

On Land Warfare and Motor Vehicles: From Biblical Times, Through Tomorrow

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Abstract

For the past three millennia or so, land warfare has been based upon three types of fighting forces, infantry, rapid deploy forces (such as horse-based cavalry) and armoured vehicular forces. This article discusses aspects of the latter. We examine a bit of the history and attempt some extrapolation to conceive where this force may be headed. In that sense, the article is also speculative.

Basically, where are armoured fighting vehicles going (pardon the pun)? At present, it appears that they may have reached a technological impasse, as motor technology has not advanced significantly for the past century-fuel use today is remarkably similar to that of the original Ford Model T.

We begin the discussion with historical aspects emphasising the difficulty of powering mechanisms, continue with electronic vulnerabilities that are not well-known and then finish with powering issue for the future. Tanks historical success has been firstly based upon their power-source, with vulnerabilities coming into play primarily when the issue is tank-to-tank; this may change. Today's vulnerabilities may be more profound than is generally perceived.

Keywords: Tanks; Armoured fighting vehicles; Vehicular hacking

Introduction

There is a rich history of armoured fighting vehicles-astoundingly (at least to some) this history begins in the Bible, with the first such weapon coming on line shortly after the Exodus.

In a general way, it seems that these systems may be near their technological apex. The motor that drives them simply has not significantly advanced technologically for a century-fuel use and utilisation reached its current level long ago and seems to be stuck there. Internal combustion engines, whether gasoline (benzene) or diesel have horrible levels of efficiency and they do not seem to have advanced, at all; despite fantastic piles of money thrown at them by the automobile manufacturers.

The question arises; can this issue be addressed by what we see today in the laboratories? Can power plants' utilisation of fuel reach levels that make a real difference for the future of these critical weapon systems? It is this author's belief that the answer to this is affirmative, but not a trivial one to address.

This article briefly examines the history of armoured fighting vehicles and then uses various sources to speculate upon the possible directions new power plant technology, which may have the potential to revolutionise this field, may take.

Biblical References

Interestingly, the first historical reference to armoured military vehicles appears in the bible. The Tribes entered the Land of Israel with a devotion and ferocity that was unprecedented. This was matched by an ability to combine highly effective military art with very strong religious beliefs [1,2].

*One of the earliest commentators, Rabbi Hezkia Ben Manoah (France, b. ~1250) showed clearly that the intention of the term was purely military - thus "armoured" is the proper translation - Rabbi Yosef Haim David Azulai proved conclusively that this commentary was one of the earliest of commentaries. The word used is "TZAV" (tortoise) which only appears three times in the entire Bible, once concerning prohibited foods and twice in the military sense (Isaiah 66, 20).

²Tabernacle

"And they brought their sacrificial offerings before the Lord, six armoured wagons¹ and twelve bulls, a wagon on every two Leaders and an ox for one, and they brought them to the Mishkan². And the Lord said to Moshe thus: accept from them and they will be to perform the tasks of the Mishkan and give them to the Levites, as per their tasks. Moshe took the wagons and the bulls and gave them to the Levites. Two wagons and four bulls he gave to the Clan of Gershon as per their tasks. Four wagons and eight bulls he gave to the Clan of Merari as per their tasks, under Itamar the Son of Aaron the Cohen. But to the Clan of Kehat he gave none as their tasks is to carry on their shoulders" [3-9].

This reference clearly infers that the "motors" of these carts were bullocks, oxen. The people had just come out of Egypt, which as the leading military power in its day, used horse-drawn chariots extensively. These carts/wagons were drawn by oxen. This likely infers that they were too heavy to be drawn by horses. We do not know what their armour was, wood or metal, though we see the wagon was heavy. "Too heavy" infers that the armour may have been made of something of greater weight than wood. We cannot know what this may have been. We know that iron chariots existed. Were these plated with iron? Perhaps bronze?

As living creatures, it is obvious (today) that the oxen were the weakest point in these armoured vehicles as a tactical weapon-kill the beasts and the vehicle is immobilised. From that, one may infer that these were primarily useful as tactical foci, to anchor a line with a semi-mobile strong point, and not as tanks are used today, as highly mobile fighting vehicles.

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Unfortunately, we do not know a great deal about these. Nor do we know their armaments: archers, some kind of catapult or trebuchet, or “Greek Fire”, for instance.

We do not have a source to inform us of the answers to these questions, but we do know from the same source that these “former slaves” had amazing military success. ‘Something’ gave them a significant tactical military advantage.

All we really know for sure is that they evidently worked. Kingdoms were conquered, that had been entrenched for some time.

Leonardo da Vinci's Tank

Such armoured mobile weapons seemed to disappear from warfare after this, for many years, except for horse-mounted knights, which did not have very much success when mounted against other fighting forces. (They did fine, pitting knights against knights.) Once again, hurt the horse and the fighting man, no matter how well trained, is immobilised and basically useless [9].

Saladin used this weakness to great effect and advantage. He won, completely, against some of the greatest knights of all time (Richard I, Lionheart and his fellow knights of the crusades).

Forward to one of the greatest European geniuses, Leonardo da Vinci and his tank. We move forward 2,799 years, from 1312 BCE to 1487 CE—from a working fighting vehicle to a theoretical device that was as complete a failure as can be described (Figure 1).

De Vinci's machine was human powered, by eight men with hand cranks; but at least they were protected—he solved the issue of the bullocks' vulnerability to immobilisation. Many aspects of De Vinci's invention were ingenious. His armour was a superb advance. The armament was cannons with a 360° view. His mobility was not successful. Even with positive gear ratios the effort was unreasonable. It was never built nor tried.

The Beginnings of “Motorised” Fighting Vehicles

The first motorised fighting vehicles engaged an enemy in World War I. [9]

Interestingly and perhaps a bit surprisingly, there were no tanks, no armoured military vehicles of any kind, in any war, between the Israeli Exodus and World War 1, not even in the US Civil War, where armoured ships did appear in battle. The reason for this is quite clear;

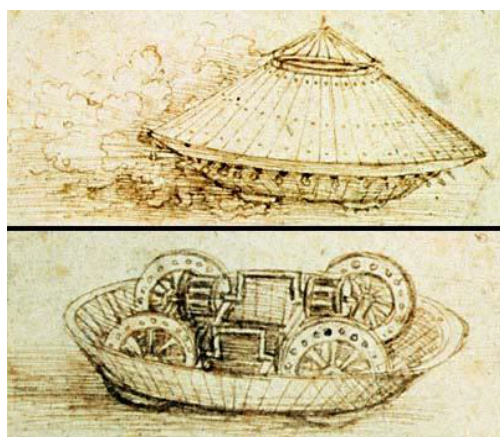


Figure 1: Leonardo da Vinci's Tank.



Figure 2: The beginnings of “Motorised” fighting vehicles.

there existed no motorised package that could reasonably propel them in anything approaching a satisfactory manner.

World War 1 tanks boasted two important and critical innovations, a diesel motor that could propel them, despite their great weight and caterpillar treads that enabled them to function in a broad variety of terrain types [10].

These were the missing technologies that would have allowed such a machine earlier.

- Note that Holt and general electric built a tank model (never implemented other than the initial single prototype) that attempted to utilise partial electric power for the tracks, alongside gasoline power [11].

- There were many types/models of tanks in World War 1. Almost all countries in the fighting produced them. The variety is not a relevant issue for this article, as technologically, they were all pretty much the same (Figure 2).

- Once those two innovations came on board, the world stopped looking. This statement is still relevant for today's tanks. They still stink, they still grind, they still have horrible fuel efficiency.

Weapons Hacking

While the main thrust of this article discusses the power plants of motorised fighting vehicles, it would be grossly remiss to gloss over an additional risk that needs to be assessed for them, and that is their “hack-ability”. Can a technologically advanced army immobilise the enemy's fighting capability by hacking their tanks?

Most people are probably accustomed to thinking about guns as clever devices that propel metal pellets via a small, controlled, chemical explosive charge. That is, of course fine, as that is an excellent initial definition, albeit at about 1,000 years of age, beginning to become somewhat limited in scope. Guns today, include much more than ‘just’ propelled pellets.

This article discusses a different kind of *gun*; perhaps one should say, a ‘gun’ that *goes bump in the night*. This is not science fiction; this is science now. Islamic State has a laboratory in what used to be Syria doing this work now. The “Government” of Iran, the world's largest and most funded terrorist organisation, has already used these technologies! In other words, people have already died from this; and not a trivial number of them. The United States military establishment left some six billion dollars of equipment on the ground in Iraq, after its hasty retreat [2, 12]³. All exemplars of equipment were promptly shipped “next door” to Iran and Iran has reverse-engineered virtually all the technologies.

³Page 279

Stuxnet was described as, a 'guided missile' directed at Iranian nuclear plants. Iran admitted damage, though for obvious reasons, no details have been disclosed. As a four-decade professional in many Information Technologies aspects, with significant security experience, I estimate four countries had the capability to produce such a weapon, and China and India as far as I perceive, lacked motivation. I certainly cannot say where this software originated and if I did know, I could not say. As far as has been disclosed, no persons were harmed by Stuxnet, though there seems to have been significant damage to equipment and production schedules. A new kind of 'gun'? The first weaponized computer Malware designed to attack both a specific target (Iran) and type of system (industrial).

All motor vehicles have massive amounts of software and many tens of interconnecting computing devices. Automobiles have ~100 million lines. (In "Glitch" Papaws predicted that "by 2016, 62.3 million global consumers will have Internet access in their cars" [8,13]⁴. Airplanes' complexities reach tens of millions, with some reaching twenty to fifty times that amount. The massive quantities of software means that there are massive 'opportunities' for anomalies and glitches of all kinds occurring, many that may prove untraceable given the complexity. The amount of code in a modern tank (more on this concept below) is unknown, but is clearly very high.

The F-35, for instance, makes a new precedent; the entire platform is controlled via ground-based software (as opposed to 'on-board' control, though the on-board software is additionally extensive). In other words, if there is a problem with either the software or the communications uplink, the plane either does not take off or, if it is already in the air, does not perform. Hundreds of billions of dollars in costs, not to mention embarrassments, bad publicity and liability lawsuits, can be jammed by a State or non-state actor, rendering the platform worthless. Feder, in "Defense Systems Analysis, William et al. ("Perspectives on Defense Systems Analysis")⁵, quite rightly notes that "...stealth aircraft are called low observable, not unobservable." One does need to "observe" if one can simply shut it down. The British did exactly this to Saddam in 1991, to all his anti-aircraft defences purchased from them [6].

Cars' (i.e., private automobiles) internet access makes possible myriad automotive software applications, with the ability to repair them via 'up-down-load' via the net. Microsoft has used this repair concept extensively and successfully for many years, to constantly improve applications and operating systems. Equal with the manufacturer's motivation is that of consumers'. Why would a purchaser of an expensive car not desire to have it loaded with the most up-to-date software to ensure everything functions as well as possible and that inevitable software errors are found and repaired, with no fuss to the owner?

This is certainly not limited to cars. Just so there is no misunderstanding, Boeing does it, Airbus does it. All software can be repaired via upload link. All airplanes are linked via com-links. It sounds almost utopian? The entire F-35 programme is based upon this concept and design.

The coffee shoppe metaphor

In vehicles, today-automobiles, military vehicles and airplanes-it is important that all applications have strict security measures built into them, with clear user identification; whether a consumer application or a manufacturer's. None of this security presently exists, for any

commercial product. This means that a 'hacker' (any person skilled in software code encryption, decryption and manipulation) can devise a software application capable of identifying a specific person in a precise automobile, truck, airplane (etcetera) anywhere-anytime; even a Crown Prince of England.

The same, or a different person, may devise a 'Stuxnet-like' application that travels to that vehicle, identifies the target, and perhaps other passengers, and 'powers down' the car's or truck's braking system, or the ability to extend landing wheels, or simply takes over and heads for the nearest tree at full speed or any of another hundred or so ways to make the vehicle into a death device.

All this can, of course, be done from the comfort of one's favourite armchair at home or from an internet-linked Coffee Shoppe, anywhere, anytime [1,6].

Assassination can be prevented via building strong firewall protection around all com-link applications, but this defeats the download device to repair failures before they occur, at very considerable saving of consumer lives and cost savings to manufacturers a fascinating dichotomy between abilities and requirements.

A Mercedes travelling at high speed, crashed into a tree on 18 June, exploding into flames and killing the driver; the engine ejected 50 meters from the car. Was it an accident or was the car hacked, driving it off the road by remote control? It might sound like a movie, but the driver was identified as journalist Michael Hastings, who was known for revelations on US military and intelligence agencies. Hastings had emailed colleagues the day before saying he was going "off the radar for a bit" to chase down a "big story". Accident or intent-conspiracy theorists claim to know, I can only ask because I have no data.

This capability is a new kind of gun and we need to enhance awareness of the possibilities. Who is responsible for ensuring security of vehicles-cars, trucks, airplanes and etcetera? Interestingly, in an analysis of DHS budget reports from the past five years, exactly zero dollars have been allocated to this issue.

For perspective: engineers Javier Vázquez Vidal and Alberto Garcia Illera built a \$25 device to bypass automobile electronic control unit security; and a wireless version is on the way or already functional. This is one effort of the kind, of many.

So much for private automobiles. How far is it from this to hacking enemy tanks, as a 'live' war weapon? Nobody really knows the answer to that question. From my experience, I would estimate it at a distance of millimetres.

Today's Most Advanced Tank

Israel's Merkava Mark 4 is usually considered the world's best tank. "Best" is a difficult, if not impossible, description for a battle weapon. What are today's primary criteria?

- Protection: The Merkava is the most highly protected tank. External armour is modular and can be reconfigured. In addition to very sophisticated passive armour, it also boasts several layers of active protection. These include highly-refined threat identification systems.

- Bit has a battle management system. Some reports have hinted that this system is swarm-integrated with helicopters, F-16s and other tanks, making the tank simply an integrated part of a total battle management system.

- Another interesting advance is that the motor subsystem can be totally replaced within 30 minutes, in the field. A variant of the Merkava M4 exists as the Namer, an armoured personnel carrier [12].

⁴Page 22

⁵Page 80



Figure 3: Today's most advanced tank.

- The weapons' systems contain several packages, machine guns, missiles, cannon and etcetera (tank weapons are out-of-scope of this essay).

How vulnerable is the Merkava Mark 4 to hacking attacks? Nobody external to those that "need to know," knows. Certainly, nothing is (or should be) published concerning this issue.

In the twenty-first century, swarming and high integration are the keys to significant battle power advantages, but they may contain hacking vulnerabilities that have so far been untested (Figure 3).

What I personally find most frightening however is not the hacking vulnerability-real or imagined. People are generally aware today of this type of threat, and awareness is the beginning of protection. What interests this article "here and now" is that there has essentially been no power advance since World War I-we still power the tanks of today, regardless of all their other sophistications, with the same internal combustion engine used a hundred years ago.

To take this technology further, this issue needs to change significantly.

Future Power

Asking Google: "What percentage of potential energy in petrol is actually used?" Elicits four million times "HUH!"

The California energy commission publishes a site with consumer "advice" where they supply some quantification of energy density for automobiles. They claim that about fifteen percent of the energy poured into the automobile actually is used and the remainder is inefficiencies. This includes some sixty-two percent lost in the engine. The US Department of energy puts this number at fourteen percent-the difference is statistically insignificant [4].

The equivalent US DoE site for Diesel claims that diesel fuel contains a higher energy content, but provides no number-guidance as to fuel efficiency or energy density. On Hybrids, the equivalent US Government site claims twenty-five to forty percent (25% to 40%) fuel efficiency [14,15]. While finally the US Government equivalent site for all electric vehicles claims that seventy-four to ninety-four percent of the fuel is used to move the car [16]. All things considered, the US Government's "political" agenda seems more to be advanced here than science [17].

Why do I say that? Why do I doubt this source?

If all-electric cars were so super-efficient, I believe we would see highly successful products. So far, the best that can be said for all-electric automobiles is that they may be reasonable for some niche applications but they are still far from viable for the vast majority of consumers.

Future Vehicles

Are we headed towards a world where individual mobility will be based upon all electric vehicles? So far, electric vehicles are based upon lithium-based batteries. Lithium is in constant short supply. Battery technology advances at a rate of about six percent per year. At that rate, several decades more are needed before the all-electric vehicle may become a viable universal product. Simply put, this is too long to wait, for a highly questionable product.

Science Fiction: It is well-known that science fiction writers provide a vast source of inspiration for engineering advances. What may we learn from science fiction towards mobile fighting vehicles?

There have been three military science fiction series that came out on-screen. There have been no exceptional military science fiction books (at least, not for a very long time). Star trek and star gate (regardless of any opinion as to the various qualities) were space-based and ground based military, but all ground based action was based upon highly trained, special forces. Hence, for our purposes here, they are not helpful.

The first Star Wars movies were introduced in 1977-exactly half a century ago, with the second series of movies beginning in 1999. In this second series, the so-called "prequel," that we saw a vision of ground-based military action, that also used motorised vehicles. Considered observation of these "suggestions" indicates that they are all possible, but are today blocked by our continued dependence upon ridiculously inefficient internal combustion engines. It is clear that petrol-based fuel is an excellent fuel source; but it is also clear that the internal combustion engine is a dead end that has reached, or very nearly reached, its efficiency apogee; despite excellent attempts to alleviate the absurdity of inefficiency that exists today [6].

What is likely to be the direction for the "new engine" that we may attempt to imagine here? Clearly, this is speculative. My personal experience indicates that whatever any one of us expects, someone will surprise us with a direction that was less expected [7].

(I have visited this company-Aquarius engines-and their technology is amazing. Is it 'sufficient' to revolutionise all aspects of motorised fighting vehicles as envisioned by this article? Quite certainly not! The inventor made it very clear to me that they are designed for a specific purpose and for that they are superbly suited. They are a significant step in making standard automobiles quite a lot better in terms of their fuel efficiencies. Can they be engineered differently to suit them for exceedingly heavy vehicles? That is quite unclear.)

My personal view is that the most likely direction may be something like either a plasma-based engine or a pulse-ion-based engine, fuelled by fossil fuel-petrol (liquid fossil fuel). How likely is this? Nobody knows or can know. What we do know is there exists plenty of liquid fossil fuel, that it is fantastically rich in energy and that it is readily available-these liquids are definitely not about to give out! [5].

Theoretical and Practical Considerations

There exist two basic questions.

- Are heavily armoured mobile fighting vehicles still needed or are they obsolete in today's milieu of Special Forces?

- Can the speculations presented here solve the issues and are they ready for deployment in a foreseeable future?

Heavy armoured vehicles are needed and, I believe, will continue

to be needed. Mankind is a fighting species. Even if we do transplant to other planets at some time in the future (I am not optimistic for that chances of that to occur within the twenty-first century) they will still be needed. As a matter of fact, I believe a vast compendium of science fiction-movies and novels-seems to show that this type of warfare is highly unlikely to “go away” at any time in our collective future. Special Forces are very important. They will always have a significant role, and it seems an increasingly significant role. However, they will not replace heavily armoured fighting vehicles.

How likely are such concepts as plasma-based or “pulse-ion-based” technologies? We do not know. Surprise me! That is likely the realm of science fiction, but in any case, outside the scope of this brief opinion piece.

What is, I believe, significant here is not the supposed technologies that I perceive, from my view of laboratories, but the fact (inescapable) that a new and significant technology for engines is needed-not an incremental improvement such as the Aquarius engine sighted above, but something that will revolutionise fuel use.

Conclusion

Fighting vehicles have gotten significantly smarter over the past two or three decades. They may have even gotten a bit faster. But they have not really improved in anywhere the same types of improvement that we see in the air or the sea. Basically, the motor to drive them is retarded. The basic internal combustion engine has stayed put where it “began” a century ago-not because of issue with the fuel, but because they still use an absurdly tiny percentage of the energy potential of the fuel for actual motion. Too much is wasted on noise, vibration and other forms of energy waste. This is, of course, the same issue with automobiles. The basic lack of efficiency of the power source is astounding. It is also socially and economically debilitating-it is also a pollution and climate issue (but they are out of scope of this paper).

A new level of thinking is needed and a new way of thinking about powering large, heavy vehicles must be invented.

This speculative paper briefly surveys the history of armoured

fighting vehicles and then speculates on the possible directions for this new type of power source.

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