What Can Modern MBT Designs Tell Us About The Future?

The battlefield must be examined as a whole, it is senseless to only evaluate a tank without thoughts on what war the tank will be fighting and where. In addition, other aspects such as the army using them must be considered.

Questions such as what other supporting elements the army has, the quality of their other service branches, and the likely opponents the army will be facing must all be considered when evaluating the merits of various tank designs.

It must be remembered that no tank in history has proven itself to be invulnerable, and nearly every positive design decision also results in a trade-off somewhere, whether this is an immediate design trade-off, or an economic or manufacturing trade-off, all of which may help a country to win a war, which is the ultimate purpose of a tank after all.

DIFFERENCES IN EASTERN AND WESTERN DESIGN PHILOSOPHY

Engineers in the East and West had competing design philosophies which were largely borne out from experiences in the Second World War and the wars that followed. Both of these philosophies have led to the tank designs of today, and an analysis of their relative advantages provides clues about what to expect from the future.

Soviet tank design philosophy had a preference for two tiers of tank, with one tank which is less capable, but can be produced in greater numbers, and a more capable tank which was less numerous, but better-suited to tank combat. These pairings can be seen with the T-54/55 and the T-64, or with the T-72 and the T-80. With the advent of the main battle tank concept, Western planners broadly speaking preferred to use a single main battle tank platform forming a unified fleet of tanks. Soviet designers exhibited a preference for making tanks

relatively small, low-profile, and not too heavy, while Western vehicles became progressively larger and heavier through the second half of the XX century, with notable exceptions to this trend being the Leopard 1 and AMX-30 tanks.

The results of this difference in philosophy can be easily seen when, for example, comparing the T-72 and the Leopard 2, or the M1 Abrams series of tanks. The T-72s are significantly smaller, shorter, and lighter than their Western counterparts. This has some advantages, insofar as the T-72s are significantly cheaper to produce and cost less to maintain, allowing the user to field a larger fleet of T-72s than they could with Western tanks for the same budget. In addition, they can be dug into protected positions more quickly, they don't require an engine as powerful as those required by modern Western tanks, more of them can be transported per ship or other transport vehicle, and they can be more easily recovered by recovery vehicles. The low-profile layout of Soviet-designed tanks was intended to present a more difficult target to enemy fire, minimising the risk of being spotted or hit, and came at the cost of a more cramped and less comfortable interior and a lower range of gun depression. The lighter weight of Soviet tanks also presented its own trade-offs insofar as it meant that Soviet tanks tended to lag behind the heavier US and British designs such as the M60 and Chieftain in terms of the level of passive armour protection they provided. Although Soviet designers did adapt to the crucial threats of the day by developing layered armour solutions such as the Combination K package used on the T-64, the greater breakthrough which to an extent vindicated the lighter tank design philosophy was the use of explosive reactive armour (ERA). This provided significantly greater protection against shaped-charge threats in particular, and has since also become more effective against armour-piercing fin-stabilised discarding sabot (APFSDS) rounds as well.

Western tank designs from approximately 1980 onwards have been looked at more kindly in the public imagination, due in large part to the apparent successes of its designs shown through low losses in conflicts until around 2006. However, this perception has begun to change as the technologies built to defeat these tanks have landed in the hands of the people actually fighting against these tanks. In more recent conflicts such as Syria and Yemen, where rebel groups have had access to more modern anti-tank guided missiles (ATGM), many Western tanks have been shown to have significant vulnerabilities. However, while most attention tends to focus around tank losses, it is perhaps more significant to see the toll the heavier tank philosophy has exacted on their users and on budgets.

In the present day, Western tank fleets are often seen as cumbersome tools by their primary users, being too expensive to purchase and operate in large numbers, and too heavy, which prevents them from being rapidly deployed to where they are needed in any meaningful quantity (1, 2). The extreme costs of purchasing and maintaining an active tank fleet have led to repeated cuts to active tank personnel and increasing numbers of tanks being mothballed in warehouses and relatively small tank fleets compared to those maintained by major European countries during the Cold War. Some of this is due to risk-averse strategies to increase survivability, such as simply adding increasing quantities of various passive armours and tolerating the weight increase, or an aversion to gambling on riskier technological advances and new designs, or budgetary constraints and greater budget priorities. However, regardless of the cause, in a time of strained defence budgets, and due to the changing character of modern warfare, it is becoming evident that fleets of post-1980 Western tank designs do not represent a sustainable and flexible option for most Western armies. A re-evaluation of some core design concepts will be necessary in the tranche of new tank designs which are due to emerge post-2035.

ALEKSANDR POTAPOV,
GENERAL DIRECTOR OF
URALVAGONZAVOD

I can say that our equipment is at a sufficient stage of readiness, and has a sufficient level of digital capability, that the transition to an unmanned vehicle variant is already a natural direction

T-14 Armata, Russia

It is also important to note that over the past half-century there have been very few clashes between Western and Eastern tanks of the same generation, or between those upgraded to a similar standard. With the possible exception of several tank battles during the Iran-Iraq war there seem to be almost no examples of significant numbers of tanks of a similar standard clashing in combat. Even the examples in the Iran-Iraq war, such as the Nasr Operation which took place in 1981 and represented the largest of the tank battles during this war, holds relatively few lessons which pertain to tank design compared to the lessons it provided in tank tactics and the importance of reconnaissance (3, 4, 5). With all this in mind, it is still possible to evaluate some of the most significant modern tank designs and get an idea of the direction tank design is heading in.

T-14 ARMATA

The T-14 Armata has easily been the most-discussed tank in recent memory, and with good reason. The most notable feature of the tank is that it uses a layout of an unmanned turret and protected crew citadel which has previously not been used on any tank entering serial production. The concept however is not a new one, and has been examined by a number of countries over the years in various concept prototypes.

These concepts notably include:

• Russian Object 195 (T-95) – began development in 1988 and was cancelled in 20106 .

• US M1 Abrams Tank Test Bed (TTB) – began development in the early 1980s, a prototype (SRV) built by 1983, and was cancelled in the early 1990s7 .

• US Teledyne Expeditionary Tank – began development in 1982, eventually losing out to other designs in the AGS competition in 1992, and was effectively cancelled by the mid-1990s8 .

• Soviet Object 450 (T-74) – began development in 1972 and was effectively cancelled by 19749 .

• British COMRES 75 test bed vehicle – built in 1968 and did not progress significantly (10).

Unmanned turret designs have therefore been of significant interest to militaries for a long time, and with good reason – while the turret is perhaps the most definitive feature of the tank, its presence is also greatly problematic for tank designers as it represents perhaps the tank's greatest vulnerability which must be addressed. In order for the gun to depress sufficiently to aim and fire at targets located lower than the tank, the turret needs to be reasonably tall, to allow the gun trunnions to be fitted higher in relation to the hull, and to allow sufficient space for the breech to move upwards. However, with manned turret designs this would lead to creating a bigger target, allowing the vehicle to be spotted at greater distances and more easily hit. In addition,

because the majority of the crew are located inside the turret, it becomes necessary to add more armour to the front and sides of the turret, in order to protect the crew. If the turret is already large, the designers need to provide protection to a greater surface area, which makes the turret and the entire vehicle much heavier.

On most designs the turret face is the best-protected portion of the tank, simply because it presents the likeliest target for enemy fire and has to protect two or three members of the crew. However, doing so means adding much more weight to the front portion – typically the frontal 60° of the turret, and this can throw the turret off-balance, with too much weight centred on the front portion. This can be balanced by adding a bustle to the rear of the turret to act as a counterweight, but doing so makes the turret an even bigger target, and this added weight increases the inertia of the turret while traversing, which requires more powerful motors to traverse the turret. Without more powerful motors the ability of a turret to aim at different targets in quick succession would be adversely affected (11). This increases weight and power requirements, which can lead to some of the previously-mentioned problems associated with modern tanks.

The unmanned turret of the T-14 Armata solves some of the greatest disadvantages of turreted tank designs. However, it has not managed to achieve this without some significant departures from Soviet tank design philosophy. For starters, the size, and reported cost of the vehicle has risen to standards almost comparable to Western designs, although the weight remains slightly lower. This is indicative of a cultural shift within the Russian Armed Forces which has been ongoing for the past decade, aiming to professionalise and modernise. With the replacement of conscripts by Kontraktniki (contracted professional soldiers) wherever possible, these professional soldiers became an investment which need to be protected by modern equipment, and for tanks this means a design which provides a radical increase in survivability. The T-14 certainly meets these criteria for crew survivability, however it has also made some significant trade-offs which affect its suitability for warfighting, and its cost and ease of production in order to attain its level of capability.

To start with the turret, the models shown so far have been fitted with a ‘soft-skin’ of steel approximately 5–7 mm thick around the turret’s systems, which is unlikely to be capable of protecting against heavy machine gun fire, to say nothing of its inability to keep out automatic cannon fire. Doing so is not necessarily bad – it saves a great deal of weight and allows the T-14 to be more deployable than its Western analogues, and makes the tank cheaper and simpler to manufacture. However, it also creates a problem of a lack of protection for the vehicle’s expensive electronic components, such as the sighting systems and radars. As such, these expensive components are highly vulnerable to common battlefield threats – artillery, machine-gun fire, and cannons. Although the crew may survive such threats easily, the tanks which have sustained fire to their optics and radars will be unfit to send into combat. This forces the army which uses the T-14 to invest significantly more into logistics, repairs, and spare parts, or forces them to limit the conditions under which the vehicle can be deployed to combat. This last point is perhaps more significant one, as no army would like a vehicle which is limited in terms of deployability. The T-14 seems to be well-suited to engaging rivals in tank-on-tank combat, but much less suited to engaging nonstate armed groups in the complex, low-intensity conflicts which are more common today. In such conflicts, it is a more expensive and less efficient tool for the job than a T-72B3, and this is perhaps why the T-14 has yet to be spotted in Syria.

Ultimately, wars are won by achieving the right balance of priorities, and while the T-14 is undoubtedly a very advanced and capable tank, it is of less use to most armies than a more flexible platform such as an IFV, which is cheaper, more deployable, less of a logistical burden, and has a more flexible mission profile. While these critiques have been raised here in discussing the T-14, in reality they are equally applicable to Western armies and Western tanks also. The tank still has an important place on the modern battlefield, but its primacy has been overtaken by its smaller and lighter cousins such as IFVs for cost and flexibility reasons. Modern Western tanks likewise have difficulty protecting their external components such as optics or radars from artillery and machine guns, simply because it is difficult to make a valid tank design which can protect these. As such, this problem is global, and without an obvious solution, it is likely to be a very expensive factor which every actor simply has to accept as a design limitation through the XX century. There are certainly a number of important innovations on the Armata which should influence future tank designs, and chief among these is the location of

the crew and remote turret concept, and the level of automation invested in many of the tank's systems. As battlefield threats increase in speed and complexity, it is naturally to be expected that many human tasks will likely need to be fulfilled by machines.

M1A2 ABRAMS The US M1A2

Abrams, while a highly capable vehicle, also suffers from a great many of the problems previously outlined with tank fleets. It is provided with high levels of protection for the turret based around a multi-layer sloped passive armour array in the turret sides and bustle, and on domestic variants the front of the turret includes depleted uranium (DU) armour elements (12, 13, 14, 15). It should be noted that the export variants of the tank, such as those in use by Saudi Arabia, did not receive the DU armour elements, and this may be a partial contributing factor in their loss rates in Yemen (16).

ROSS COFFMANN,
BRIGADIER-GENERAL, DIRECTOR OF THE NEXT GENERATION COMBAT VEHICLE CROSS-FUNCTIONAL TEAM (CFT)

We're going to make a decision on what the Abrams replacement will be, which is really exciting, because it might not be a tank. It is decisive lethality – and what that decisive lethality is will be determined by academia, our science and technology community in the Army, as well as industry

M1A2 Abrams, USA

The wisdom of using depleted uranium (DU) as an armour material for the M1 Abrams has been put into question, having been cited in a number of cases related to health risks (17, 18). While a clear consensus is unlikely to emerge, this issue may have been a contributing factor to the decision to add a graphite coating to the DU armour elements in the first Systems Enhancement Package (SEP v1) upgrade (19, 20). It is also notable that no other mass-produced tank design has copied this particular feature of the Abrams. Nonetheless, the Abrams family's performance in Iraq has shown that the protection along the frontal portions of the vehicle is extensive against many commonly-available AT weapons. However, the protection of the upper surface seems to have been a low priority, as the Abrams has notably thin and weak roof armour (21, 22). While the roof armour of nearly all vehicles is rather thin, some NATO countries have taken the threat from artillery bomblets and top-attack missiles a bit more seriously, and have provided additional roof protection for the tanks, while on the Abrams this is notably absent, even on the M1A2C variant, judging by available images (23, 24).

The Abrams series has undergone significant upgrades since the original model, and these upgrades have largely focused on improving the passive protection, the engine, the sighting system, digitisation, and power storage. A key element which has not been upgraded is the gun, which remains the M265 L44 smoothbore gun used on the M1A1. This leaves it with a gun capable of generating significantly less muzzle energy than those used by the British Challenger 2 (L55), the French Leclerc (L52), and later variants of the German Leopard 2 (L55). The Russian 2A46 series guns are also alleged to provide a higher muzzle energy, however their potential in tank combat has been partially held back due to ammunition being limited to a length of approximately 640 mm to fit into the T-72 and T-80 autoloaders25, 26. Although it became possible to fit the longer 740 mm Svinets round into the T-90A and T-72B3 models, overcoming the fundamental limitations to Russian tank ammunition and adopting longer penetrator designs was only truly possible by moving to a larger hull design which could provide the space needed to accommodate an autoloader with larger munitions of a new generation – the T-14 (27).

The Abrams' impact on future tank design is difficult to quantify, as although it is a capable vehicle, two major design features, the gas-turbine engine and the DU armour elements, stand out as features unlikely to be used in a future MBT. The gas-turbine engine for example requires significantly more fuel than high-end diesel engines and generates a larger heat signature. The DU armour, as previously discussed, is unlikely to re-emerge due to uncertainty regarding its effects on personnel.

LEOPARD 2

The most upgraded variants of the Leopard 2 are perhaps the most combat-capable tanks in the NATO arsenal. It is difficult to criticise vehicles such as the Leopard 2A7V without reference to their extreme cost to build and operate, and their lack of an active protection system. The losses of Turkish Leopards in Syria should not be seen as a true lesson on the vulnerability of this vehicle, as the Turks were using the much older Leopard 2A4 standard, which is significantly less capable than more modern variants. In addition, the lack of support for the Turkish Leopards was a contributing factor in their loss, as tactics which do not provide adequate support are liable to be punished, as was shown. Perhaps the biggest lessons to be learned from the Leopard 2 is that the inbuilt modularity and upgradeability is a necessary factor in any future tank design to maintain pace with future threats. The newest variants of the Leopard 2, such as the 2A7, are almost a completely different vehicle when compared to the older models such as the 2A4, and are capable of withstanding fundamentally greater threats. Other tanks have shown themselves to also be upgradeable to a high standard, but none exemplify this characteristic to the same extent as the Leopard 2's evolution has shown. However, the still-greater significance of Leopard 2 may be political rather than its battlefield capabilities.

JENS STOLTENBERG,
GENERAL-SECRETARY
OF NATO

You know that in Europe there are
17 different types of main battle tanks.
In the United States there is
only one. In Europe there are
13 different types of air to air missile.
In the United States they have three.
And European nations have
29 different types of naval frigates.
The United States have four.
I mention this because it highlights
the importance of more cooperation
in Europe when it comes to European
defence. Therefore, European Defence
Fund is good, the PESCO is good,
because these are ways to try
to address this fragmentation,
to increase efficiency and to make
sure that European Allies, the
European Union, is delivering more
when it comes to defence.
This is something I strongly welcome,
and which I, on behalf of NATO,
has many times expressed
that we support

As Europe proceeds to seek greater integration in the defence matters, it is likely that European leaders will seek to coalesce future designs around a common platform for greater interoperability and to create larger economies of scale. This has already started to happen with the 'OMBT-Leo2' pooling and sharing initiative of the European Defence Agency (EDA), which seeks to upgrade Leopard 2 tanks to the Leopard 2A7 standard and lease, rent, or sell these tanks to European countries which wish to replace their obsolescent (and often Soviet) tank fleets (28). The legacy of the Leopard has also been shown by the increased cooperation between Germany's Krauss-Maffei Wegmann and France's Nexter Systems, with projects like the 'Leoclerc' designed to test the compatibility between the two companies in terms of expertise and cooperation (29). As Europe looks to the future, the idea of common vehicle fleets will seem increasingly attractive to its members.

A GLANCE TO THE FUTURE

The Israelis have shown in concepts a vision for what might be a viable alternative to existing MBT design with the Carmel. This vehicle is still in development, so hard facts about its performance cannot be drawn, but the major design principles can still be evaluated. To begin with, it represents a heavy IFV more than it does a tank. Concept art and small-scale presentations by Israeli defence companies involved with the project has shown the vehicle to use a two-crew layout, with the crew sat in a protected citadel like in the Armata. It has a remote turret which is armed with a medium-calibre automatic cannon, and on top of the turret there are two remote weapon stations which have a machine-gun and two ATGMs each. The vehicle relies on an active protection system such as Trophy for defeating RPGs and ATGMs. From the crew position, the crew have large displays showing them the tank exterior, and the Iron Vision 360° see-through armour system allowing them to see all around the vehicle without having to rely on exposing themselves or using periscopes. The vehicle also has a very high level of automation, with automatic vehicle terrain navigation, automatic target recognition and independent target search functionality for all weapons. This means that in combat situations, the vehicle is capable of locating

targets independently and the crew would simply need to prioritise or select the targets they want to engage and the vehicle conducts the engagement automatically. This level of automation also allows the crew to be removed from the vehicle altogether and for it to be used as an entirely unmanned platform.

As we noted at the start, the tank must be built first and foremost to be suited to the type of war an army is prepared to fight. Israel's Carmel design therefore reflects their likely opponents insofar as it prioritises extremely fast sensor-to-shooter times, flexible multipurpose armament choices, and deployability over raw protection and raw firepower. Insofar as the Carmel is a demonstration of what to expect in the future, the most prescient innovation is probably the level of automation, which reduces the level of cognitive load on the crew, and allows training to be simplified. The optionally-manned component is also a component likely to be copied in future designs, having already become a component of the US Optionally-Manned Fighting Vehicle (OMFV) program to replace the Bradley.

BARUCH MATZLIACH,
BRIDAGIER-GENERAL, COMMANDER OF THE TANK PROGRAM ADMINISTRATION (MANTAK) AT THE ISRAELI MINISTRY OF DEFENCE

Battlefield threats are divided into three categories: short range shaped charge projectiles (antitank missiles) – this is a category of threats that enables an infantry detachment to destroy a tank. The second category consists of anti-tank armor-piercing rounds fired by tanks, and the third threat category consists of belly or roadside explosive charges. Active protection systems provide a solution only for the first threat category. The kinetic threat does not have a full-proof solution. The Iron Fist system has the potential of reducing the severity of this threat, but you will still need reactive armor and passive armor to stop it completely

However, due to the wars which are likely to be fought, Western designs are likely to pursue a large-calibre gun instead of relying on missiles which are more easily intercepted by active protection systems. As such, the tanks will need to be bigger than the Carmel, comparable in size to modern tanks. Western vehicles are also highly likely to borrow the Russian design philosophy of using an autoloader and with it, the rationale of an unmanned turret. This is because larger-calibre guns are seen as a future requirement – a 130 mm gun has been developed by Rheinmetall, and the French have already tested a 140 mm gun design (30). With larger guns, it becomes more difficult for a human to handle the heavier ammunition, and so an autoloader is a logical solution to the problem. This also allows a reduction from four to three crew, and makes it possible to eliminate crew from the turret altogether, as the Armata has done. The appeal of a smaller crew is simple – it means that engineers can make a smaller vehicle with a smaller protected surface area, and save some weight, and for military planners it allows them to simplify training and eliminate 25% of the personnel costs of a tank force. The Israeli innovation of moving to a two-person crew by providing the vehicle with an autonomous driving capability is likely to appeal even more for exactly the same reasons.

Top-attack threats deserve further discussion, because they remain a challenge for both existing tanks, even those fitted with rotating active protection systems such as Trophy and Iron Fist (31). They are more difficult to intercept, and they target the weakest portion of the vehicle. As ATGM designs continue to evolve, a top-attack functionality is likely to become increasingly common, and so future vehicle designs will be required to factor in protection against them in order to remain relevant.

Leopard 2A7V, Germany

While there are some lessons to be learned from existing designs, there are sadly insufficient conclusions to draw because the modern vehicles discussed have never been engaged in the type of combat scenario which truly puts their design capabilities to the test. With an absence of such data, it is difficult to make a comprehensive assessment. However, the most concerning trend for tank fleets globally are the costs associated with running them. In order to remain relevant in the XX century, tank designers are faced with the colossal challenge of making their vehicles more deployable, and more affordable in large quantities in addition to being highly capable.

Text by **John Smith**

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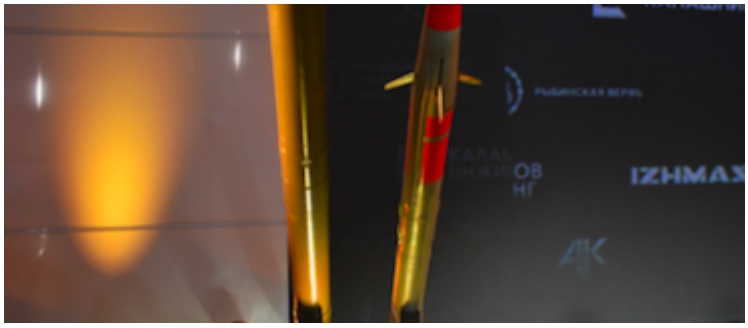

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