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2010/04/10

The case for a medium calibre all-round gun

I've been fascinated by the ARES XM274 75mm cannon for years. This piece of the 80's was a 75mm rapid fire cannon (up to 60 rounds per minute) in a very light armoured fighting vehicle (AFV). The idea at the time was to equip a light tank (RDF/LT) with the firepower to defeat Soviet main battle tanks (MBT) without using tactically unreliable anti-tank missiles (and much more).
It was unfortunate that the idea of such a medium calibre gun was mated with the ill-fated idea of using a "Light Division" with many relatively light armoured vehicles. Such "light" Division and Brigade concepts have been discussed in the U.S.Army since the 70's and never yielded more than prototypes and the 8x8 "Stryker" vehicles.

Another attempt with such a gun was the Italian OTOMATIC SPAAG prototype - unfortunate as well because a bulky and heavy naval weapon was used. Naval guns have never been very suitable for land warfare (except in railroad artillery).

There have been two 60mm guns from Italy and Israel, of which the Israeli one (60mm HVMS) has gone into Chilean service as part of an upgrade project.

Experiments with a naval 57mm weapon on armoured vehicles went nowhere (except as specialised Eastern SPAAGs).

None of these guns has ever demonstrated the full potential of the medium calibre in my opinion.

Let's take the ARES XM274 cannon as a benchmark and assume the following:

- 75 mm calibre

Wehret den Anfängen

Internetzensur: Wehret den Anfängen

Finally, pigs can fly!

Battlefield visual ranges

A little bit German artillery and anti-tank defenc...

A quote of "Omar"

Rehabilitating "Operation Gericht" (Battle of Verdun)

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The case for a medium calibre all-round gun

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Karzai acting strange (finally!)

They lost their mind completely

Tomorrow's Wars

► March (19)

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- 30-60 rpm

- 60 ready rounds (spall-protected stowage)

- proximity fused HE-frag ammunition with electronic time fusing option

- APCBC-HE (armour piercing capped, ballistic cap - high explosive) ammunition with delay base fuse for explosive filler- one-man (tank commander, 340° field of view) turret

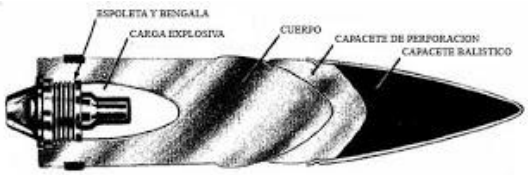
- shorter (62 cal) rifled tube than the extremely long one (overhang!) of the XM274

- 45° elevation/ 15° depression

- - - - -

I wrote "all-round gun" in the title, so what could such a gun do?

Anti-tank capability with APCBC-HE



- unable to defeat main battle tanks reliably in their frontal 90° sector

- able to penetrate and defeat much other vehicle armour

- APCBC-HE (armour piercing capped ballistic cap - high explosive) is a robust WW2 technology for armour piercing rounds that could prove to be more resilient to active protection systems than modern subcalibre projectiles.

- superior behind-armour effect thanks to explosive filler and delay base fuse of APCBC-HE shell

- the cap enables the penetration at difficult impact angles

- the ballistic cap improves the ballistic coefficient for better performance at long range

- effective range 2+ km

Yes, this is pretty much the same penetration and behind armour effect as possessed by a Pzkw V Panther tank at the end of WW2.
This suffices because later armour strength advances have been applied almost exclusively to main battle tank (MBT) frontal armour. A Panther with improved ammunition could still defeat a Leopard 2 with a side hit. Much of a MBT's side protection is often from its diesel fuel's effect on shaped charge jets.

This idea of a 75 mm-armed tank is not meant to fully replace MBTs and their niche capability of penetrating frontal MBT armour (by the way, that MBT capability is not ensured either due to the offence-defence spiral).
The APCBC-HE would penetrate more than 100 mm RHA at 2 km and both shells would have a muzzle velocity of about 925 m/s. This suffices to extend the useful combat distance to about 2 km - it's thus unlikely to be out-gunned in most terrains against anything but MBTs exposing only their front.

Modern armour penetration rests on either shaped charges or subcalibre projectiles. Neither provide a primary behind armour explosion. Both depend on spall for effect to the sides of

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their path of flight. The spall can be and has been mostly mitigated by spall liners on the inside of armour and the interior of modern AFVs has been modified to minimize the chance of secondary fires and explosions. The behind armour effect of both shaped charges and subcalibre munitions has proved to be less reliable in combat than anticipated in peacetime.
A 75 mm diameter hole would produce much more spall and the explosive filler adds a hand grenade-sized primary explosion behind the armour.

The 75 mm APCBC-HE offers reliable penetration against the vast majority of armour plating and a reliable mission kill behind armour effect. It's a compromise below a full main tank gun - a compromise that avoids the latter's disadvantages.

Anti-tank capability with HE

The HE shell can be fired in an electronic timing fuse mode. This enables the tank crew to spray the target with fragments.

- The fragments would damage many exposed components, such as sensors, smoke dischargers and active protection system munitions.

- The crew might also be partially exposed if they didn't button up yet.

- The high rate of fire turns this into a practical approach; it takes only a single additional second to fire a HE shell in advance of two APCBC-HE shells.

- HE with delay fuse setting could penetrate lightly armoured AFVs and explode inside

The use of such HE shells against AFV could master the challenge of active defensive suites.

Anti-air capability

- sufficient rate of fire and maximum gun elevation for AA role

- AA range exceeds that of all self-propelled anti-air guns (SPAAG); up to 6 km against slow-moving targets under favourable conditions

- Indirect hit (proximity fuse) capability enables the destruction of small drones with one shot in what would otherwise be an immunity zone

- Passive sensors (radar warning receiver, laser warning receiver, infrared air search sensor), laser rangefinder, IFF interrogator and data link provide a good chance of detecting, identifying and hitting a distant target

- the increased range can provoke greater stand-off, thus degrade the enemy air power's sensor image quality

This isn't just a replacement for dedicated SPAAGs. Modern armies are insufficiently prepared to deal with small & cheap drones because their battlefield air defences were designed to defeat large & expensive manned combat aircraft. Even man portable air defence missiles (ManPADS) are more expensive than a normal reconnaissance or radio jamming drone needs to be.
Said drones could fly at 3-4 km altitude. Normal SPAAG (20-35 mm calibre, HE shells) would expend much of their ammunition before they could score the necessary direct hit on such a drone.

The increased range is also an advantage in itself as it adds risks and problems for an attacker.

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Capability against "soft targets"

- 75mm was the standard calibre for infantry support in WW2 (assault guns, infantry guns).

- The medium calibre gun would combine rapid fire with HE+frag effect and have an airburst (electronically time fused) capability not shared by other armoured fighting vehicles (the Puma IFV's 30mm airburst is effectively a shrapnel/cannister technology, not a real HE airburst tech).

- Its blast is inferior to larger calibres, but we've got a "larger calibre" (120 mm) in our main battle tanks.

The inferior blast effect in comparison with main battle tank calibres (100-125 mm) was seen as a powerful counter-argument in previous medium gun calibre projects. 75 mm is probably the threshold. Earlier projects had furthermore no multifunctional fuse (delay / proximity / electronic time) as it is feasible today.

The calibre should be considered in the context of other calibres in use; at least either missiles or 120 mm tank cannons would be available to the same unit.

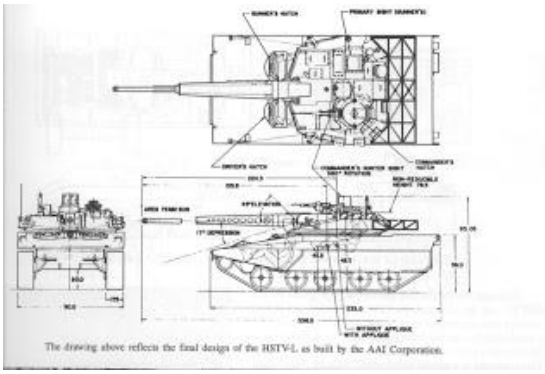
The success of relatively slow-firing 75 and 76 mm guns in support of infantry during WW2 (with vastly inferior ammunition technology!) should be evidence enough for a "good enough" rating of a modern 75mm gun against "soft targets".

Modern tank main guns of 105-120 mm calibre have rather few ready rounds. Most combat against soft targets would need to be done with the coaxial 7.62mm machine gun; a firepower matched by every other AFV. The use of a 75 mm calibre would allow for much more cartridges to be stored in the tank - maybe three times as many.

Capability in valleys, urban settings

- high angle of elevation (45°) vastly exceeds the elevation of main battle tank guns (usually only 20°)

This capability is rivalled only by the smaller calibre 20-40 mm autocannons of IFVs and 40mm automatic grenade launchers on light AFVs, not by any high velocity HE guns


The drawing above reflects the final design of the HSTV-L as built by the AAI Corporation.

Normal main battle tanks have serious problems with their gun elevation - it's one of their major weak spots. Normal infantry fighting vehicles have a major problem with their tiny shells if they face opponents behind walls. 25-40mm APFSDS ammunition can penetrate walls, but the chance of achieving anything by doing so is small and the cost is high. 20-40mm HE ammunition is unable to penetrate strong walls and the ammunition expenditure is high if good effect shall be achieved against weak and normal masonry.

The medium calibre provides a balance of good gun elevation and explosive power with the added benefit of a true air burst HE munition with all-round fragmentation pattern. The HE shell might even be built strong enough to penetrate weak walls and explode inside the room (or inside the wall for a big enough entry hole).

Indirect fire

- 75 and 76 mm have been popular light field artillery calibres in both world wars.

- A 75 mm medium calibre tank gun could occasionally be used for very interesting indirect fire missions. The HE shell would be set to its proximity fuse mode.

- The high muzzle velocity coupled with modern fire control, radio comm, precise position-finding and an electrically trained turret and elevated gun could yield a very quick on-target fragmentation effect in response to calls for fire.

- The proliferation of these medium guns on many combat vehicles (let's say we replace half of the IFV) coupled with a quite long range (about 15 km, significantly more than typical 120 mm mortars) would create a firepower potential of several hundreds of 75 mm air burst HE shells on target in less than a minute.

- Fleeting targets such as "shoot & scoot" mortar teams could be caught like that even if no dedicated indirect fire support was available for counterfire.

Indirect fire would be a useful capability to meet peak demand for indirect fires. The regular use of such guns in a "self-propelled cannon" role would consume much ammunition and wear out the tube. The 75mm indirect fire capability should thus be a supplement to, not a replacement for mortars and artillery.

The original advantage of the howitzer over field cannons - the descent of the shell more close to vertical with a resulting better fragmentation pattern - was partially negated by the introduction of air burst fuses (first used in late 1944 in a land battle). The advantage of larger calibres given by cargo shells (with submunitions) has been negated by the cluster munitions ban (Germany joined that treaty).
A relatively small 75 mm shell with airburst fuse has thus become a logistically quite efficient alternative if indirect fires shall provide fragmentation effect.

The 75 mm guns' specific advantages (high muzzle velocity = short time of flight, great quantity of tubes) would be an interesting addition to the indirect fire repertoire of a battalion combat team.

Survivability by minimum silhouette in "hull down" fighting positions

- thanks to the good gun depression (15° instead of typical 7-10°)

- further improved by one-man turret (narrow frontal silhouette in general)

This is less relevant, but nevertheless a small advantage.

Less hazardous gun

Main battle tanks and infantry fighting vehicles use mostly saboted ammunition against hard targets. These sabots separate beyond the muzzle and create a danger zone of up to 100 m length and 50 m width in front of the firing vehicle. Keep in mind that the vehicle may have turned in reaction to a surprising enemy and you arrive at a 100 m danger zone around such vehicles. This restricts actions.

105-125 mm main battle tank guns are furthermore very powerful guns with a huge propellant charge. Their muzzle blast creates a dangerous overpressure up to about 50 m away (no matter what kind of ammunition was fired). Again, it's very restrictive in regard to nearby exposed soldiers, civilians and even structures.

This medium calibre gun proposal would address these problems that we've become used to.
I proposed no use of a 75 mm saboted munition (using APCBC-HE instead) and the blast danger zone of a 75 mm gun is significantly smaller than the one of a 105 mm or even 120 mm gun.

- - - - -

I laid out my concept for a rapid fire combat vehicle on heavy (40-50 ton) chassis before:

Challenging the IFV concept - Part 2

T-95

The concept truly fascinates me with its ability to address existing shortcomings and to provide a great deal of versatility. The T-95 text mentioned the possibility that the cannon could be combined with kinetic energy antitank missiles like C-KEM. This would add the niche capability of defeating MBTs with a frontal hit at low weight.

S O

edit: 2010-04-12: I'd like to add that the XM274 was an experimental gun that had a couple technical issues because it used many new technologies at once. There were issues with a novel propellant, it used telescopic cartridges ... in the end, it was technically not ready for deployment because some of these experiments were failures (the propellant produced a wide range of muzzle velocities, for example). I'm convinced that the described example gun would be feasible today, though.

edit 2011: There's a theoretical C-RAM capability. C-RAM has been attempted with 155 mm howitzers (IIRC and AFAIK successful demonstration), so a 76 mm HE shell with proximity fuse should have some potential as well (easier intercept, but smaller radius warhead effectiveness).

edit 2014: Three more remarks
(1) A precursor shaped charge could be under the ballistic cap of the shell to improve penetration, but maybe that's not desirable because it could trigger reactive armour.
(2) The non-ballistic cap (first "C" in "APCBC") was meant to prevent bouncing and shattering of the main penetrating body. Both cap and the ballistic cap needed to correct the former's shape may be unnecessary if much tungsten can be employed in this armour penetrating munition. It would then be rather "APHE" or "HEAT-APHE" with a precursor charge.
(3) In fact, one might delegate all anti-MBT firepower to the HVMs and then make do with a thick-shell HE ("SAP") round as the general purpose round for the 76 mm, since it would still be able to penetrate IFVs.

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Labels: Army, Military Hardware, Selection

at Saturday, April 10, 2010

12 comments:

So? 10 April 2010 at 05:57

T-95, along with BMD-4, Koalitsiya-SV, BMPT, 2S25 Sprut-SD have all been cancelled a few days ago.

Reply

S O 10 April 2010 at 12:05

Cancelled or proposed for cancellation. The Ares article wasn't 100% on this.

The real question is what this means. Does it mean they leap over one generation of equipment and go for the next one or does it mean that they don't want to spend much on AFV in general?

They're already scrapping old AFVs. It looks as if they're stuck with T-80/-90, BMD-2/-3, BMP-2, 2S6 and 2S3/2S5 for a while.

Reply

So? 10 April 2010 at 14:12

Defense journalist Victor Murahovskiy is the original source of the news. He was in a round-table discussion with the Russian armaments chief Vladimir Popovkin. The gist of the message is that these are left-over Soviet projects. It makes no sense to build the tank of tomorrow with yesterday's technology, especially without concrete requirements. Much of the industrial base is antiquated, and production is concentrated in mega-plants that make everything vs having lots of small medium plants concentrating on their core competencies.

http://otvaga2004.mybb.ru/viewtopic.php?id=151&p=8#p15680
Translation:

"Let's forget about the Soviet times and look into the eyes of reality: we don't have modern engines, transmissions, controllable hydro-pneumatic suspensions (?), modern microelectronics, MEMS, precision actuators. The ammo situation is dire, control systems are lagging behind a generation, protection systems archaic .. . What components do we build the next-gen AFV from? We can build wonder weapons in a shed in single-digit series, but it's a waste of money. We decided to stop this practice. This decision is wholly justified, because with a serious military budget we get pathetic results. Money was "successfully" wasted on several armament programmes, but in South Ossetia the army ones again rode BMP-1's and used an ancient comms system. The defense sector is now awaiting a transformation as radical as the Putin-Serdyukov army reform.
PS
Things aren't all that bad everywhere. I'm seeing a trend of younger developers in the defense sector, who are doing amazing things, looking at which I feel like exclaiming - Das ist Fantastisch!"

Reply

So? 10 April 2010 at 14:18

BTW, there are quite a few modern 2S19s. Also in VIM's opinion, (and I would hazard a guess people like Fofanov), upgraded T-80/T-90 are good enough. They may have issues with ergonomics and vulnerable ammo storage, but on the whole they are in the same league with other MBTs.

Reply

S O 10 April 2010 at 14:26

"(?)": He likely meant active suspensions. Such suspensions compensate for uneven ground and can increase the practical seed on rough terrain. The same tech can also be used to extend the gun elevation/depression by tilting the hull itself (that's probably why the South Koreans use it).

As an European, I'd be content if the Russians had no good army equipment at all. Their developments are primarily interesting because they aren't in the Western arms development group think and often come to quite interesting, dissimilar answers to common challenges.

Reply

B.Smitty 10 April 2010 at 16:47

Sven,

I was facinated by the 75mm ARES back in the day too. However now I have trouble justifying development of a new gun and munitions line for it.

Instead, maybe one could adapt a 105mm howitzer. IIRC, a 105mm howitzer round is only a bit bigger than a round for the 100mm gun used on the BMP-3.

It could fire the full range of existing 105mm ammo and a HEAT, HEP or sabot round could be developed for use against armor.

LAHAT could be integrated for long ranged shots against tanks, helicopters, UAVs or fortifications.

It could retain some of its indirect fire capability, but perhaps sacrificing the zone charge system for simplicity.

Reply

S O 10 April 2010 at 16:57

An Abbot/M108 revival would not cover the air defence capability and would generally have a MUCH lower RoF.

Reply

B.Smitty 12 April 2010 at 16:13

Sven,

In order to take advantage of the greater AA range, won't a 75mm-equipped vehicle require a radar and more sophisticated fire control?

IMHO, outside the autocannon AA range band, I prefer missiles. The current crop of "heavy" MANPADs like RBS70 and Starstreak out-range the 75mm from a much smaller and lighter-weight package. (albeit using a more expensive round)

IMHO the primary benefit for using the 105mm howitzer round is that it's a NATO standard, and is already in use by many militaries.

A 105mm fixed/semi-fixed round is a lot smaller than a 120mm tank gun round (or even a 105mm tank gun round). It is larger than your 75mm though.

Outside of AA, is the ROF really that important? Currently, militaries use autocannons and MGs for suppressive fires. I admit, firing one 75mm round per second would be impressive, but it would deplete its ammo rather rapidly.

The Israelis make a 105mm tank round called APAM, that disburses six submunitions over a target, showering fragments over a large area. I imagine something like this could be adapted for the 105mm howitzer. It could approximate the effects of multiple 75mm airburst rounds, and provide a useful anti-vehicle/anti-structure munition.

I have recently wondered if you could build a BMP-3 like turret combining a 105mm howitzer and a 30x113mm autocannon that would fit on an IFV. An L119/M119 105mm would be preferable, but even a 14-cal gun like the OTO-Melera Mod 56 would be useful.

The 30x113mm HEDP isn't a great armor killer, but it has a high HE-to-round-weight ratio and greater range than a 40mm grenade launcher. It is also widely used by helicopters and aircraft.

30x173mm could also be used, but the round and gun are both much larger.

Of course the whole thing may just be too big and complex to be worthwhile.

Reply

S O 12 April 2010 at 17:33

Startstreak and Bolide don't outrange a 75mm gun by much if at all (OTOMATIC has a claimed effective anti-helo range fo 6 km), and both are inadequate against cheap UAVs.

105mm would at most add elevation andgle and indirect fire capability to a tank and would be quite similar to 120mm otherwise. Again; I don't see a sufficient niche for a modern Abbot. It would be moved into Arty and be considered the inferior little brother of 155mm SPH just as it was in the 70's.

APAm - albeit great - is likely covered under the Cluster munitions ban (relevant to most countries) and thus unavailable.

An IFV with BMP-3-like weaponry would still not contribute much to battlefield air defence (thus requiring a separate SPAAG). The 100/105mm gun would duplicate 120mm tank gun capabilities.

Reply

B.Smitty 12 April 2010 at 18:04

Sven,

It could contribute to low-altitude air defense with LAHAT.

Why are Starstreak/Bolide inadequate against cheap UAVs? Either should be more accurate than an unguided 75mm round.

Missile per-munition costs are higher than 75mm, but the MANPADS firing platform itself can be far less expensive than the radar and fire control needed to get a 6km effective range out of a 75mm gun.

Of course you can go with a more expensive vehicle mount like ASRAD-R, but you don't have to. Man-portable or truck-mounted systems work too.

Helicopters may also become primary anti-UAV systems. I imagine Apache Longbow would work well here if paired with a small AAM. There was talk of testing an air-launched Starstreak for this purpose.

Also, against small, low-altitude UAVs, IFV-mounted autocannons can do a lot of what you want the 75mm to do too, especially with new airburst rounds.

The spirit of the ban was to eliminate munitions with a high dud probability. I don't know what the operational dud probability is of APAM, but only having 6 large submunitions just feels like it would produce fewer duds than a traditional DPICM. But who knows.

But getting back to 75mm. It takes a long time to develop and qualify a munition. Are we really willing to wait the (up to) 10-15 years needed to productionalize this concept?

Reply

S O 12 April 2010 at 18:17

LAHAT requires SAL guidance and isn't very maneuverable. It couldn't defeat more than a hovering helicotper and would require an additional laser target designation capability. It would also be quite slow if fired from a howitzer.

Starstreak and Bolide are more expensive than a cheap UAV with a 152mm radio jamming shell as payload. Starstreak would furthermore most likely not even hit the UAV and even a hit on the wings would not necessarily yield a kill. keep in mind its special direct hit-dependent design.

You need no radar for air defence. A combination of passive sensors and a LRF (see blog text) suffices for ranges up to 6 km.
Helicopters will more likely threatened by hunter UAV swarms than contribute to their defeat - and helicopters provide no good coverage in time and space.

I read the cluster munitions ban treaty a few days ago. It does ban 105 and 120mm APAM. CCM Art. II.2 is very clear. It's a pity.

Tome ain't the problem, we seem to have plenty unless we insist on jumping into stupid needless wars. 10 years is actually short in modern arms R&D, procurement.

I doubt that it would take that long anywy. Take some insensitive chemicals, order fuses from known manufacturers and otherwise do what has been done in a matter of months 70 years ago.

Reply

B.Smitty 12 April 2010 at 19:48

LAHAT wouldn't need to be particularly fast or maneuverable to kill cheap, low-altitude UAVs. It would need laser designation, but IMI offers a designator upgrade to a vehicle's standard laser rangefinder.

However killing UAVs is not its forté.

The Thales marketing info indicates Starstreak is capable against UAVs. Of course the devil is in the details.

If we really are worried about mass swarms of small UAVs, then, IMHO, just upgrade the standard IFV armament to 35-40mm with anti-UAV fire control upgrades and 3P ammunition.

This instantly gives you a large number of AA-capable vehicles that can push safe UAV operating altitudes up past 4km, where missiles can take over. The further away these UAVs can safely operate, the larger they will have to be to carry the required sensors. The larger they are, the less numerous they will be, and the easier they are to handle with missiles.

Just MHO.

I don't know how worried I am of UAV swarms though, at least in the near term. The command and control complexities alone make this difficult to scale.

Hunting munitions are a different problem, assuming automatic target recognition algorithms ever pan out.

Reply

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