

Tank design

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Academic integrity declaration

I declare that:

- the report submitted has been written by me alone.
- the report submitted has not been previously submitted to this university or any other.
- that all content, including primary and/or secondary data, is true to the best of my knowledge.
- that all quotations and references have been duly acknowledged according to the requirements of academic research.

I understand that to knowingly submit work in violation of the above statement will be considered by examiners as academic misconduct.

Abstract

This report the evolution of tank design will be examined from its conceptual origins to its present-day role in warfare. Following conducting desktop research- It is proposed that tank development has been driven by the continuous technological innovation and the change in tactical demands. Early designs in the First World War, such as Little Willie and the Mark I, emerged as attempts to break the stalemate of static trench warfare, yet suffered from severe mechanical limitations, poor visibility, and minimal protection. The Second World War saw Britain encounter issues with fragmented doctrine which heavily impacted their ability to respond to Germany's integrated, mobility-focused Blitzkrieg, which exploited communication, speed, and combined arms to achieve rapid encirclement.

Post-war advancements culminated in modern main battle tanks such as the Challenger 2, which integrates the "iron trinity" of firepower, mobility, and protection through composite armour, advanced optics, and a 120 mm rifled gun. Contemporary conflicts, particularly in Ukraine, demonstrate that while tanks remain essential for protected firepower and ground-holding, they now operate in a multidirectional threat environment shaped by drones, precision munitions, and electronic warfare. Overall, this study shows that tank design continues to evolve in response to emerging threats, ensuring the platform's enduring relevance.

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1 Introduction

When thinking about the evolution of tank design the initial thought is often associated with World War I (WWI). However, the intellectual origin stems back from a lot deeper into history. In 1487, Da Vinci proposed the 'armoured car' which proposed the concept of combining armour, mobility and firepower into a singular system [1]. It had the capacity of holding 8 men and took inspiration from a tortoise with its conical shape [1] as seen in Figure 1, the slanted angle purpose was to deflect enemy fire. Da Vinci imagined the armoured car would be made from wood and then reinforced with metal plating and fitted with 16 cannons around the perimeter [2]. Essentially the design is a box mounted on top of a tractor chassis [2].

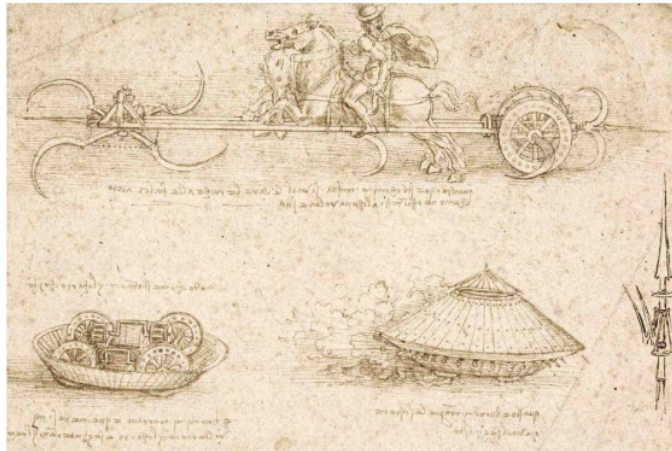


Figure 1 - Da Vinci armour car [2]

2 Early designs of WWI

The Idea of the tank was to protect the men from death and destruction whilst remaining invulnerable [3], which is not a new concept. In WWI the tank needed to be able to restore mobility and help to break the stalemate which occurred due to the static trench warfare.

2.1 Little Willie

In 1915, the design proposed by William Tritton and Walter Wilson famously known as Little Willie as seen in Figure 2 for the landship committee [3] was the first prototype which by design was a repurposed tractor on tracks which was never meant to go to battle. It had a top speed of 3.5mph with un-sprung suspension which made traveling cross country extremely slow [4]. The design did demonstrate the benefits of using continuous track opposed to wheels which would improve the mobility across trenches, shell holes and enemy wires.

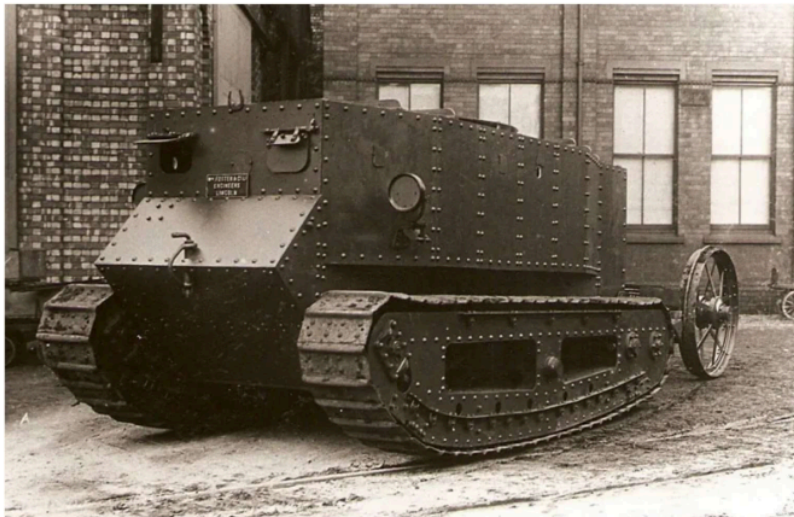


Figure 2 - Little Willie prototype [4]

From this design it was realised that the imported Bullock caterpillar tracks [3],[4] would result in Little Willie being difficult to manoeuvre due to the extended ground contact, causing them to sag and become detached [4]. This was due to originally being used on tractors this was not an issue with them lying flat against the ground [3].

2.2 Mark I

Even though the mark I was introduced after Little Willie, production began weeks after Wilson suggested the track run all the way around the vehicle [6] as seen in Figure 3; it is famously known in history as the “Mother” Tank. It was made up of nickel steel plating which was thickest at the front and thinnest on the belly [3]. The armour only had the ability to protect against enemy fire of a rifle not artillery and the engine would frequently overheat, tracks would break, shred or become derailed under stress similarly to Little Willie [6].

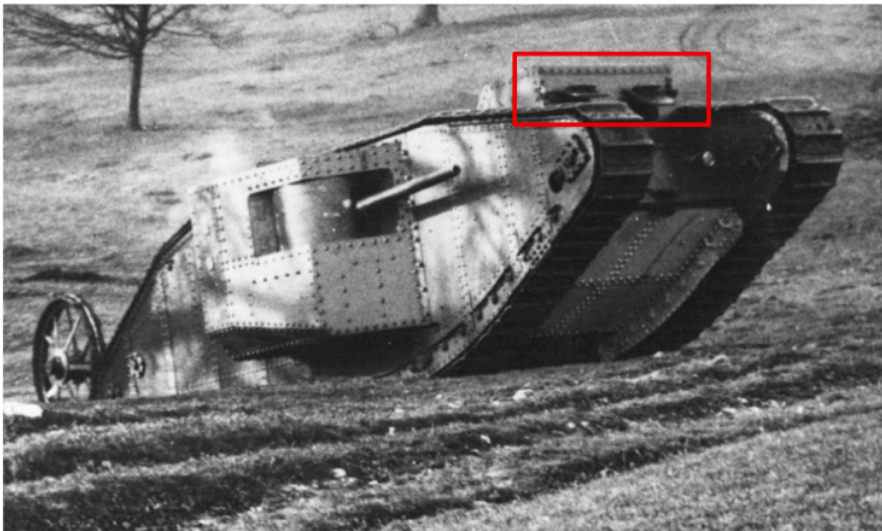


Figure 3 - Mark I Tank [3]

One of the major limitations of this design, are the slit like openings cut in the armour as highlighted in Figure 3. As a result, the crew had only a narrow tunnel-like view of the battlefield, severely limited situational awareness which made

navigation difficult. There were also attempts recorded for landships, all of which had wheels - it was quickly realised that the size of the wheel to achieve enough ground contact to pass over the top of the trenches would be impractical, which is illustrated in Figure 4 [11].

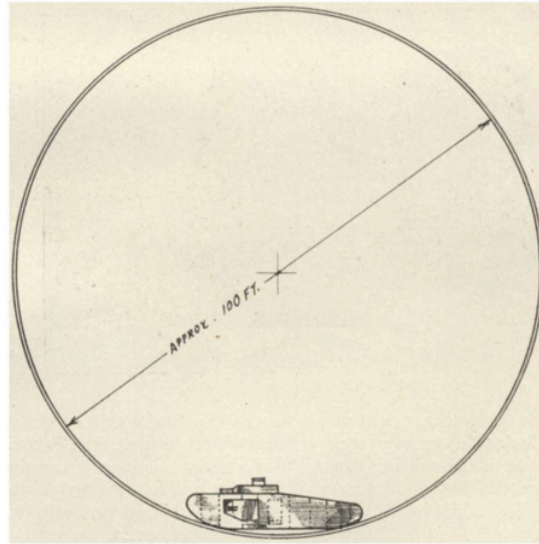


Figure 4 - Ground comparison [11]

2.2.1 Renault FT

The Renault FT Figure 5, designed by Louis Renault, revolutionised tank design in comparison to the British tanks of its time and is widely regarded as the first modern tank. Just under 3000 were produced between 1917 and 1918 with a top speed of 4.6 miles per hour [7], the innovative design was a combination of mobility, visibility, and a fully rotating turret. It became the template for all future tank design [8] and is known for being greatly feared by enemy against enemy troops.



Figure 5 - Renault FT Tank [7]

3 British vs German approach in World War II (WWII)

In WWII, British forces entered the war with two tank design variations which caused strain on industry resulting in production being rushed, causing issues with reliability- 200 were ordered without even receiving a prototype [10]. The split in design requirements meant that British troops were left poorly prepared at the start of the war due to the conservative approach of the government, because the doctrine neglected utilising tank - infantry cooperation.

This differs from the German approach as the focus on effective integration of communication and firepower- Their tank design featured less variation and focused on making sure their tanks were capable of fast penetrating manoeuvres such as the Blitzkrieg tactics. Fig. 6 is a visual comparison of the differences in the approaches that were adopted by the opposing forces.

<u>British approach</u> • Cruiser tank - faster and lighter armour [3] • Churchill Infantry tank - slower with heavier armour [3] • Conflicting design requirements • Issues with reliability and inconsistent performance • Neglected tank/ infantry cooperation [9]	<u>German approach</u> • Focused on fewer design variations • Emphasised on high velocity guns, armour and speed[10] • Integrated radios contributed to the success of blitzkrieg tactics • Production was influenced by strategic shortages • Expensive and time-consuming manufacturing process
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Figure 6 - Approach comparison

4 Churchill I

It was apparent from the introduction of the Churchill I seen in Figure 7, lessons were not learned from WWI, as production was again rushed. This resulted in multiple mechanical issues. The primary role of the Churchill I was close infantry support, designed with thicker 102 mm armour at the front [12], with the ability to tackle the difficult terrain, opposed to speed, as it was only able to reach 8 mph cross country.



Figure 7 - Churchill I Tank [13]

The Churchill tank was known as one of the toughest tanks within allied forces; even though it was slow, it was able to navigate trenches effectively, addressing issues from WWI. A limitation of the design was its 2-pounder British anti-tank gun, which proved to be outmatched by the superior German tanks at the time [11].

5 Blitzkrieg encirclement

The concept adopted by German doctrine was based on the realisation that the combination of firepower, protection through armour, movement speed and communication could be utilised to penetrate weak points in the enemy lines [14]. Figure 8 depicts the different phases of the Blitzkrieg tactics and how these were utilised to exploit weaknesses behind enemy lines.

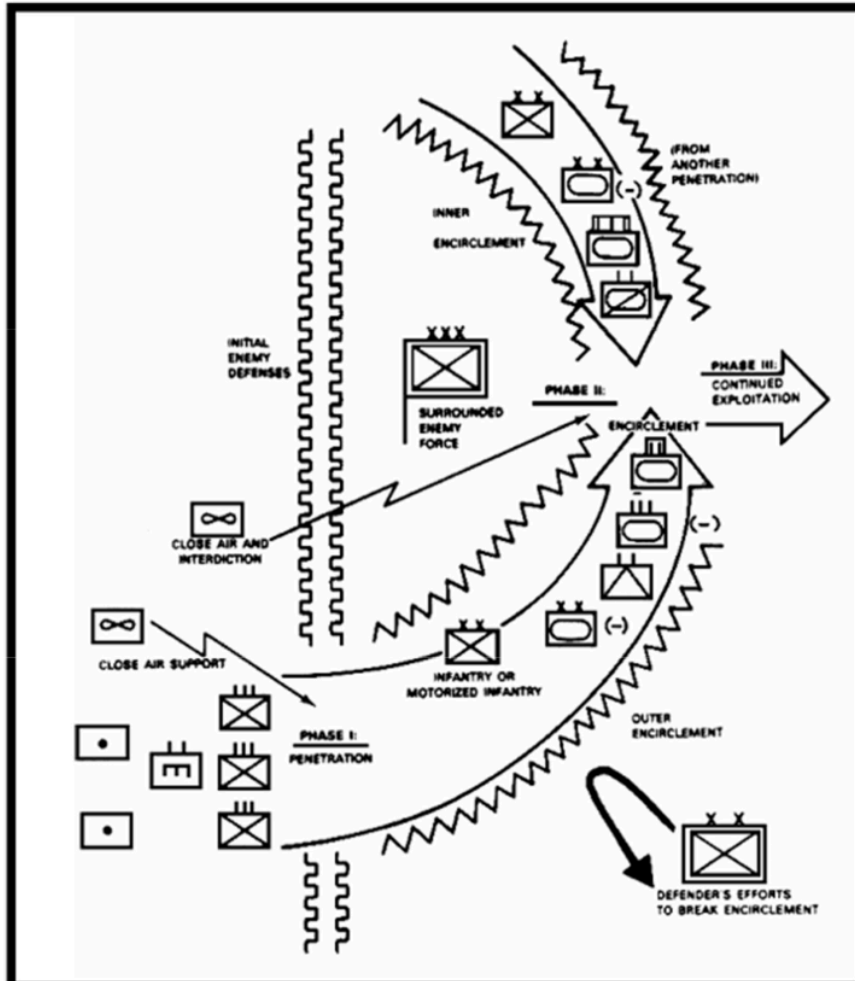


Figure 8 - Blitzkrieg tactics [14]

Table 1 outlines the three sequential phases of the manoeuvre, showing how each stage contributes to the progressive isolation, encirclement, and eventual collapse of the enemy force.

Phases	Function
Phase one	Demonstrates how the infantry would advance towards the enemy line accompanied by close air support to strike the enemy position
Phase two	Forces closely circle the enemy, followed by friendly forces that also encircle the enemy, acting as a reinforcement, cutting them off from supplies and communication.
Phase three	Continued exploitation where advances continue deep into enemy territories. This caused disruption in the enemy forces, resulting in rapid collapse and due to the British failing to implement radios into their tanks meant the lack of communication meant they were unable to recover.

Table 1 - Blitzkrieg tactics [14]

6 Modern-day tanks- Challenger 2

The Challenger 2 seen in Figure 9 entered British army service in July 1995 and was originally manufactured by Vickers Defence Systems, which is now BAE, and its main armament was the unique 120 MM L30A1 rifled gun [15]. The modular ammunition allowed for the older L11 rounds to still be fired [16]. The Challenger 2 is a capable platform as it has a clear balance of the 'iron trinity', which is the combination of protection, firepower and mobility capabilities [18].



Figure 9 - Challenger 2 [17]

The Chobham composite armour [15] was a significant improvement to its predecessor, allowing the platform to encompass survivability as well as firepower. More advanced fire controls and improved sight of the commanders allowed the gunner to be more efficient and effective at finding targets and neutralising the threat with munitions such as High Explosive Squash Head (HESH) rounds. A Hesh round flattens explosive against a target and detonates to send shockwaves through the armour, causing deadly internal spall rather than penetrating directly [21].

7 Impact of tactical developments

World War I was defined by static linear trench warfare, which created a stalemate which, partnered with unreliable Mark I tanks, caused issues with an unreliable frontal assault [4]. By World War II, rapid technical advancements enabled far greater mobility and the development of combined-arms operations, allowing German Blitzkrieg tactics to achieve fast manoeuvre and encirclement of Allied forces. In contrast, modern warfare has evolved into a multi-dimensional battlespace that leverages precision-guided munitions, advanced surveillance, and integrated domains, while new technologies such as nuclear weapons, cyber warfare, and unmanned drones have expanded both the opportunities and threats faced by contemporary militaries.

8 Comparison in designs

The table below shows how tank design evolved from WWI to the modern era by comparing the Mark I, Churchill, and Challenger 2. The WWI Mark I had extremely limited mobility, thin armour, and basic armament, reflecting early experimentation with armoured warfare. By WWII, the Churchill demonstrated major improvements, with thicker armour, better climbing ability, and more effective guns, though still relatively slow. The modern Challenger 2 represents a fully developed main battle tank, with high speed, advanced composite armour, digital survivability systems, and a powerful 120 mm rifled gun, highlighting the dramatic progression in mobility, protection, and firepower over time.

	Mobility	Survivability	Armament
WWI- Marks I	• Max speed 3mph [3] • No suspension • Prone to overheating	• Armour thickness 6-12 mm [3] • Poor visibility	• 6-pdr naval guns / Machine guns [6]
WWII- Churchill	• Max speed 9mph • Improved climbing capability [3]	• Armour thickness • 152mm (turret and hull front) 95 mm sides [13] • Improved optics	• 2-pdr/ 6-pdr naval guns [12] • 75 mm tank gun
MBT- Challenger 2	• Max speed 30mph [15] • Capable of rapid acceleration and complex manoeuvres	• Composite armour • Thermal imagers • Laser warning receivers [16]	• 120mm rifled tank gun – approx. barrel life 450 rounds [18]

Table 2 - Tank comparison

9 Impact of the introduction of drones

The introduction of drones in modern-day conflicts in Ukraine has forced tanks to operate differently due to the threat from the enemy now being multi-directional. This has meant adaptations were required to the external armour (an example of this is shown in Figure 10). This change occurred following anti-tank missiles being dropped directly from above the tank, exploiting the weaknesses in the armour [20]. By 2023, First-Person View (FPV) drones improved strike accuracy on mobile targets by 70% [19].

The use of drones has become a central part of the Ukrainian army's strategy to defend itself, aiming to mass-manufacture 1 million FPV drones alongside 10,000 strike drones in 2024 [19], demonstrating the rapid acceleration of front-line drone- intensive warfare,



Figure 10 - Ukrainian Tank [20]

The M1 Abram tank, which had been utilised in 2023 without sufficient armour, resulted in multiple tanks being lost. Troops quickly realised that the addition of anti-drone netting (as demonstrated in Figure 10) and also reactive armour, which would explode on drone impact whilst minimising the damage to the tank [19].

The trench-style warfare being experienced in Ukraine demonstrates a high-intensity conflict that differs drastically from the counter-insurgency style war experienced in Afghanistan and has heavily influenced the design requirements for the tank as a platform. Even though the threat and role of the tank as a system have changed, they are still extremely useful to deliver heavy protective firepower for infantry support, urban assaults and maintaining their position. However, it is important to note that tanks are left vulnerable to legacy threats such as landmines in conjunction with the proliferation of drones capable of hunting down individual soldiers [20].

10 Conclusion

The evolution of tank design reflects throughout history highlights the impact of technological advancements on doctrine and tactical necessity. From the First World War, the first prototype Little Willie confirmed the mechanical feasibility of producing an armoured vehicle and it was no longer a theoretical proposal to help aid the stalemate of trench warfare. Even though the first designs had limited mobility, multiple mechanical issues and poor visibility highlighted in Figure 3 demonstrated their potential in becoming an effective platform.

By WWII, divergent national doctrines shaped tank development in markedly different ways: Britain's fragmented approach contrasted with Germany's integrated, mobility-focused Blitzkrieg, demonstrating how communication, speed, and combined arms could transform armoured warfare. Post-war advancements culminated in modern main battle tanks like the Challenger 2, which embody the "iron trinity" of firepower, protection, and mobility through composite armour, advanced optics, and highly effective armament.

Contemporary conflicts, particularly in Ukraine, highlight that while tanks remain essential for delivering protected firepower, supporting infantry, and securing ground, their operational environment has fundamentally changed. The proliferation of drones, precision munitions, and multi-directional threats has forced tanks to operate within a wider, multi-domain system rather than as independent manoeuvre assets. Ultimately, this report demonstrates that tanks have retained their relevance not through static design, but through continuous adaptation to emerging threats and tactical realities, ensuring their enduring role on the modern battlefield.

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Tank design

GRADEMARK REPORT

FINAL GRADE

72/100

GENERAL COMMENTS

Hi Ellie,

This was a great assignment, marred a little by a few grammatical errors throughout. As you move up the Levels to Level 6, please ensure that you get a peer review from a colleague or line manager.

Overall, you clearly understand the concept of technical authoring and the technical report was suitably supported by useful figures and tables that enhanced the story you were telling. This is a 1:1 submission, where marks were principally lost on the grammatical errors.

In detail:

1. A few grammatical errors throughout. Try and get a peer review. For example, "This report the evolution....." is not structured well, and in the following sentence you have research - It.....This is not a correct sentence, so in the first two lines of your abstract, you have two errors. Also which heavily impacted..... No need for a capital on impacted. In section 2 we have The Idea.....

2. Aside those observations, the abstract is good, drawing the key conclusions from your report.

3. Sensible structure, with excellent use of figures and tables. All captions and cross references applied correctly. Very technical authoring, well done.

4. I very much liked the intellectual origins taking us back to Da Vinci.

5. Section 2.1 - sage and decom detached?

6. Excellent explanations of the pros and cons of the WW1 tank designs. Imagery entirely appropriate and annotated to reflect the paragraph descriptions.

7. Loved figure 6, what an excellent comparison to summarise your discussions. Communication and simple design were the key. Which do you think the British should have focused on - the Cruiser or the Churchill?

8. Figure 8 very relevant, again well done. I'm glad you put Table 1 in as I was just going to ask for a description of the phases.

9. You described several OME concepts within the submission and demonstrated you understand HESH as well as AP.

10. Excellent section on impact and comparison. Table 2 was the icing on the cake, allowing me to visualise the journey of the holy trinity.

11. Interesting section on drones. Is this the end of the tank as a force multiplier on the battlefield? Will the tank need its own anti drone drones?

12. Excellent conclusion and well referenced, demonstrating a significant amount of independent study. You also addressed the comments raised in the presentation, so well done.

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