"TWO WAYS TO BUILD A BETTER MOUSETRAP"
RUSSIAN AND AMERICAN TANK DEVELOPMENT DURING WORLD WAR II,
AN EXAMINATION OF THE PARALLEL DEVELOPMENT OF THE T34 AND THE
M4 MEDIUM TANKS AND THE DOMESTIC INFLUENCES ON EACH.

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ABSTRACT

During the majority of the 20th century the tank has been the dominant weapons system of land combat. The two most produced, and possibly the two most influential examples of this type of weapon were the T34 Medium tank, designed in the Soviet Union and the M4 Medium tank, designed in the United States. Both tanks were produced in incredible quantities; largely sacrificing marked technical improvement in favor of continued high-rate production. The central focus of this thesis is an examination of the developmental and production histories of these systems including the doctrinal, cultural and political factors influencing them. These, non-technological influences are critical because they had as direct an effect on the vehicles that were produced as technological advances. The comparison of the systems themselves reveals that they were very similar in terms of potential effectiveness, with each having their own advantages and shortcomings. From the comparison we determine that the M4 was superior to the T-34 in terms of firepower and survivability, counter to popular history. Clearly of more significance are the influences on each of the design and production processes and how they differed between the two nations. The Soviet T34 was a revolutionary design largely originated at the bottom of the hierarchical chain, by its design bureau. The American M4 was a doctrinally driven design, largely determined by
requirements articulated from the top, these disparities of origin run counter to conventional logic that would predict that, the centrally-controlled command economy of Soviet Russia and the independent spirit of American ingenuity would have caused the reverse to be true. What is clearly demonstrated is that each nation’s military and industrial “character” reflects in its product, with the American product being precisely and reliably made but only of adequate design, with numerous versions being produced simultaneously in order to satisfy all consumers and maintain production rates. The T34, on the other hand, was an incredibly innovative, but simple design built crudely and in huge numbers. Production was maintained by standardization and adhering to the basic, solid design until it could no longer compete with its German adversaries.
Dedicated to my wife Christine

and also to the tankers who fought for what they believed in using these vehicles.
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CHAPTER ONE

INTRODUCTION

During the majority of the twentieth century the tank has been the most dominant land-based, offensive weapons systems on the battlefield.¹ Modern conventional armies are normally built around mechanized formations equipped with large numbers of armored fighting vehicles (AFVs) and tanks. For the period, from the start of the Second World War until the present, two major powers, the United States and the Soviet Union/Russian Federation have dominated tank development. These nations have pursued very distinct and separate philosophies in the design, production and development of the tank; this has been, for the most part, consistent and in some respects reflective, of their national military, industrial character. This paper will examine these two competing design philosophies and their implications in the context of the T34 medium tank, produced by the Soviet Union and the M4 medium tank, produced by the United States. An analysis of the operational employment of these systems or the influence their performance had in this respect will not be undertaken in this study.

The parallel development of the American M4 Sherman and the Soviet T34 medium tank introduces us to many of the similarities and differences between the two

¹ Foss, “Jane’s Main Battle Tanks, Second Edition”, 5
country's tank development programs. It is not surprising that these two programs, occurring at roughly the same time and with a common opponent had some striking similarities. What is interesting is not only the closeness of some of these similarities but the divergent ways in which these issues were addressed. A surprising and counter-intuitive result of my research was to challenge the commonly held notion that the T34 was superior to the M4 Sherman. In a detailed examination, we will see that in many ways the M4 was the technically superior vehicle, offering better frontal armor, a more effective anti-tank gun and a much more "fightable" combat platform. This is to be expected taking into account the slightly later development of the M4 and should not obscure the revolutionary nature of the T34's design.

In order to compare these vehicles and their development, my primary focus will be the technical aspects of each followed by a more subjective examination of the military, industrial culture that effected their design, product improvement and production. This will be accomplished through a detailed examination of their development from concept stage through their various models and improvements ending with their final production models.

As with any combat system, tanks are designed as a series of compromises. These are generally in the areas of firepower, mobility and protection; I have added the area of communications due to its critical role in armored combat and modern maneuver warfare. By analyzing trends as to how each nation addressed these areas in vehicle design, the priorities and basic philosophy of each become more evident.
CHAPTER 2

T34 DEVELOPMENT

Early Development:

Soviet military doctrine of the mid 1930s called for large numbers of tanks, largely in the roles of infantry support and cavalry exploitation. The primary infantry support tank in the Red Army was the T26, essentially a locally-improved version of the British Vickers 6-ton light export tank while their primary cavalry tank was the BT series, a license built Christie tank. The Christie tank was named for its designer, J Walter Christie, an American engineer who incorporated into his tanks a suspension drive system combining conventional drive wheels and a caterpillar track. The tracks of these vehicles could be removed and the vehicle driven on its running wheels over prepared road surfaces, this had the combined benefit of increased speed and fuel efficiency. Additionally significant numbers of the heavier T28 medium tank, a multi-turreted 28 ton vehicle armed with a combination of machineguns and a 45mm main gun, were the mainstays of the Russian tank force prior to 1941.² Both the T26 and BT were eventually

armed with a very effective 45mm duel purpose gun\(^3\) and clearly outclassed most fielded designs of the day in fire power.\(^4\) The BT and the T26 performed well against German and Italian tanks in the 1936-1939 Spanish Civil War, but more importantly their experiences served to inform Soviet tank designers with practical lessons in what worked and didn’t work on the battlefield. From the fighting in Spain several critical lessons emerged; first, the importance of a dual-purpose gun that had the ability to effectively engage both infantry and armored targets. Second, the need for improved armor in order to protect against evolving anti-tank guns; finally, was the requirement to use diesel, rather than gasoline to fuel vehicles to avoid the highly combustible nature of gasoline.\(^5\) While gasoline is no more flammable than diesel fuel in liquid form, it is highly volatile, producing fumes, which readily explode when a fuel tank is pierced or ruptured.

In 1936, as the initial combat was taking place in Spain the Komintern Factory in Kharkov\(^6\) received a new chief designer, engineer M. I. Koshkin. Koshkin immediately went to work attempting to improve the BT series tank, however it was not until 1937 that the factory was officially assigned the task of designing a new cavalry or “fast” medium tank to replace the BT2s and T28s. This new tank, was one of three new tanks being called for, the other two being an infantry tank and a heavy tank, to modernize the expanding armored formations the USSR. Koshkin, started development from his

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\(^3\) The term “duel purpose” denotes the ability to be used effectively in both the anti-tank and infantry support rolls.

\(^4\) Ogorkiewecz, “Armor, A History of Mechanized Forces”, 225


\(^6\) Kharkov is located in what is presently Northwest Ukraine.
preliminary work improving the BT, incorporating the 45mm gun but he also added the sloped armor of the BT-IS developmental tank. Finally he retained the Christie wheeled-tracked driven hybrid suspension system; this combination resulted in the A20 experimental medium tank.

Figure 1: A20 Experimental Tank, 1939

The A20 was officially initiated with Government Resolution #94 that directed “the design and creation of an experimental version of a high-speed wheeled-tracked tank.... to be mass-produced by 1939”. In addition to its innovative drive system and 45mm gun, the A20 was the first “shell proof” tank, designed with sloped and thicker armor in order for it to be more survivable on the battlefield.

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7 All T34 photographs courtesy: Potapov, Valeriy Editor. “Russian Battlefield Webster”, [http://history.vif2.ru/] (7 March 2001)

8 USSR Government Resolution # 94, 15 August 1937, “Prototypes of the T34-76” [http://history.vif2.ru/t34_76_1.html]

9 “Shell proof” was a term used by Soviet military and design personal to describe a tank that was capable of surviving direct hits from the current anti-tank weapons then in use.
An additional developmental version, the A32, was produced with a conventional caterpillar drive track system that did not allow for the vehicle to operated without its tracks but retaining the Christie style suspension. The A32 had been up-gunned with a 76.2mm gun but in most other respects it was identical to the A20. Both vehicles incorporated revolutionary improvements in armor slope and mobility and the A32 in firepower due to the use of the 76mm gun. Both designs were presented to the Chief Military Council of the Soviet Ministry of Defense (MOD) in August of 1938. This meeting, chaired by Viacheslav Molotov and attended by Joseph Stalin was intended to select the vehicle to be further developed as the next Soviet “fast” tank.¹⁰ No selection was made at this meeting as to which design was to be pursued and further development of both was directed in order to determine which would prove superior. The lack of a decisive choice appears to be largely due to the influence of Stalin’s presence and input, the former causing an unwillingness to voice an opinion that might be counter to that of the Premier and the latter due to Stalin’s voiced interest in pursuing a design utilizing the

¹⁰“Prototypes of the T34-76” [http://history.vif2.ru/t34_76_1.html], 1
new drive system. This same tendency would continue to be a factor in design questions discussed with Stalin as demonstrated by a later conversation he had with Colonel General B.L. Vannikov concerning whether to increase the standard tank gun from the 76.2mm, then in use, to a 107mm gun in development. Stalin repeatedly encouraged the use of the larger gun stating, “these guns are good very good: I know them from the Civil War.” As Vannikov later recounts “Stalin was talking about a field gun of World War I vintage. Except for the diameter of the bore, it had nothing in common with the gun that had to be designed for modern tanks....A remark casually dropped by Stalin usually determined the outcome of a matter, and so it turned out this time, too.”

The issue of whether to use the wheel-track system or a more conventional caterpillar drive system dominated the early selection/development process. High level discussion was held focusing on the advantages and disadvantages of each system; these discussions focused largely on the testimony of veterans of the Spanish Civil War and members of the Red Army. Differing opinions offered by the veterans of Spain failed to establish a clear advantage for either system, although in another area it was decided that the current thickness of armor was insufficient.

11 “Prototypes of the T34-76” [http://history.vif2.ru/t34_76_1.html], 1
12 Bialer, “Stalin and His Generals”, 155
13 Ibid., 156
Factory trials were held in August and September of 1939 between the A20 and the A32, again with no definitive winner identified. Both tanks were presented again during a tank demonstration to the Red Army on 23 September; the performance of the A32 was significantly superior to that of the A20 primarily in terms of mobility and firepower. It was decided that the A32 should have its armor increased from 30mm to 45mm and its final development completed. The A32 had two clear advantages over the A20, first was that it was armed with the 76.2mm L-11 gun and the A20 was armed with the considerably smaller 45mm gun. The other distinct advantage was in the potential level of armor protection the vehicle could accommodate. The A20 had 25mm of frontal armor where the A32 initially had 30mm; this was to be increased to 45mm because the A32 had a sufficiently robust suspension and the potential for wide enough track to support the additional weight of more armor. When the decision was finally made the flexibility offered by the wheeled-tracked system of the A20 did not warrant its increased production cost, system cost and increased complexity. Testimony had shown that the wheeled-tracked system employed by the Red Army was simply not utilized very often and that the primitive road network typical in Russia did not support such use.

15 “Prototypes of the T34-76” [http://history.vif2.ru/t34_76_1.html], 5

16 Track width was increased from 26cm to 48.5cm to accommodate the additional weight.

17 Zaloga, “T34/76 Medium Tank, 1941-1945”, 5
In November of 1939 the Ministry of Defense (MOD) issued decree SNK USSR #443 recommending the acceptance of the up-armored A32 as the A34. One caveat contained in the decree was that acceptance was predicated on the vehicles “successfully pass [of] a 2000km race [trial]”. This “race” was a testing requirement for the prototype vehicles to complete a minimum of 2000km during trials prior to their presentation in Moscow on 5 March 1940. The first production prototypes, designated A34s were completed in January of 1940 and their trials begin in February. During trials the two test vehicles experienced a series of engine and mechanical failures and had only completed a small percentage of the required 2000km by the end of the month. It was decided that the test vehicles would roadmarch under their own power from the Kharkov to Moscow to fulfill the mileage requirement. This roadmarch was conducted starting on the 5th of March 1940 and after several breakdowns both tanks eventually arrived in

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18 USSR MOD Decree SNK USSR #443, November 1939, “Prototypes of the T34-76” [http://history.vif2.ru/t34_76_1.html]
Moscow in time for the demonstration. After a demonstration held in Ivonov Square in the Kremlin, attended by both Stalin and Molotov on 17 March the T34 was ordered into production at factory # 183 and at the Stalingradsky Tractor Factory (STF). The Central Committee of the Communist Party signed a resolution “about manufacturing T34 tanks in 1940” that directed factory #183 to produce 500 tanks and STF to produce 100 by the end of the year. By the outbreak of hostilities with the Germans in June 1941 a total of 1100 T34s had been produced but few were in service with combat units.

Factors that proved critical in the early development of the T34 were the type of drive to be used, the amount of armor and the gun size. A reluctance to commit to a decision concerning drive type without the expressed support of Stalin delayed production at a critical time. Influential issues during the process were whether the track/wheel drive was necessary considering the Russian communications network and a

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19 Early in the roadmarch one of the tanks burned out its main friction clutch (a problem to plague the T34 throughout its life) and had to be left behind for the factory maintenance staff to repair it, it eventually made it to Moscow under its own power.

20 SNK USSR and the Central Committee of the Communist Party Resolution, 5 June 1940, “Prototypes of the T34-76” [http://history.vif2.ru/t34_76_1.html]

21 Actual production in 1940 only achieved 115 tanks from Factory #183 and 23 half-assembled tanks from the STZ factory in Stalingrad. Delays were caused by troubles associated with retooling, adjustment problems on the V-2 engine and a change in the standard gun from the L-11 to the F-34 that resulted in the end of production of the L-11 in 1939.

22 Grove, “World War II Tanks”, 110
definite urgency in the need to begin production, as demonstrated by Resolution #94 outlining the requirement for mass production by 1939.

The T34 was a revolutionary advance in tank design because it was able to combine unprecedented improvements in mobility, protection and firepower in a single vehicle. The design innovations included the Christie type, independent suspension combined with an extremely wide track allowing for high speed cross-country mobility and the increase in overall weight associated with increased armor. The increase in overall armor thickness combined with the use of highly sloped armor provided unprecedented protection in a medium tank for its day, this protection was complimented by the use of a diesel fueled engine decreasing the risk of fire caused by fuel, making the new tank one of the safest in the world. The use of the 76mm gun that was capable of effectively using both high-explosive and armor-piercing ammunition provided a marked increase in firepower over any of the T34's contemporaries. Disadvantages of the original design included a cramped two-man turret with inadequate visibility for the commander, a poorly designed steering and breaking system, a 4 speed manual transmission, low quality steel and low overall production quality control standards.  

T34-76 Model 1940 Medium Tank:

23 Perrett, “Fighting Vehicles of the Red Army”, 33

The initial production T-34, (T34-76 Model 1940/T34A) was produced from mid 1940 through mid 1941 at STF and Factory #183. An approximate total of 950 systems were produced, 115 in 1940, the remainder in 1941. The vehicle weighed 26000kg combat loaded and was armed with the L-11 (L/30), 76.2mm gun. Production of the L-11 gun was halted in 1939 because of its poor performance in testing and it was replaced by the longer F-34 (L/40) gun mounted in a welded steel two-man turret. Its armor consisted of 20mm-51mm (45mm frontal) of steel at angles ranging from 0-90° (30° frontal), this model was produced with a combination of cast and welded turrets of generally of the same design. It used a Christie-type suspension and a V-12 diesel engine.


26 Only 400 T34s were armed with the L-11 gun prior to its replacement with the longer F-34 gun.
engine producing 500hp, giving it a maximum speed of 40-55km/h and a range of 300km+.

T34-76 Model 1941 Medium Tank:

In 1941 production of the Model 1940 was replaced by the model 1941; changes included standardization of the longer (41.2 caliber) F-34 (M-40) gun, the replacement of the 4 speed transmission with a 5 speed model and an up-armored turret manufactured from rolled plate, increasing armor from 45mm to 52mm. The new gun increased muzzle velocity from 612m/s to 655m/s and could penetrate up to 65mm of rolled homogeneous steel at 30° at a range of 500m. These improvements resulted in an

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27 Latter production 1941 models reverted to a cast turret but retained the increased armor.

28 Grove, “World War II Tanks”, 110
increased weight of 2000kg, a decrease in power-to-weight ratio from 19.2 hp/ton to 17.9 hp/ton, and an increase in ground pressure from 0.64 kg/cm² (9.1 psi) to 0.75 kg/cm² (10.7 psi).

In 1942 a 1941 production T34-76 was tested by American engineers at Aberdeen Proving Grounds providing a unique opportunity to examine the technical aspects of the vehicle from an American prospective. Unfortunately after the vehicle was driven only 343 km the engine experienced catastrophic failure and further automotive evaluation was impossible. Official test results stated that the engine failure was caused by aggregate ingested by the engine due to a poor air induction system. At this point the vehicle was withdrawn from automotive testing and moved to ballistic testing where it was fired at by a Soviet KV tank, and an M10 tank destroyer.

The Aberdeen test produced findings in the following categories:

Automotive:

The tested vehicle was noted as being slow, 25.5 km/p cross-country, this was primarily attributed to the 4 speed gearbox that was soon to be replaced by a 5 speed version.\(^{30}\)

The diesel engine was highly regarded by the testers not only for its use of a reduced volatility fuel but also for the power it produced for its weight. The largest problem was the extremely poor quality of the air filtration system that, as noted earlier was the attributed reason for catastrophic engine failure in the test vehicle. The air induction system on early and mid model T34s was, in theory an oil bath system but due to its poor design and manufacture little actual filtration occurred. Additionally the filter mechanism reduced airflow to the extent that even at idle there was insufficient airflow for maximum performance. A centrifugal “cyclone” system was later adapted as a standard feature on T34s relieving this problem.

The suspension was rated as poor due to the low quality of the steel used in the springs; this reduced ground clearance after only limited use. The use of steel track was highly regarded and the innovative design of the T34’s track initially drew great attention; this same innovation, however, combined with the lightweight construction and poor quality of materials used in the track caused it to be excessively prone to damage and ware resulting in a short usable life-span.\(^{31}\)

\(^{30}\) It is also possible that this poor performance and the almost immediate failure of the drive train were caused by a lack of experience concerning its operation by the testers.

\(^{31}\) The T34’s track pins were free floating and utilized a cam mounted on the hull to keep them in the track. Under certain circumstances this cam would bend or brake the pins causing the track to separate.
The transmission was extremely difficult to operate and thermal treatment of the cogwheels proved of such low quality that many of the gears catastrophically failed through the course of the test. The friction clutches used for brakes and steering also proved very unreliable, hard to operate and prone to excessive ware. This was attributed to poor design, poor quality of the steel used and the low quality of the machining during manufacture.

Armor:

Analysis of the armor demonstrated that the surface received tempering only to a shallow depth and that the majority of the inner plate was extremely soft. The hull was noted for being excessively prone to water leakage causing problems with the tank’s electrical system and hull stowed ammunition after the conduct of swim testing.

Turret: The lack of crew space in T34’s two-man turret was cited as a primary weakness, additionally the turret drive had problems with both the drive motor and the gearing. The turret drive motor was under-powered and had a propensity for sparking when in operation, additionally the gears in the drive mechanism lost teeth during use, presumably due to metallurgical and machining shortcomings.

Armament: The tested tank was equipped with an F34 gun that was highly regarded by the testers who cited it for its simplicity and reliability. The only problem noted was that of low muzzle velocity of armor piercing rounds (655 mps (3200 fps) on the F34 compared to 1,036 mps (5700 fps) on the American 3in gun. The optics were

32 This is a criticism the testers also had for armor on the M4, that did not have the benefit of the T34’s slope or thickness
singed out as being the best the testers had ever seen “Incomparable [sic] with any existing tanks or any under development”.

Communications:

The radio installed in the tank was cited for its compact size and its effective placement, additionally it performed well in static and laboratory tests. During actual tests in the vehicle its range was limited to 10 miles due to poor shielding and protection in the tank.

Conclusion:

The tests at Aberdeen concluded that the T34 was superior to comparable US models (presumably including M4s) in terms of the use of a diesel engine, thick and well sloped armor, a reliable main gun and well designed track. It was noted as inferior in terms of driveability, maneuverability, the penetrating ability of the main-gun, ease of maintenance and mechanical reliability.

The most consistent fault found was a combination of poor quality of steel and low standards in terms of manufacture. Although several design aspects were cited as deficient, these were issues that would largely be corrected on later models. 34

T34-76 Model 1942 Medium Tank:

33 What the testers failed to note was that the American gun being used as a comparison was not the current produced weapon on the M4, this was the M3 75mm gun, which was actually inferior in terms of muzzle velocity to the F-34 gun. (F-34 muzzle velocity: 655 mps, the Sherman’s M3 gun muzzle velocity: 619 mps (2,030 fps).

34 The replacement of the oil-bath airfilter with a cyclone type filter is one such example.
Figure 7: T34, (T34-76 Model 1942/T-34C)

The Model 1942 replaced the Model 1941; beginning in late 1941 this model instituted incremental improvements in armor, track and production methods of the tank as well as standardization of all prior improvements. Armor increased up to 60mm on the new cast turret but the poor visibility of the commander caused by the forward opening hatch and the lack of a gunner remained unaddressed.\textsuperscript{35} Fuel capacity was increased with the addition of external jettisonable tanks greatly increasing the range of the vehicle.\textsuperscript{36} Weight increased to 30000kg largely due to the new turret.

T34-76 Model 1943 Medium Tank:

\textsuperscript{35} All T-34s prior to the Model 1943 had a two-man turret with a loader and a commander/gunner. This crewing arrangement overloaded the tank commander (TC) by requiring him not only to control the tactical employment of the vehicle or the larger element he commanded but also to engage targets with the vehicle main-gun and coaxial mounted machinegun.

\textsuperscript{36} Jettisonable tanks were also retrofitted on all earlier models, as they became available.
The Model 1943 was the next version produced and it corrected several longstanding problems of the T34 primarily associated with its turret. The new turret was designed for three men and was equipped with two hatches; this increased the fightability of the tank significantly by providing a designated gunner, thus allowing the commander the freedom to actually command the vehicle tactically instead of having to focus on firing the main-gun. Later models had cupolas added to the commander’s position further increasing his visibility while buttoned-up and increasing his situational awareness in combat. Additionally the overhang to the rear of the turret was eliminated.
reducing the tank's vulnerability to infantry attack. The armor thickness of the new turret increased to a maximum of 70mm in front and 52mm on the sides.

**T34-85 Model 1943/44 Medium Tank:**

![T34-85 Medium Tank](image)

**Figure 9: T34-85, (T34-85 Model 1943/44 (T34/85I)**

The T34-85 Model 1943 was actually not produced until January of 1944, it responded to the increasing armor and gun size of the German tanks encountered during the Battle of Kursk. Initial T34-85s were equipped with the 85mm D-5T (100-300

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37 The turret overhang characteristic of earlier model T-34s proved vulnerable to dismounted infantry who would place mines or other explosives between it and the hull.

38 At a conference held at the end of August 1943 the People's Commissar for Tank Industry, V. A. Malyshev commented on the T-34's performance at Kursk: "Enemy tanks opened fire on ours at distances of up to 1,500 meters, while our 76mm tank guns could destroy "Tigers" and "Panthers" at distances of only 500-600 meters. Imagine the enemy has a kilometer and a half in his hands, while we have only half a
tanks) gun mounted in a two-man turret, this proved unsatisfactory and the majority of T34-85s were produced with the ZIS-S-53 85mm gun mounted in a new three-man turret derived from the KV85. These improvements represented the single most significant evolution of the T34 not only providing a greatly needed increase in armor-penetrating ability but also providing the vehicle with a gunner. The new gun was a derivative of the M39 anti-aircraft gun and had a muzzle velocity of 792 mps (2,600 fps)\(^3\) firing BR-365K Armor Piercing (AP) ammunition and could penetrate 85mm of steel at 30° slope at 1000m.\(^4\) This marked a notable improvement in capability especially when dealing with the German Tiger and Panther tanks. This change in main-gun did, however require a major rework of the entire vehicle because the turret ring had to be increased from 1,420mm of the standard T34 to 1,600mm required for the new gun and turret. The decision to temporarily reduce production to facilitate this extensive amount of change in the vehicle’s design was critical because of the need to resupply the losses at Kursk but also to enable future offensive operations into Germany. While the hull armor remained the same as earlier models the turret’s armor increased to 90mm. The total weight of the vehicle increased to 32000kg and the corresponding decrease in power to weight ratio to 15.6hp/tonne and an increase in ground pressure to 0.78 kg/cm² (11.1psi) followed. In response to the declining performance due to increased weight an improved version of...
the V-2-34 engine, the V-2-34M generating 520hp (20hp more than the previous model) was installed in vehicles produced after March of 1944.

Production of the T34 continued possibly as late as 1964\(^{41}\) with from 40,000 to 54,550\(^{42}\) examples being produced.

Several influences based in Soviet and Russian military, industrial culture are evident in the evolution of the T34; first, was the basic, robust but utilitarian character of the design. Simplicity was maintained with innovation coming in the form of significant increases in armor protection and firepower over other tanks, then in production around the world. This simplicity was influenced by a requirement to mass-produce the tank in great numbers utilizing the industrial capabilities of the Soviet Union. Ergonomics of the tank design sacrificed comfort for the crew, and in some cases the “fightability” of the tank to maintain this simplicity. Politically, the personal influence of Stalin on the progress of the design and the critical direction of many issues following the original design reflect the central control of Moscow, even to the point where the final acceptance testing was performed in the Kremlin for Stalin himself. This is contrasted by the initiative of the vehicle’s designer, Koshkin who as the head designer at Kharkov first initiated development by improving the BT series tank. The command-based economy dominated the production and improvement of the T34 maintaining, for the most part, a single, standard production model throughout all production facilities. Production rates

\(^{41}\) Foss, “Jane’s World Armored Fighting Vehicles”, 77

\(^{42}\) Western and Russian sources vary greatly in this regard with Russian sources sighting numbers as high as 54,550. Grove, “World War II Tanks”, 113, Zaloga, “T-34/76 Medium Tank, 1941-1945”, 35
were the driving factor in limiting product improvement and it took incredible losses at Kursk to foster a major product improvement in the form of the T34-85.
Early Development:

Between World War I and World War II the United States had virtually abandoned any meaningful pursuit of the tank as an independent weapon of war. With the National Defense Act of 1920 independent armored units were disbanded and all tanks were assigned to the infantry, this led to a near total halt in tank development. The few tanks that were developed were conceived primarily for the role of infantry support and most of them were light tanks armed only with machine guns.\(^{43}\) American doctrine in 1922 officially defined the role of tanks in combat: “facilitating the uninterrupted advance of the riflemen in the attack.” This led to two primary types of tanks; the first, was the light tank that was used for the direct support of infantry in their advance, the second, was the use of medium tanks or “leading tanks” to reduce strong-points just forward of the advancing infantry.\(^{44}\) In 1931, after several attempts at forming mechanized forces during the 1920’s, responsibility for armor development was assigned to the U.S. Cavalry. Although the infantry still retained their tanks, any meaningful

\(^{43}\) Grove, “World War II Tanks”, 121

\(^{44}\) Ogorkiewecz, “Armor, A History of Mechanized Forces”, 190
development in terms of mechanization or armored forces shifted to the Cavalry. Most of
the development through the 1930s focused on light tanks, or combat cars as they were
called outside of the infantry to bypass the congressionally imparted segregation of tanks
to that branch. It was out of this predominantly light tank development that medium tank
development would latter draw their automotive components.45

With the outbreak of war in Europe the United States was caught woefully
unprepared to fight a war that would be dominated by mechanized, armored formations.
As the Germans launched their offensive against the low countries in May of 1940 the
U.S. possessed a grand total of 18 “modern” medium tanks, 46 all of these tanks were M2s
designed for infantry support and were armed with a 37mm main-gun and eight machine-
guns. It was from the M-2 that the initial designs of the M4 Sherman originated.

Initial development on a new medium tank for the United States Army began in
1938 with the T5 Medium tank built at Rock Island Arsenal. This developmental tank
was envisioned primarily to fill the doctrinal demand for an infantry support tank and was
armed with six .30 cal machineguns and a single 37mm main-gun mounted in a 360°
rotating turret, it had a combat weight of 15 tons and a crew of five. Initially it utilized as
many parts as possible from the M2 Light tank but replaced the Christie type suspension
with a new vertical volute spring type.47

45 Significant automotive innovations evolving from the light tank development program included the
Continental air-cooled radial engines, improved transmissions, the volute spring suspension and rubber

46 The volute spring type suspension system mount most components of the suspension externally in
“bogies”, this system was largely unique to American tank designs. Grove, “World War II Tanks”, 124

47 Chaimberlain, “An Illustrated Guide to World War II Tanks and Fighting Vehicles”, 172
The T5 evolved into the M2 Medium Tank of which 15 were produced by August of 1939. The M2 weighed 19 tons, was powered by a Wright Radial 9-cylinder air-cooled engine that generated 350 hp and had a maximum speed of 42kph (26 mph). Again designed as an infantry support tank it had a crew of six and was armed with eight .30 cal machineguns and a single turret mounted 37mm gun.48

The next version was standardized as the M2A1 in 1940 and was similar to the M2 except for an increase in armor thickness, a larger turret and the addition of a supercharger, increasing the engine output to 400 hp and giving the vehicle a maximum speed of 48kph (30 mph). The up-armored version had a maximum thickness of armor of 38mm (1.25 in). On 13 August 1940 the United States Army ordered 1,000 M2A1 Medium tanks, these vehicles were outclassed by German tanks rolling across the field of Europe by the day of their acceptance.49

Prior to the order for production of the M2, reports from combat in Europe clearly demonstrated the inadequacies of the 37mm gun as an anti-tank weapon.50 Development was undertaken to mount an existing 75mm gun on late T5 chassis; the method used was to place a 75mm-pack howitzer in a sponson on the right side of the hull. This was clearly inferior to a 360° rotating turret but insufficient developmental work had been done towards a turret large enough to mount such a gun.51 The resulting vehicle, with

49 Grove, “World War II Tanks”, 125
50 Gabel, “Seek, Strike, and Destroy: U.S. Army Tank Destroyer Doctrine in World War II”, 7
51 Chaimberlain, “An Illustrated Guide to World War II Tanks and Fighting Vehicles”, 174
more armor and fewer machineguns was initially classified as the M2 75mm but would eventually become the M3 Lee/Grant. On August 28th 1940, just 15 days after the initial contract, the contract for the M2A1 was changed to production of the M-3. The M3 was clearly recognized as a temporary measure in order for the United States to begin production of a viable medium tank as soon as possible.\textsuperscript{52} The initial production M3 was delivered in January 1941 and fielding began by mid 1941. Throughout this entire process the doctrine of infantry support continued to dominate tank development, the role of destroying enemy tanks was assigned to anti-tank guns and the yet to be formed anti-tank units.\textsuperscript{53}

The M3 Medium Tank:

\textit{Medium Tank M3 "Lee"}

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{M3_Tank.png}
\caption{M3 Medium Tank, 1941}
\end{figure}

\textsuperscript{52} In August 1940 a combined board of Armored Forces representatives and Ordnance Department representatives issued specifications for a new medium tank with the requirement of a turret mounted 75mm gun and heavier armor than the M3. Chaimberlain, "An Illustrated Guide to World War II Tanks and Fighting Vehicles", 174
The M3 Medium tank was armed with a 37mm gun mounted in a 360° rotating turret and an M2 (short) 75mm gun mounted in a limited traverse sponson on the right side of the hull. It had a cast turret and a riveted hull with armor thickness ranging from 37mm – 12 mm and it weighed 60,000lbs. It was powered by a Wright Continental R-975 9-cylinder radial engine that produced 340 hp and gave it a maximum speed of 26 mph. It further maintained the vertical volute spring suspension and rubber block track of the M2 Medium tank. One innovation incorporated into its design was the use of gyro-stabilization in both the 37mm and the 75mm guns allowing, theoretically, for the accurate firing of the guns while the tank was moving. The combination of the 75mm and 37mm gun was intended to provide the vehicle the ability to, both support infantry and engage enemy armor if required.


54 The gyro-stabilization on most early tanks was not reliable and would often be disconnected by its crews to prevent it from interfering with target engagement. Operations Research Office “Study of the Employment of Armor in Korea, 10 April 1952”, 2
A total of 6,258 M3s of various models were built from August of 1941 until December 1942.\textsuperscript{55} Further development resulted in the elimination of the riveted hull in favor of welded and cast hulls, an improved 75mm gun (M3), and a multitude of powerplants ranging from its original radial engine to five standard car engines on a single drive shaft.\textsuperscript{56} The primary limitation of the M3 included the limited traverse of the 75mm gun, the use of highly flammable gasoline as its fuel in most models, an extremely high silhouette and insufficient armor to protect it from emerging German anti-tank capabilities.\textsuperscript{57} It was provided under Lend-Lease to the British and the Russians seeing

\textsuperscript{55} Grove, “World War II Tanks”, 126

\textsuperscript{56} Chaimberlain, “An Illustrated Guide to World War II Tanks and Fighting Vehicles”, 173-175

\textsuperscript{57} Hoffschmidt, “German Tank and Antitank”, 36-39
its only significant employment in North Africa by the British and later American forces. In the desert the M-3 proved extremely effective combining an adequately armored platform (at this stage of the war) and the ability to fire both armor piercing and high explosive rounds. Shipment of the M3 to the Soviet Union stopped at Stalin’s request due, primarily to its use of gasoline for fuel that gave the vehicle a well-earned reputation for burning when hit.  

The M4 Medium Tank:  

Work began on 29 August 1940, the day after the initial contract for the M3, to rectify its shortcomings, most notably the lack of a proper turret able to both carry a 75mm main-gun and rotate 360°. By 16 September 1941 a prototype vehicle utilizing as many parts of the M3 as possible but having a turret mounted 75mm gun was designated the T6 medium tank. By October it was standardized as Medium Tank, M4. The amazingly rapid development of the M4 was only possible through the acceptance of many of the existing components used on the M3; this was especially true of automotive components including the suspension, track and drive train. As has already been discussed the M3 inherited much of its automotive components from the M2, while this was expeditious in terms of rapid development it meant that the initial M4, weighing 66,500 lbs. had a suspension, track and drive-train essentially designed for a 38,000 lbs. vehicle.  

58 “M3 “General Lee” Medium Tank” [http://history.vif2.ru/library/lend/lee.html], 2  
The initial M4 was armed with the M2 75mm (short) gun that was power operated in both traverse and elevation and was gyro-stabilized in elevation. The large, one-piece cast turret had 76mm of armor in front but was poorly sloped. The tank was powered by the same Continental R-975 radial engine as the M-3 medium tank and initial models also shared its volute spring suspension. The suspension was soon modified to the Vertical Volute Spring Suspension (VVSS) on all production models, the most notable aspect of this change was the movement of the return rollers from the tops of the bogies to a trailing position. The hull was of welded construction, had sloped frontal armor with a thickness of 51mm and vertical side armor with a thickness of 38mm.\textsuperscript{60} The primary

\textsuperscript{60} AGF Board No. 2, "Development of Armored Vehicles, Volume I, Tanks, 1 September 1947", 538
reason for the box-like shape of the hull was ease of production and to accommodate the transmission and final drives in its front. The vertical drive-shaft of the radial engine accounted for the especially high profile of the hull, a feature maintained on all models regardless of power-plant in order to simplify and standardize mass production. A total of 6,748 M4s were produced from July 1942 to January 1944.61

The M4A1 Medium Tank:

Medium Tank M4A1 "Sherman"

Figure 13: M4A1 Medium Tank, 1941

61 Bos, Note to Mark Falkovich, director Historical Office, U.S. Army Tank-Automotive Command reporting U.S. tank production figures. 26 May 1987
The M4A1 was the next Sherman standardized, in December of 1941, and was actually the first production models delivered in February 1942. This version was essentially identical to the M4 except for its use of a cast, as opposed to a welded plate hull. Armor thickness remained essentially the same but the cast hull had the advantage of sloping the armor on the sides, although only slightly, thus improving armor protection. Most other differences were superficial such as the short-lived addition of two machineguns protruding from the front of the hull. This model retained the same drive train as the M4 and weighed 69,000 lbs. Additionally most M4A1s were produced using the longer M3 75mm gun (37.5 caliber) replacing the shorter M2 (28.5 caliber) gun. The new gun increased muzzle velocity for its armor piercing round from 1,850 fps (564 mps) to 2,030 fps (619 mps) substantially improving its penetrating capability. The length of the gun also had the added benefit of improving the effectiveness of the gyrostabilization mechanism and the breach now opened to the side instead of vertically enabling greater depression of the gun. This improvement was however not limited to the M4A1 model with the longer M3 gun being installed whenever it was available. A total of 6,281 M4A1s were produced from February 1942 to December 1943.

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62 Grove, “World War II Tanks”, 130
63 AGF Board No. 2, “Development of Armored Vehicles, Volume I, Tanks, 1 September 1947”, 540
64 Bonds, “An Illustrated Guide to World War II Tanks and Fighting Vehicles”, 130
65 Grove, “World War II Tanks”, 134

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Figure 14: M4A2 Medium Tank, 1941

The M4A2 Medium Tank:

The M4A2 was also standardized in December of 1941, and was similar to the M4 in that it had a welded hull and cast turret. The significant difference associated with the M4A2 was that it was powered by a pair of General Motors 6-71 12 cylinder, liquid cooled diesel engines that produced a combined output of 410hp. The longer M3 75mm gun was also installed on a large number of the M4A2 model. A total of 8,053 M4A2s were produced from April 1942 to May 1944.\(^{67}\)

The M4A2 was not used in combat by American forces but instead was provided to several allied nations through Lend-Lease. Large numbers of M4A2s were sent to the

\(^{67}\) Grove, “World War II Tanks”, 134
Soviet Union.\textsuperscript{68} This specific model was selected due to its use of diesel fuel after the Soviets had protested the M3 Medium tanks they had received due their propensity to burn, largely due to their use of gasoline.\textsuperscript{69}

The M4A3 Medium Tank:

\textit{Medium Tank M4A3 "Sherman"}

\begin{figure}[h]
\centering
\includegraphics[width=0.7\textwidth]{medium-tank.png}
\caption{M4A3 Medium Tank, 1942}
\end{figure}

The M4A3 was standardized in January of 1942, and was similar to the M4 except that it was equipped with a purpose-built V-8 Ford tank engine. The Ford engine was

\textsuperscript{68} A total of approximately 5,000 medium tanks were provided to the Soviet Union under Lend Lease program, these were a combination of M-3s and M-4s but the vast majority were M4A2 and M4A2 (76)s. "Commanding the Red Army’s Sherman Tanks, The World War II Memoirs of Hero of the Soviet Union Dmitriy Loza", xiv

\textsuperscript{69} Loza, “Commanding the Red Army’s Sherman Tanks, The World War II Memoirs of Hero of the Soviet Union Dmitriy Loza”, xiv

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gasoline fueled, liquid cooled and produced 500hp giving the A3 a power-to-weight ratio of 16.5 hp/ton and a max speed of 42 kph. This engine/drivetrain combination occupied considerably less space than the Continental engine and would have allowed for a substantially reduced hull profile but it was decided to maintain a standard hull configuration on all four M4 models then in production. Two thirds of M4A3s were produced equipped with wet storage for its 75mm ammo in an attempt to reduce its susceptibility to secondary fire when hit in its thin side armor. This innovation became standard on all 76mm versions substantially reducing the percentage of tank fires caused due to the combustion of stowed ammunition. A total of 3,071 M4A3s were produced from June 1942 to September 1943.

70 Baily, “Faint Praise, American Tanks and Tank Destroyers during World War II”

71 “Wet storage” of ammunition was a system where by the ammunition was stored in a water and glycerin jacketed honeycomb. In the event of a round penetrating the hull and the ammunition it would also penetrate the water jacket causing the ammunition to be covered in water, reducing the risk of fire. A “W” was added to the designation of all M-4s receiving this modification.

72 Grove, “World War II Tanks”, 134

73 Bos, Note to Mark Falkovich, director Historical Office, U.S. Army Tank-Automotive Command reporting U.S. tank production figures. 26 May 1987
Assault Tank M4A3E2 "Sherman"

Original Drawing by D.P. Dyer
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Figure 16: M4A3E2 “Jumbo” Assault Tank, 1944

In an attempt to provide a heavily armored “assault” tank the M4A3E2 “Jumbo” was developed. This version of the Sherman retained the 75mm M-3 gun but had substantially increased armor protection. The basic hull and running gear of the M4A3 remained but a 38mm armor plate was welded to its front and sides and an a substantially thicker cast transmission housing was used increasing its armor protection from 108mm to 140mm. A completely new turret was used with 152mm of frontal protection and an additional 89mm plate welded onto the front of the gun mantel. The additional armor caused the weight of this vehicle to increase to 42 tons, the speed to decrease to 35kph (22 mph), and its ground pressure to increase to 14.2 psi. To deal with the increased
ground pressure all E2s were permanently fitted with extended end connectors to widen the track. A total of 254 M4A3E2s were produced in June and July of 1944.  

The M4A4 Medium Tank:

Medium Tank M4A4 "Sherman"

Figure 17: M4A4 Medium Tank, 1942

The M4A4 was standardized in February 1942, and once again varied from the basic M4 primarily in power plant. The M4A4 was powered by the Chrysler 5-line water-cooled tank engine that consisted of five gasoline car engines operating on a common drive shaft. In order to accommodate this unusual engine the hull was lengthened by 6 in, as was the track and corresponding suspension support. This variant was primarily provided to England and was the first phased out of production due to

74 Chaimberlain, “An Illustrated Guide to World War II Tanks and Fighting Vehicles”, 182
concerns over the complexity of its powerplant. A total of 7,499 M4A4s were produced from June 1942 to September 1943.

Other Models of the M4 Medium Tank:

The M4A5, this was the administrative designation given by the U.S. to Canadian built “Cruiser” or Sherman VC tanks. These tanks were essentially M4A1s with minor modifications to make them compatible with Canadian requirements. The M4A6, this was only produced in limited quantity (75 vehicles) and was never used in combat; this version of the Sherman was powered by and RD-1820 air-cooled radial diesel engine.

The 76mm Gun:

The evolving realization that tanks would have to actually kill other tanks combined with increasing thickness of German armor produced a requirement for a more effective armor-defeating gun for the M4. This became most evident in the latter stages of the Italian campaign and with the invasion of France in 1944 where 75mm armed Shermans were simply not able to penetrate the front armor of the latest German tanks. Throughout the development of the M3, and most of that of the M4, United States Army doctrine provided that the mission of the medium tank was to support infantry, primarily

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75 The combination of five conventional automotive engines on a single drive-shaft produced incredible mechanical complexity and its corresponding lack of reliability. One example would be that this engine required 45 sparkplugs. Grove, “World War II Tanks”, 134

76 Bos, Note to Mark Falkovich, director Historical Office, U.S. Army Tank-Automotive Command reporting U.S. tank production figures. 26 May 1987

77 Chaimberlain, “An Illustrated Guide to World War II Tanks and Fighting Vehicles”, 14

78 Ibid., 178
in the attack, killing tanks was the purview of the Tank Destroyer Corp.\textsuperscript{79} Because of this doctrine the lower velocity 75mm gun was maintained, even though a significantly superior, in terms of armor penetration, 76mm gun was available as early as 1942. It was in 1942 that the Ordnance Department, working at its own initiative, combining the existing 76mm anti-aircraft gun, with the turret from the developmental T23 medium tank. Testing proved satisfactory but the Armored Command limited the production of this vehicle to 12 to be used only for further testing. This decision was caused by the previously mentioned Tank Destroyer doctrine that directed the use of massed, dedicated anti-tank assets to kill enemy tanks. Army doctrine maintained that the M-4 should fill the role of infantry support, for which the 75mm gun was superior.\textsuperscript{80} In August 1943 Armored Command reversed itself and recommended the procurement of 1,000 76mm armed medium tanks. By January 1944 production begun on 76mm armed M4s, M4A1s, M4A2s, and M4A3s using essentially the same turret/gun system developed in 1942.\textsuperscript{81} Even at this point only the partial shift in production to the 76mm was authorized, accounting for the simultaneous production of both 75mm and 76mm model M4s.\textsuperscript{82}

\textsuperscript{79} Gabel, "Seek, Strike, and Destroy: U.S. Army Tank Destroyer Doctrine in World War II", 69

\textsuperscript{80} The 75mm fragmentation round carried a larger explosive charge than that of the 76mm but was inferior in all other aspects.

\textsuperscript{81} Chamberlain, "Pictorial History of Tanks of the World 1915-1945", 180

\textsuperscript{82} The reason for this is that even with the realization that tanks would sometimes have to kill other tanks doctrine had still not changed and the destruction of enemy tanks was still the primary responsibility of the Tank Destroyer Command. This would continue to be an issue through the end of the war with the best anti-tank ammunition being reserved for the Tank Destroyers even though the 76mm armed M-4s would have been able to fire it. Gabel "Leavenworth Papers #12, Seek, Strike, and Destroy: U.S. Army Tank Destroyer Doctrine in World War II", 19
The production of 76mm-armed M4s installed the new turret on existing production hulls. When finally adopted the M1A1 and M1A2 76mm gun substantially improved the armor penetrating capability of the M4. Firing the M62 armor piercing (AP) round the new gun had a muzzle velocity of 792 mps and could penetrate 88mm of steel at 1000 yards (914m). With the adoption of the new gun 76mm versions of all models of M4s were produced incorporating the specific nuances of each model and many new innovations including applique armor, wet storage for ammunition and on later

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83 Of note is the fact that the British advocated the adoption of their 17-pounder high velocity gun to which the US replied in the negative. According to British tests (Ross, p.330) the 17pdr could penetrate 130mm of armor with AP ammo while the US 76mm gun could only penetrate 90mm at the same range using M62 ammo. The British undertook limited conversion of Shermans to the 17 pdr and landed substantial numbers of these at Normandy.
models the horizontal volute spring type suspension. A total of 3,396 M4A1(76mm)s, 1,615 M4A2(76mm)s, 3,370 M4A3(76mm)s were produced from January 1944 to April 1945.\textsuperscript{84}

\textbf{Medium Tank M4A2(76)W "Sherman"}

![Diagram of M4A2(76)W Medium Tank](image)

\textit{Original Drawing by D.P. Dyer}
\textit{© Copyright R P Hunnicutt 1978}

\textbf{Figure 19: M4A2(76)W Medium Tank, 1944}

The 105mm Gun:

In order to provide better fire support for armored unit a series of 105mm armed M4s were developed starting in 1942. The outcome of this development mounted a standard U.S. 105mm howitzer in M4 and M4A3 turrets with the (105 mm) designation being added to the nomenclature. These vehicles began production in 1944 and

\textsuperscript{84} Grove, "World War II Tanks", 134
paralleled improvements on the more common M4s. A total of 800 M4 (105mm), 500 M4A3(105 mm), 841 M4(105mm) HVSS and 2,529 M4A3(105mm) HVSS were produced prior to the end of the war in 1945.

Horizontal Volute Spring Suspension (HVSS):

One problem that continuously worsened for M4s through their development was their increasing ground pressure caused by greater combat weight due to the addition of larger guns and appliqué armor. To address this problem several innovations were attempted in suspension and track width, the most common being the addition of extended end connectors to the track to try and increase its width. In 1944 the Horizontal Volute Spring Suspension (HVSS) was adopted to effectively deal with this

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85 This included the addition of appliqué armor and the installation of the HVSS suspension.
86 Chamberlain, “Pictorial History of Tanks of the World 1915-1945”, 181
87 Culver, “Sherman In Action”, 35
problem. The new suspension system redesigned the bogies and shock absorption system but, more importantly, changed from a system where the track had guides on both sides of a single roadwheel to a two roadwheel system with a center-guide on the track running between a pair roadwheels. The practical advantage of this was a 61mm (24in) wide track that was 19mm wider than the previous model. The new suspension was adopted on late production models and retrofitted to existing vehicle when possible, all vehicles with the new suspension had the HVSS added to its designation. With the addition of HVSS the M4 was able to largely correct one of field commanders greatest complaints about the vehicle, that of poor off-road mobility. With the reduction of ground pressure also came a better ride that directly equated to a more stable firing platform.

The M4 Sherman medium tank was, according to western sources, the most widely produced and the most widely used allied tank in World War II with 46,129 examples being produced. The desire to maintain high levels of production and the character of the American industrial complex was the cause of several highly unique features of the program; first, was the decision to continue production of the M4 through the end of the war when numerous, vastly superior designs were available. Next, was the variety of models produced simultaneously that were primarily different, not because

88 Grove, “World War II Tanks”, 133
89 In after action reports (AARs) given by American units at the end of the war several comments concerning the M-4 are universal, one is that prior to HVSS they were greatly inferior to German tanks in terms of “flotation” or their ability to cross soft ground. White, “United States VS German Equipment, AAR prepared by 2nd Armored Division, 1945”
90 Bos, Note to Mark Falkovich, director Historical Office, U.S. Army Tank-Automotive Command reporting U.S. tank production figures. 26 May 1987
91 Ogorkiewecz, “Armor, A History of Mechanized Forces”, 198
of product evolution, but instead due to the need to manufacture the vehicle or the engines in a wide range of configurations. Instead of forcing all suppliers to drastically re-tool and change production to manufacture a specific engine, each was allowed to produce their model, or one they could change to readily, and models of the M4 were adapted to utilize that engine. This was also true in terms of how the hull and turret bodies were fabricated, the base vehicle utilized welded plate but where large casting facilities were available a cast hull and turret were developed. The final factor is how the vehicle was improved as technical problems were solved, such as the suspension and ammunition storage. When a new component was fielded facilities would convert to the new equipment only when the old model was exhausted. In some cases vehicles were deliberately produced with an old style component while the new style was already available, the vehicle was then converted to the new component only when production was complete and sometimes only after it was shipped into the theater of operation. While this may not appear practical, it was done to maintain overall production rates, where it would have taken longer to convert the production line than to convert the component later.\textsuperscript{92} The effectiveness of American industry, in mass-producing tanks is clear when we consider that in 1940 the total number of tanks produced in the United States was 330. In 1941 U.S. industry produced 4,052, this number skyrocketed to 24,997 by the following year and by 1943 production had reached 29,487 tanks in a

\textsuperscript{92} Ross, “The Business of Tanks 1933-1945”, Ch 22
single year. Contrast this to total German tank output from 1939 through 1945 that
totaled only 23,500, less than U.S. 1943 production alone.\textsuperscript{93}

\textsuperscript{93} Grove, "World War II Tanks", 3,122
CHAPTER 4

VEHICLE COMPARISON

In order to compare the development of the T34 and the M4 it will be useful to compare their relative combat potential. To systematize this comparison the technical characteristics of each vehicle will be examined, primarily focusing on initial production, mid life and final production models. This will be done by a categorical comparison utilizing the areas mentioned in the introduction: firepower, mobility, protection and communications followed by a more subjective examination of the military, industrial culture that was reflected in each design.

Firepower:

In the examination of tank firepower two primarily areas must be addressed; anti-tank (AT) fire and infantry support fire. The relative importance of each in combat is dependent on the doctrine, tactics and the environment the tank will be used in. Both subjects in this examination were fielded by armies that recognized the need to utilize armor as part of a combined arms force incorporating infantry, armor, artillery and airpower together to magnify the overall effect. In the Soviet case combined arms was however secondary to the use of mass in the form of overwhelming size of primarily
attacking forces. Both designs were meant to maintain the momentum of infantry
attack and were originally armed primarily for this purpose with only secondary attention
being given to the anti-tank role. In both cases the ability to fight enemy tanks increased
with the life of the vehicle, resulting in substantial improvement in this area, it is in how
this happened that my comparison will focus.

Both the M4 and the T34 possessed similar infantry support characteristics and
were equally capable of supporting infantry in combat operation. Both vehicles had a
main-gun of 75mm or greater bore and normally carried effective fragmentation
ammunition, both had coaxial mounted 7.62 machineguns and both had a single bow
mounted 7.62mm machinegun on the vast majority of their production vehicles. Several differences of minimal significance do, however exist in terms of combat
potential in fighting or supporting infantry; first, the M4 normally had a 12.7mm
Browning M2 heavy machinegun mounted on the turret roof, this was primarily for use
as an anti-aircraft weapon, but it could also be aimed at ground targets. The limiting
factor for this weapon was that the operator had to expose himself to enemy fire when
using it, normally standing on the back-deck of the vehicle almost fully exposed except to
the front. The second difference, was in the method used to feed ammunition that each
vehicle’s 7.62mm machineguns, the M4 utilized the M1919A4 machinegun that was fed

94 "Russian Combat Methods in World War II", 24, 25

95 This is not to give the impression that either tank could operate without infantry support. It is a universal
requirement that tanks need infantry support to operate effectively.

96 Early production (1941) M-4s had two additional fixed, hull mounted 7.62mm machineguns, and these
were eliminated from all subsequent vehicles due to their lack of utility.

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by a cloth belt; this method provided continuous feed of hundreds of rounds of ammunition without the need to reload. The T34 utilized the DT machinegun that utilized 63 round magazines and had the disadvantage of having to be reloaded regularly by its operator. The final difference, in terms of infantry support, was driven by necessity and doctrine, the Red Army used its tanks as the primary transport for the infantry assigned to support those tanks, to aid in this practice hand-holds or “infantry rails” were welded to the hulls and turrets of most T34s by the end of the war. Although these differences reflect slightly varied methods of completing the same task, the basic ability to perform the mission is not substantially different. This is not necessarily true in the other areas we will examine.

Two factors are critical in anti-tank fire, the ability to hit and the ability to penetrate an opponent. This analysis will concentrate primarily on a tank's ability to penetrate the armor of an enemy tank. While the ability to hit, or accuracy of a tank is equally important, in this examination, we will assume each vehicle possessed comparable abilities to engage enemy targets within the range of its weapons effective ranges. This is acceptable due to the fact that the mean range of engagement for tank vs. tank combat in Europe during World War II was only 660 yds, well within optimal range for both vehicles.97

Both the M4 and the T34 were originally fielded with guns that were excellent for infantry support but only marginally effective in terms of armor penetration. The Soviet 76.2mm, L-11 gun had a muzzle velocity of 612m/s and could penetrate up to 56mm of

97 Peterson, “The Range and Angular Distribution of A.P. Hits on Tanks”, 4
RHS at 1000m; this was on par with the American 75mm, M2 gun that equipped initial M4s. The American M-2 tank gun had a muzzle velocity of 588 mps and could penetrate up to 55mm of RHA at 914m (1,000yards).98

The original weapon for each tank was determined to be sub-standard soon after production began and both tanks received new, longer guns of the same caliber. In both cases the new guns had notably higher muzzle velocities, the M4 with the M3 gun and the T34 receiving the F-34 gun. Of these two guns the American model was significantly superior to the F-34 in terms of armor penetration.99 At 1000m the American M3, 75mm (Long) gun could penetrate 80mm while the Russian F34, 76.2mm gun could only penetrate 58mm.

The best German tanks in the field from 1941 until late in 1942 were PzKpfw IIIs and IVs that only had 30mms of frontal armor. Additionally the majority of German armor when they invaded Russia was a conglomeration of obsolete PzKpfw Is and IIIs and captured Czech and French vehicles also obsolete, with limited numbers of PzKpfw IIIs and IVs for a spearhead.100 Accordingly, when they were fielded, both the American and Soviet guns were extremely capable of dealing with their German adversaries. This situation changed drastically in 1942 and 1943 when significant design improvement were implemented on the PzKpfw IVs and fielding began on two new German heavy

98 The different ranges are due to the different measuring systems standard to each country, while most European countries would test their weapons at 1,000m the United States did so at 1,000yds (914m).
100 Macksey, “Tank versus Tank”, 83-85
tanks, the PzKpfw V Panther and PzKpfw VI Tiger.\textsuperscript{101} These vehicles had frontal armor ranging from 80mm to 120mm in thickness making both the American and Russian guns essentially useless when engaging the frontal armor of these German tanks, this was especially critical when considering that the majority of tank engagements occur on the vehicles front armor.\textsuperscript{102}

The obvious reaction in both the American and Soviet cases was to adopt improved high velocity guns, in the American case it came in the form of the 76mm, M3 gun and for the Soviets it was the 85mm, Zis-S-53. The American 76mm could penetrate 92mm of 30° sloped armor at 914m (1000yds) with conventional ammunition while the Soviet 85mm gun could penetrate up to 85mm of 30° sloped armor at 1000m.\textsuperscript{103} Both guns were more effective than their predecessors and represented a needed improvement in armor penetration, but were delayed in fielding and by the time they arrived in numbers on the battlefield were only marginal improvements. The process by which each country adopted its new gun is significant, in the Soviet case the need for a more effective gun was identified as a direct result of the tank battles at Kursk in 1943. This critical victory for the Soviets had been a costly one, where they lost 9,000 tanks compared to the German loss of 2200 tanks.\textsuperscript{104} Soviet industry was able to greatly out-produce the Germans in terms of monthly production rate, but even with this they had

\textsuperscript{101} Chamberlain, "An Illustrated Guide to World War II Tanks and Fighting Vehicles", 57-59

\textsuperscript{102} Peterson, "The Range and Angular Distribution of A.P. Hits on Tanks", 15

\textsuperscript{103} 100mm according to some Russian sources, Potapov, Valeriy Editor. "Russian Battlefield Webster", [http://history.vif2.ru/] (7 March 2001)

\textsuperscript{104} Nikiforov, "The Brief History of T-34-85", [http://rkka.doainvalet.com/dv_gct/9717/t-34-85.htm], 1
difficulty making up for losses on the scale of the Kursk victory. A program was immediately initiated to develop a new gun that could penetrate the improved German armor, this program focused largely on the 85mm anti-aircraft gun that was already standard in the Soviet inventory. This choice had originally been conceived before the war as the T34M, but was abandoned, largely because of the outbreak of the war and the fear that shifting production to the new model would slow output. It was maintaining production that also contributed to the eventual utilization the existing 85mm anti-aircraft gun, modified for tank use, instead of a larger caliber weapon favored by Stalin.

American gun development had followed similar tracks with the Ordinance Department’s early attempts at fielding a 76mm high velocity gun on initial M4s, but in this case the project was shelved due to the doctrinally motivated limitations discussed earlier. Even with their improved guns, both tanks had difficulty penetrating the front armor of the German tanks they were facing. The T34-85 could only penetrate Tiger frontal armor at 500m and Panther front slopes at 100m, this while each of these tanks could defeat the Soviet tank’s front armor at ranges of 1500m or grater. American tank crews considered the 76mm gun a considerable improvement over the 75mm, but universally noted it as inferior to its German counterparts. The new gun was only reliably effective when using the Hyper Velocity (HVAP) ammunition that was available.

105 Keegan, “The Second World War”, 471
106 Zaloga, “T-34/76 Medium Tank, 1941-1945”, 13
107 Bialer, “Stalin and His Generals”, 155
108 Macksey, “Tank versus Tank”, 107
only in limited quantities, even by the end of the war. The continued need for improved armor penetration ability lead, eventually to the US adoption of the 90mm armed M26 Pershing and the Soviet adoption of the 100mm armed JS-2 late in the war.

Mobility:

In terms of mobility, the T34 was a clearly superior vehicle, with a lower ground pressure and higher power-to-weight ratio than the M4, in almost all models it could simply go places the M4 could not and at a higher speed. Additionally, although the T34 only had a range of 300 km from fuel that was internally stored it was provisioned with jettisonable external fuel tanks that could almost double its range.

The initial version of the T34 exerted a ground pressure of 9.1psi. Although this soon rose to 10.4psi by 1941 it was still significantly below that of the initial M4s at 13.7 psi. The reason for the difference was simple, the T34 had track that was 55 cm wide, and the Sherman had track that was 42 cm wide, this was combined with a combat weight 1800-4000kg greater for the M4. M4 development eventually dealt with this issue by adopting the HVSS suspension adopted in 1944, with this system came a substantially wider track (58.4cm) and a reduction of ground pressure to 11.0 psi even though the overall combat weight had increased to 33650 kg (M4A3(76)W HVSS). Soviet development had not substantially changed the suspension on the T34 and the later

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109 Every AAR report from 2nd Armored Division remarked that M4s were vastly inferior to German tanks specifically noting that the 75mm gun was ineffective against PzKpfw V and VI s front armor and that even with the 76mm gun defeat of German tanks was generally only achievable through vastly superior numbers enabling them to maneuver to the enemy’s flank. White, “United States VS German Equipment, Armor, AAR prepared by 2nd Armored Division, 1945”

110 Foss, “Jane’s World Armored Fighting Vehicles”, 77
production T34-85 (1944) had an increased ground pressure of 11.1 psi but this still provided for outstanding performance. The transition to HVSS substantially improved the M4's ability to maneuver on soft ground but this modification was not fielded quickly enough to significantly improve American armored forces mobility in World War II.\textsuperscript{111}

In terms of speed the T34 again had a distinct advantage, initial models had a maximum road speed of 55 kph and a cross-country speed of 40 kph. The initial M4s only had a maximum road/cross country speed of 34kph. The primary cause for the advantage in speed for the T34 was a power to weight ratio of 19.2 hp/ton initially then dropping to 16.7 hp/ton by 1942. This drop in power-to-weight ratio was more than compensated for with the adoption of the 5-speed transmission in that same year.\textsuperscript{112} The 400hp Continental powered M-4s had a much lower power to weight ratio of 13.2 hp/ton and an even worse ratio on the diesel powered A2s of 12.9 hp/ton. This was improved slightly on the 500hp Ford V-8 powered A3 that increased this figure to 14.9 hp/ton.\textsuperscript{113}

Overall range for the M4 was better than the T34, but only when limiting the comparison to internal fuel tanks. The M4 maintained a road range of from 412 km to 475 km but had no provision for additional fuel. The T34 on the other hand had a road range of from 280 km to 300 km on internal tanks but as already mentioned could virtually double this with the addition of external fuel tanks. External fuel tanks were

\textsuperscript{111} White, “United States VS German Equipment, Armor, AAR prepared by 2nd Armored Division, 1945”

\textsuperscript{112} Grove, “World War II Tanks”, 112

\textsuperscript{113} AGF Board No. 2, “Development of Armored Vehicles, Volume I, Tanks, 1 September 1947”

54
used universally by the Soviet Union throughout the war and subsequently and are still used extensively by its successor states.

The final factor concerning mobility is that of maintainability, and while there is little hard data available concerning this attribute it still must be addressed. The M4 appears to have the advantage in maintainability and dependability while the T34 has the advantage in simplicity. This reputation has continued long after production of the M4 ceased as noted by the continue use of the basic vehicle by the Israeli Defense Force in lieu of large numbers of more modern Soviet manufactured models. Several things contributed to the relative ease of maintenance on the M4 as opposed to the T34, first was the larger amount of work area provided by the designs. The M4 had an oversized hull; it was especially large due to the initial design needing to accommodate the Continental radial engine and its unusual vertical driveshaft. The turret was substantially larger than that of Soviet models because it was designed for three men and US tank designs.

114 As of the writing of this paper no data had been found concerning the mean time between failure or number of hours of maintenance required per hour of operation for these systems, all information concerning this are is therefore anecdotal in nature.

115 General comments in this regard permeate most anecdotal accounts by crews of these vehicles; the best references for the M4 are the AARs of 2nd Armored Division and Loza’s account of Shermans used by the Soviet Army. White, “United States VS German Equipment, Armor, AAR prepared by 2nd Armored Division, 1945”; and Loza, “Commanding the Red Army’s Sherman Tanks, The World War II Memoirs of Hero of the Soviet Union Dmitriy Loza” For the T34 they include, Zaloga, “T-34/76 Medium Tank, 1941-1945” and MCIA, “Soviet/Russian Armor and Artillery Design Practices: 1945-1995”

116 During and interview conducted by LTC (USAF) John Guilmartin in 1972, Yitzak Rabin, former commander of the Israeli Defense Forces during the 1967 “Six Day War” noted that the IDF had continued to maintain M4 Shermans in lieu of the numerous, more modern captured Soviet manufactured vehicles because of the high level of reliability of their automotive components. Guilmartin, John, Dr., (guilmartinj@nasm.si.edu) “Re: Thesis Draft,” 18 March 2002. Personal email (14 March 2002)

117 Because of the central, vertical driveshaft of the radial engine the M-4’s drive shaft was routed under the crew compartment in the hull adding significantly to its overall height.

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generally have larger crew areas than Russian designs. While American tankers are generally accepted regardless of stature Russians restrict the eligibility for tank crewmembers according to individual size. Another design feature that contributed to ease of maintenance on the M4 was the external placement of its suspension components; both the VVSS and the HVSS had externally mounted suspension bogies. While this external placement was probably not beneficial to the armor protection of the suspension it did make it easier to access than the T34’s internally located torsion bars.

Both tanks were “known” for their dependability, but the tests conducted at Aberdeen on the Soviet T34 demonstrated a significant shortcoming in the quality of its manufacturing. This was true in both quality of parts and design, the latter being demonstrated by the outdated and sensitive nature of its steering system and the ineffectiveness of the air induction system. Several comments were made in the test report noting the low quality of metal and machining used on critical gears, failure of these gears and the clutch/brake system caused the vehicle to be unrepairable after only 343km of operation.  

Protection:

When examining the armor protection of a conventionally armored vehicle there are four primary areas that must be accounted for, first the type and construction of armor, second is the hardness of that armor, third is armor thickness and forth is the slope of the armor. It is critical to incorporate all four aspects into any evaluation of the

\[ ^{118} \text{As noted previously the extremely short life of this vehicle was likely contributed to by a lack of familiarity of the operator but it does however expose component shortcomings when exposed to stress and a propensity for early failure.} \]
potential protection to be offered by an armor package. For the purposes of this comparison we will make the assumption that the quality of manufacture of the armor being evaluated is of an acceptable and equal level of hardness and homogeneity. This assumption may not be totally accurate especially concerning some of the Soviet armor produced early in the war but a detailed evaluation of that issue is beyond the limits of this study. The other assumption is that the protection provided by the two primary forms of conventional armor, Rolled Homogeneous Armor (RHA) and Cast are of equal levels.

Figure 21: Armor slope, effective armor thickness diagram
When a projectile strikes sloped armor it must pass through more steel to achieve penetration than if it strikes the armor perpendicularly, to factor this effect into an evaluation of armor effectiveness a modified armor value will be assigned. The assigned armor value will be in millimeters of RHA equivalent thickness and represent the total amount of steel that must be pass through to achieve penetration. The following formula will be used: \( a = b \times \text{Secant } C \) to calculate this where “a” equals the thickness of the armor on a horizontal line that must be penetrated in order to enter the vehicle interior. The letter “b” equals the known thickness of the armor plate. C is the angle of the slope that the armor is at on the vehicle relative to the vertical.

In examining the basic data on the armor levels of the M4 and the T34 it is clear that the M4 has thicker armor on the turret and hull frontal plates in all models. The T34 has thicker armor on its hull flanks and sides. The factor that sets the T34 apart is the greater slope of its armor, both the turret and hull armor, this difference in slope is considerable in some cases up to 60° more then the M4’s 0-47°. Surprisingly, after examining the effect this has on the effective armor thickness we see that there is still, for the most part, greater levels of protection on the M4.\(^{119}\) A separate characteristic of sloped armor is its propensity to deflect kinetic armor piercing (AP) projectiles, in this area the T34’s sloped armor has a distinct advantage over the M4’s.

Several aspects of the M4’s design had a significant effect on its actual and perceived survivability, these include its fuel and ammo storage. Unlike most models of the T34 the M4 used highly combustible gasoline and upon penetration of the hull the

\(^{119}\) See Appendices F and J
likelihood of the vehicle “brewing up” became great. This was complemented by the storage of the tank’s main-gun ammunition along the sides of the hull where the armor was only 38mm thick and had zero slope. These problems were so prevalent in the M4’s predecessor, the M3, a tank that shared these same design flaws, that Soviet Premiere Joseph Stalin commented on it to President Roosevelt: “U.S. tanks catch fire very easily when hit from behind or from the side.” This correspondence caused the United States to stop shipment of M3s to Russia in favor of diesel powered M4A2s.\textsuperscript{120} To correct these critical flaws on mid and late production models vehicles had appliqué armor plates welded to the sides of their hulls over ammunition storage areas and “wet storage” honeycombs for the ammunition installed. The issue of a gasoline-fueled engine was never addressed except for the A2 model. The practice of using gasoline-fueled engines was continued in U.S. AFV design into the 1960s.\textsuperscript{121}

Communications:

Two areas of communication are critical in the tactical employment of armored vehicle, internal and external. Internal communications refers to the system in place enabling the crew to communicate over the loud noises associated with the operation of a tank, external communications normally refers to radios used to communicate between tanks during their employ tactically.

\textsuperscript{120} Loza, “Commanding the Red Army’s Sherman Tanks, The World War II Memoirs of Hero of the Soviet Union Dmitriy Loza”, xiv

\textsuperscript{121} The M113, M114, M88 and early and mid production models of the M48 were all gasoline powered. The reason for the consistent use of gasoline powered vehicles by the U.S. is unclear.
Internal communications were a distinct handicap for crews on T34s, in virtually all models the only crewmembers who were equipped with intercom gear where the driver and the tank commander. This intercom system was renowned for its unreliability and the most common method used by Soviet tank commanders (TCs) to direct the driver was to physically tap him on the shoulder or head in a pre-determined method.\textsuperscript{122} This was in contrast to M4 crews, who like crews on all US designed tanks ensured that all crewmembers had 2-way intercom connections. This one factor undoubtedly had a profound effect on the "fightability" of the tank in combat.

The comparison of external communications reveals a similar imbalance, while all M4s were equipped with two-way radios; T34s manufactured through 1942 only had radios installed on command tanks. This practice changed starting with the Model 1943 but if one takes this into account almost 50% of all T34s produced still had no radios.\textsuperscript{123} One factor that made the lack of a radio less of a hindrance for the T34 than might have been for the M4 was the more centralized control dictated by Soviet doctrine, emphasizing adhering to the established plan and the use of battle drills. Once again this factor would severely hinder the flexibility of any Red Army formation, so equipped to adapt to an evolving tactical situation.

Military, Industrial Culture Reflected in Vehicle Development and Design:

As has been demonstrated, several characteristics of both tanks, either in design or development are very similar, an examination of the reasons for these similarities including how and why they occurred will be the next aspect of this examination. The

\textsuperscript{122} Andrzejczk, Ramund, Capt., Polish Army, interview by author, January 2000
first of these is mass, when reviewing the history of each of these combat systems one can not help but marvel at the magnitude of them as industrial products, with each vehicle being produced in numbers in excess of 40,000 before the end of the war. Total numbers of T34s produced range from 40,000\textsuperscript{124} to 54,550\textsuperscript{125} while the total number of M4s produced was 46,129.\textsuperscript{126} How each nation viewed mass is where the difference lies, in the American case it was in order to overwhelm the enemy with the industrial might of the country, filling not only U.S. Army units but also those of all allies we could get to help in the fight.\textsuperscript{127} In the Soviet case mass production was more of an enabler to build units in overwhelming proportion so that, in operational terms, massed tank formations and massed armies could achieve victory.\textsuperscript{128}

The next difference that reflects industrial culture was how each nation maintained the incredible production rates. In the Soviet case, with a command economy and a centralized planning structure, production improvements were implemented on a fleet wide basis. There were exceptions to this, where some plants produced cast turrets, some welded and others even pressed depending on their production capabilities. This was caused largely by desperation due to the threat of German forces that were rolling

\textsuperscript{123} Potapov, Valeriy Editor. "Russian Battlefield Webster", [http://history.vif2.ru/] (7 March 2001)

\textsuperscript{124} Grove, "World War II Tanks", 113

\textsuperscript{125} Zaloga, "T-34/76 Medium Tank, 1941-1945", 35

\textsuperscript{126} Bos, Note to Mark Falkovich, director Historical Office, U.S. Army Tank-Automotive Command reporting U.S. tank production figures. 26 May 1987

\textsuperscript{127} Keegan, "The Second World War", 218, 219

\textsuperscript{128} Ogorkiewecz, "Armored Vehicles and Armor", 52

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east and threw the innovation and determination of plant managers to produce the most tanks they could.\textsuperscript{129} In the case of the M4, a conscious decision was made centrally, much like the Soviets, by the Armaments Board, to produce several models of the M4 simultaneously with different manufacturing methods used on the hull and turret, also like the Soviets. But in the American case, this was also done with entirely different power-plants, sacrificing interchangeability and optimal performance for increased production rates.\textsuperscript{130} Additionally this enabled the next point, where the American design used technology and high quality manufacturing standards to improve the vehicle’s reliability and overall operational characteristics while the Soviets relied on a basic, but robust design that was not as reliant on precision manufacturing methods. Part of the reason for the Soviet stance was the immaturity of its industrial complex, but more importantly was the fact that most T34s were manufactured while the German Army occupied at least part of the country.

Implementation of product improvements represents the final factor; here the Soviets maintained standardization throughout their entire production network. Modifications to the design were normally implemented on a system-wide basis with the advantage of standardization, but with the disadvantage of slowing improvement. This is best demonstrated by the switch in production to the T34-85 following Kursk. The American method of producing numerous models simultaneously and not shifting to a

\textsuperscript{129} Bialer, "Stalin and his Generals", 204. This account deals with the aircraft industry but the same held true with tank production considering the two primary facilities were Kharkov and Stalingrad.

\textsuperscript{130} Grove, "World War II Tanks", 131, for a more in-depth examination of this subject refer to MacLeod Ross’ “The Business of Tanks 1933-1945".
significantly better design once it was available, allowed for the rapid establishment and maintaining of incredible production rates. The negative side of this method was the severe disadvantage Allied tankers had in combating German armor from 1943 on.
A detailed comparison of the potential combat effectiveness of each vehicle demonstrates that in most respects, the M4 was a technically superior tank. This runs counter to popular history where the M4 has developed a reputation as being under-armored and under-gunned, while at the same time the T34 has been called "the finest tank in the world". This popular history fails to recognize that beyond its numbers and mechanical reliability, M4s had better frontal armor, even accounting for slope and better armor penetrating capability than comparable models of the T34. Additionally, both of the M4's guns could effectively engage enemy armored targets at a greater range. This is not to discount the T34s innovative combination of excellent mobility, firepower, and armor protection combined with its incredible simplicity and robust design. What is for certain is that both vehicles were kept in production well after they were out classed by their German counterparts, in order to maintain huge numerical superiority.

Why then have these myths continued over the years? The first reason is that the Sherman was out-classed by all new production German tanks by 1943 and because of

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131 Culver, "Sherman in Action", 4  
132 Grove, "World War II Tanks", 110
this they suffered tremendous losses during the Normandy Invasion and its subsequent breakout. Next was the fact that the M4, much like its predecessor the M3, had a propensity to burn when it was hit from the side, this was especially true in early models. Of all M4s lost to enemy fire in the European Theater of operation, 90% burned. As we have discussed, this was caused by thin side hull armor, a poor storage plan for ammunition and the American use of gasoline to fuel its tanks.

During the Korean War limited numbers of tank vs. tank battles occurred between North Korean T34s and U.S. tanks including M4s, the varying proficiency of the crews and the unconventional environment in which they fought prevent us from arriving at any definitive conclusions but several points can be drawn. First is that M4s mounting 76mm guns penetrated T34-85s over 71% of the times they actually hit their target. North Korean T34-85s penetrated U.S. tanks only 32% of the time when they hit; both of these percentages are only considering target hits so as to eliminate the variable of crew proficiency. Additionally the probability of an U.S. tanker in a vehicle penetrated by a T34-85 becoming a casualty was 40%, while the chances of T34-85 crewmember becoming a casualty if his tank was penetrated was 70%. These figures clearly demonstrate the superior lethality and crew protection of the M4.

The Soviet T34 was a revolutionary design largely pursued from the bottom of the hierarchical chain, its design bureau. The American M4 was a doctrinally, top driven

133 Ross, "The Business of Tanks 1933–1945", 280
134 McRae, "Tank vs. Tank Combat in Korea", 44, 51
evolutionary design, these run counter to conventional logic that would predict the centrally controlled command economy of Soviet Russia and the independent spirit of American ingenuity would have caused the reverse to be true. This trend reverses in the production and product improvement stages of both systems returning to what logic would dictate a market and command economy might produce. What is clearly demonstrated is that each nation's military, industrial culture reflects in its product, with the American product being precisely and reliably made, but only of adequate design, with numerous versions being produced simultaneously in order to satisfy all consumers and maintain production rates. The T34, on the other hand, was an incredibly innovative, but simple design built crudely, but in huge numbers. Production was maintained by standardization and adhering to the basic, but solid design until it could no longer compete with its German adversaries.

One concept can be equally applied to both the T34 and the M4: mass production. Both vehicles had one overriding prerequisite that was constant from their early development through their entire production life and that was the ability to easily mass produce large numbers of them. Each country addressed this differently with each method having its advantages and disadvantages but both systems were able to produce over 40,000 vehicles prior to the end of the war marking what is likely the most significant legacy of each.

\[135\] Ibid., 25
APPENDIX A

ARMOR PENETRATION CAPABILITY DATA

<table>
<thead>
<tr>
<th>PROJECTILE WEIGHT (KG)</th>
<th>MUZZLE VELOCITY (M/S)</th>
<th>ANGLE OF ARMOR IN DEGREES</th>
<th>ARMOR PEN IN mm</th>
<th>457/500m</th>
<th>914/1,000m</th>
<th>1,371/1,500m</th>
<th>1,828/2,000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>75mm M2</td>
<td></td>
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</tr>
<tr>
<td>75mm/ AP (M72)</td>
<td>6.32</td>
<td>588</td>
<td>30</td>
<td>60</td>
<td>53</td>
<td>46</td>
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<td>792</td>
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<td>30</td>
<td>100</td>
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Figure 22: Armor Penetration Capability Data
Source: Hunnicutt, "Sherman" Potopov, [www.history.vif2.ru]

AP - Armor Piercing
APC-AP - AP Capped
HVAP - Hyper Velocity
APBC - AP Ballistic Cap
APCR- AP Composit Rigid
APPENDIX B

ARMOR PENETRATION CAPABILITY (CHART)

Figure 22: Armor Penetration Capability (Chart)

AP - Armor Piercing
APC-AP - AP Capped
HVAP - Hyper Velocity
APBC-AP - Ballistic Cap
APCR-AP - Composit Rigid
# APPENDIX C

## TURRET ARMOR DATA

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<td>FRONT</td>
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<td>REAR</td>
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<td>51mm/0° Cast</td>
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Table 4: Turret Armor Data

Source: AGF Board #2, "Development of Armored Vehicles" Zujan, [www.onwar.com/tanks]
APPENDIX D

ACTUAL TURRET ARMOR THICKNESS

Figure 23: Actual Turret Armor Thickness (Chart)
APPENDIX E

TURRET ARMOR SLOPE

Figure 24: Turret Armor Slope (Chart)
APPENDIX F

CALCULATED EFFECTIVE TURRET ARMOR THICKNESS

Figure 25: Calculated Effective Turret Armor Thickness (Chart)
### APPENDIX G

**HULL ARMOR DATA**

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<th>Hull Front, Glacis</th>
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<th>Hull Bottom</th>
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<td>M4</td>
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**Table 5: Hull Armor Data**

Source: AGF Board #2, "Development of Armored Vehicles", Zujan, [www.onwar.com/tanks]
APPENDIX H

ACTUAL HULL ARMOR THICKNESS

Figure 26: Actual Hull Armor Thickness (Chart)
APPENDIX I

HULL ARMOR SLOPE

Figure 27: Hull Armor Slope (Chart)
APPENDIX J

CALCULATED EFFECTIVE HULL ARMOR THICKNESS

Figure 28: Calculated Effective Hull Armor Thickness (Chart)
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