnerability, part

of the more general issue of exposure to weaponry, including in ambushes, has become more pronounced as more people live in cities, which have become a more significant area of operations. As a consequence, the potential for antitank weaponry is enhanced. The latter continues to evolve and is far less expensive and easier to use than armor. In the 2010s, more tanks were destroyed by antitank weapons than by other tanks. Emphasizing combined arms operations as a means to protect tanks does not, however, deal adequately with the challenge of this environment.[9] As another aspect of this challenge, tanks continue to play a key role in infantry support, which also exposes them to antitank weapons.

From a different direction, given the potential for antitank tactics and weaponry, tanks can be seen, in one light, as another version of cavalry and as similarly anachronistic or, at least, vulnerable to developments in firepower. Separately, cavalry ideas in the shape of the organizational and tactical structures and practices were long significant to armor, including in Britain and the United States, with an emphasis on reconnaissance and armor in a maneuver role, not a combat-support one. The latter issue was very much seen in the debate over new challenges and tasks and capabilities after the end of the Cold War.[10] Complicating it was the question of cost, which is far greater for tanks than for other armored fighting vehicles, whether in terms of purchase, maintenance, or supply.

Tanks provide firepower and protection, but the last has been lessened by the ease of the relevant antiweaponry. That critique, however, is not a reason to dispense with tanks. This is not only due to the value of existing capabilities but also because the nature of conflict is unpredictable, and, as with battleships in 1941–45 in the face of air power, while other powers have tanks, it is sensible to have them as a form of tank killer. They will also continue to provide protection for infantry, protection that is necessary in both urban and nonurban contexts.

The lightness of many US wheeled units, notably armed with Strykers, including those up-gunned with a new 30 mm automatic gun, indicated that the US army hoped the next war would be in an urban environment with light units, rather than a "tank war." However, the experience of 2004 on, whether in Iraq, Afghanistan, Lebanon, Syria, or elsewhere, made clear the value of more strongly armored vehicles. Moreover, choices are in part more effective by the acts of opponents, both in terms of this particular environment and with reference to others—for example, rural Eastern Europe, where Russia has to be confronted. Aside from standard protection issues, the Stryker also faces other issues as, like other "connected" combat systems, its processes can be hacked.[11]

Yet if you put a big gun on the top of a light armored vehicle, as with the German-Dutch Boxer, in service since 2011 (and with Britain rejoining the program in 2018), there is a question of whether tracked tanks are required. Such a vehicle cannot give you protection anywhere near that of a tank, but it is still pretty good, and the vehicle can have great tactical mobility and, therefore, operational and strategic value. The six-wheeled Boxer has remarkable off-road mobility. An earlier instance, the Brazilian Engesa EE-9 armored car, with its 90 mm gun, was an effective and inexpensive vehicle produced between 1974 and 1993 that was widely sold and is still in use.

The discussion of current options certainly casts a harsh light on J. C. Fuller's sweeping optimism in his *Tanks in the Great War* (1920), which was not a slim essay or printed lecture. Fuller was a deep thinker, an excellent writer, and a skilled military historian, but, like many other theorists, he could be overly confident in his predictions. Written the previous year, the book had closed with a chapter forecasting what tanks might do. After arguing that the introduction of the tank "entirely revolutionises the art of war," not least by replacing muscular energy as the motive force, a point he frequently made, Fuller claimed that weapons were the key element, indeed, "99 per cent," in victory. He argued that tanks' cross-country capability made the land an isotropic surface for conflict "as easily traversable in all directions by a tractor as a sheet of ice is by a skater"—a parallel, not that he brought out the point, with aircraft. Fuller also claimed that the potential would greatly and rapidly improve. Fuller predicted a speed and maneuverability for tanks they have not yet reached and, more seriously, thought little of the prospect of opposition.[12]

Just as modern commentators and the modern public look back in order to ground the discussion, the same was true for those considering the situation, including the future, in 1920. While focusing on World War I, Fuller also considered British failures in 1879–85: the battles of Isandhlwana (1879), Maiwand (1880), and El Teb (1884) and the failed relief of Khartoum (1885), defeats at the hands of the Zulus, Afghans, and Sudanese respectively. Fuller (wrongly) claimed that a tank could have covered in two days the 180 miles to Khartoum that took twenty-one days in 1885 and that "One tank would have won Maiwand, Isandhlwana, and El Teb . . . one tank, costing say £10,000 can not only win a small war normally costing £2,000,000, but render such wars in the future highly improbable if not impossible." Fuller had similar views on a successful invasion of Afghanistan from Peshawar on India's North-West Frontier, which would have been a major commitment, not only in the nineteenth century. Such an invasion was an option for Britain in the Third Anglo-Afghan War, that of 1919:

> Armour, by rendering flesh impervious to bullets, does away with the necessity of flank guards and long straggling supply columns, and our punitive expedition equipped with tanks can reach Kabul in a few days, and not only reach it but abandon its communications, as they will require no protection . . . tank supply columns . . . are self-protecting. . . .
>
> From small wars to internal Imperial Defence is but one step. Render rebellion hopeless and it will not take place. In India we lock up an unremunerative army 75,000 British troops and 150,000 Indian. Both these forces can be done away with and order maintained, and maintained with certainty, by a mechanical police force of 20,000 to 25,000 men.
>
> . . . war will be eliminated by weapons.[13]

From the perspective of 2020, Fuller's prediction appears naive, and doubly so due to the problems that faced first Soviet and then US-led interventions in Afghanistan (the country of Maiwand as well as Kabul) from 1979, as well as the difficulties of controlling Sudan (the country of El Keb and Khartoum). Aside from exaggerating the developing capability of tanks, Fuller, like many commentators, seriously underplayed that of antiweapons. Capability became in part a matter of confronting and overcoming the latter, but the initiative and advantage were far less with the tank than had been anticipated. Although the antitank potential of other tanks is significant, it is less than that of other weapons, a situation that has developed greatly due to the use of "smart bombs."

The major problem with Fuller's analysis and projections, however, was not so much the specifics, seriously misleading as they were, but rather the developmental assumptions away from people and toward machines. This was a repeated theme of Fuller's; indeed, he suggested that, eventually, one man might win a war as their controller.[14] Linked to this was his clear idea that the future brought change to a degree that the past was redundant.[15] This is an instance of the notion of a paradigm shift or, phrased differently, a "Revolution in Military Affairs." The emphasis on modernity and modernization was that also seen with air power, but the comparison does not demonstrate the validity of Fuller's approach, and, certainly, antitank weapons and methods proved more viable than their antiaircraft counterparts.

Viability is related also to cost and flexibility. The extent to which the limitations of heavy tanks on both accounts reduced, and still reduce, their value was and is not always brought out by the discussion of specifications, let alone considerations of combat effectiveness. Moreover, Fuller was seriously flawed in his pursuit of misleading parallels and analogies: "The cross-country tractor, or tank, widened the size of roads to an almost unlimited degree. The earth becomes a universal vehicle of motion, like the sea, and to those sides which relied on tanks, naval tactics could be superimposed on those of land warfare."[16]

That claim might be regarded as simply an exaggeration if the perspective was the Kuwaiti desert, but it was wrong as far as most terrain was concerned and remains so. There was also Fuller's misleading pseudoromantization of the Tank Corps: "the modern knights in armour . . . his horse now a petrol engine and his lance a machine gun."[17] Again, there was a parallel with aircraft pilots.

Although deeply flawed, Fuller's arguments continue to resonate with advocates for armor. Thus, a 2011 *RUSI* article, considering how "radical technological change has revolutionised warfare," provided an excerpt from Fuller's 1919 Gold Medal (Military) Prize—"we stand on the threshold of a new epoch in the history of war—the petrol age . . . we see that the tank can replace infantry and cavalry, can supplement artillery." The anonymous note from the journal claimed that Fuller had "quickly grasped the possibilities. . . . Ultimately it would be German officers . . . who would most swiftly adopt many of the ideas Fuller developed, and use them to devastating effect in the Second World War."[18]

So also with the claim, often made, that Fuller's understanding of both the tank and operational art were not appreciated by a hidebound and unscientific British army.[19] This was, and remains, a misleading characterization of a force that, having played a key role in the defeat of the German army in 1918 (akin to the Soviet role in 1944–45), was then translating to a range of distant and difficult commitments, from Russia and Ireland to British Somaliland and Iraq.

None of the argument by, or on behalf of, Fuller helped with a balanced assessment of the achievements and potential of armor, whether at the tactical, operational, or strategic levels. That remains the case, even if the fascination with the tank is generally now more circumscribed as the constraints within which it can act are better appreciated and the relative cost-benefit attraction of other weapon systems are considered. These shifting contexts provide a background for the need to bring into balance defense (armor), offense (gun), and mobility while, additionally, as for all weapon systems, effective mass production and easy maintenance and operability are also important, as in the T-34. Yet other specifications were also important. Thus, the Israeli Merkava emphasizes defensive ones because Israel can ill afford using tank crews. At the same time, the military restructuring plan approved by Israel's Knesset (parliament) in 2013 proposed a reduction in tank numbers as part of a move toward a lesser reliance on ground forces and a shift toward operations from the air.

However defined, the tank is far more than simply a legacy system of the 1910s or, indeed, World War II. Nevertheless, the future of the tank is unclear, and its limitations, vulnerabilities, and costs are readily apparent.

NOTES

1. Scanlon later claimed that he never heard this from Wilson's lips. See also N. Farage, "UKIP: We Are Parking Our Tanks on Labour's Lawn," *Guardian*, September 27, 2014; C. Arthur, "Why Google Is Parking Its Tanks on Microsoft's Lawn," *Guardian*, July 8, 2009.

2. R. L. DiNardo, *Mechanized Juggernaut or Military Anachronism? Horses and the German Army of World War II* (Westport, CT, 1991).

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4. For example, review in *Sunday Times* of book by Jonathan Fennell on March 31, 2019.

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17. Fuller, *Tanks in the Great War*, ix, 306.

18. J. F. C. Fuller, "The Application of Recent Developments in Mechanics and Other Scientific Knowledge to Preparation and Training for Future War on Land," *RUSI* 65 (1920) and Anon., "Military Technology and the RUSI Journal," *RUSI* 156 (2011): 114, 118.

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