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Re-purposing gun based anti-aircraft systems

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ABSTRACT
Between the late 1960s and mid-1990s, American ground forces employed the Vulcan Air Defence System (VADS), for use against short range, aerial and ground targets. The VADS was mobile and comprised a radar and a six barrelled 20 mm autocannon, but this was soon found to be ineffective against fast aircraft at low altitudes. Despite being an old technology by 1982 an Israeli VADS downed a fighter jet and this is believed to be the only time in VADS operational history. This happened during the 1982 Israel – Lebanon war in the midst of intense ground combat and where the VADS helped unexpectedly. That event, the VADS withdrawal from operations in the 1990s, and their recent reappearance in use against drones are discussed.

Introduction

The ongoing Russian-Ukrainian War is showing the effectiveness of ground fired, man portable, anti-aircraft missiles (manpads). Armoured vehicles with rapid firing, modern anti-aircraft guns and radars, are also being reported as successful against drones. Although their original anti-fighter role was gradually replaced by more accurate, missile systems, improved radars, firing computers and automatization have all helped to provide gun-based systems with more accurate targeting – although this has not stopped the replacement trend of guns by missiles.

In the early 1960s, the US Army developed a mobile missile system, the MIM-72 Chaparral, and the gun based Vulcan Air Defence System.[1] The VADS was needed because of the Chaparral's limitations. When launched, the Chaparral guided itself by sensing the heat from the rear of the jet using infra-red homing, but at short target ranges the missile would not have time to lock on. The VADS was developed to provide a solution for that shorter-range defence. Both systems, introduced in 1969,

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[1]Vulcan has become a generic term used for a multi-barrelled gatling style cannon.

were intended to protect ground forces against low-flying jet aircraft and Soviet attack helicopters. The VADS was also intended to have a secondary direct fire role. Historically that was also the case for another anti-aircraft gun, the German 88 mm gun of the Second World War which was also very capable in the anti-tank role. But the self-propelled (mobile) and towed anti-aircraft systems of that time lacked radar and were ineffective against the fast jets and helicopters of the post war period.[2] In the 1960s Germany developed the Gepard System, which is similar to the American VADS although this uses twin 35mm cannons in place of the Vulcan gun; while the Soviets developed the ZSU-23-4 Shilka which employs four 23mm auto-cannons.

VADS Technology and Limitations: 1968-1982

The American VADS Vulcan gun and radar system was mounted on a modified M113 armoured personnel carrier (APC). Introduced in 1961, the M113 had an aluminium hull, to make it air transportable and amphibious, but this also made the VADS vulnerable to anything heavier than small arms fire.

The Vulcan gun, as originally used in US fighter-jets, comprised of six, 20 mm diameter barrels, altogether firing 3000 projectiles per minute in the direct fire role and at a higher rate against aerial targets. It is a modern version of the Gatling rotary cannon invented in the USA in 1861. Aiming is made with the help of the gunner's optical eyesight with the radar and fire computer reading the incoming speed and distance from the gunner.[3]

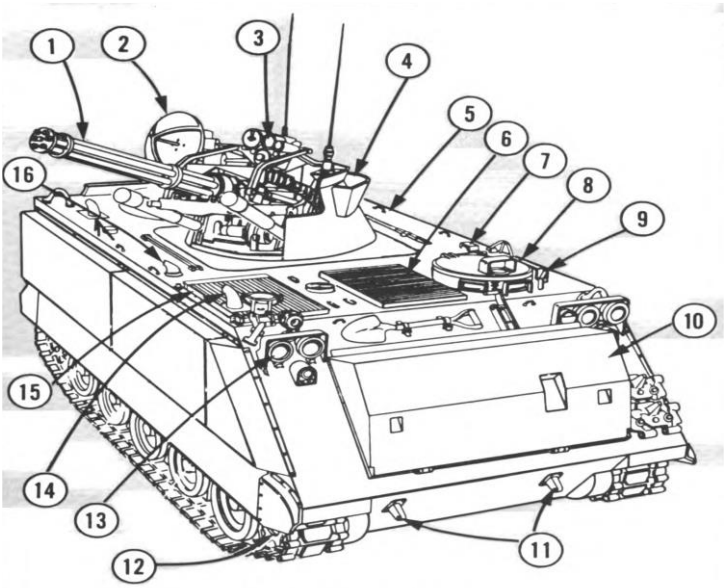
In 1966, there were concerns with possible North Vietnamese low altitude air strikes, that could not be countered by the high altitude HAWK surface to air missile. In response an older 40 mm anti-aircraft gun system, the M-42 Duster, was recalled into service, although this lacked a radar system. The M-42 had two 40mm guns mounted on a tank chassis. Since the air threat posed by North Vietnam never materialised, the Duster was used against ground forces and was found to be very effective in that role.

The VADS was first evaluated in action in 1968 and 1969 during the Vietnam War, but only in ground use since no aerial target ever appeared. One test determined that the VADS was superior to the Duster because of its much greater firing rate and better mobility, being more able to transverse rubber plantations and wet marshy rice paddies. Also noted were: the VADS vulnerability against mines; insufficient space for

[2]Chris Bishop, ed. *The Encyclopaedia of Weapons of World War II,* (New-York, Barnes & Noble,1998), pp. 160,167.

[3]*TM 9-2350-300-10 M163 VADS, Operator manual (Crew) for the Gun, Air Defence Artillery Self Propelled*, (Washington DC, Headquarters, Department of the Army,1976), p.2-117. (Digitised by Google to make it universally accessible).

ammunition; and the radar's inefficiency in locating enemy ground forces.[4] Troops, particularly impressed by its increased mobility compared to the M-42, the flat trajectory of its projectiles and the high rate of fire welcomed VADS deployment in the ground role.[5]



RIGHT FRONT VIEW

1.	20mm cannon M168	9.	Periscope M17
2.	Radar antenna (Unit 1)	10.	Trim vane
3.	Sight M61	11.	Towing eyes
4.	Mount M157	12.	Drive sprocket
5.	Chassis M741	13.	Lights
6.	Air intake grill	14.	Engine exhaust
7.	Fire extinguisher handle	15.	Exhaust grill
8.	Driver's hatch	16.	Heater exhaust

Figure 1: The VADS right frontal View[6]

[4]Albert R. Ives, Eugene B. Rishel III, *Final Report XM163 Vulcan Air Defence System AGC-64F*, (San Francisco: Department of the Army Concept Team in Vietnam, 1969), pp. III-3,VI-1,D11-D13.

[5]M163 / M167 VADS Vulcan Air Defence System. (A Global Security.Org Website https://www.globalsecurity.org/military/systems/ground/m167.htm Accessed 24 December 2022).

[6]*TM 9-2350-300-10 M163 VADS, Operator manual*, pp.1-3.

During the 1970s, the VADS was determined to be more effective against low and slow flying attack helicopters than it was against fast jet fighters. The use of VADS as a ground warfare system also became more promising due to the M-113's mobility, and since the gun had high and low angle firing capabilities, with elevation of +85 to -10 degrees, it could reach high targets which heavy machine guns and tanks guns could not.

Israeli Anti-Aircraft Gun Developments: 1969 to 1982

Between 1969 and 1970, the Israeli-Egyptian War of Attrition took place on the banks of the Suez Canal. Egyptian planes found there was a weak point in the Israeli aerial defence of its ground forces dug in on the east bank of the canal. Planes from the Egyptian west bank could come in low and fast, bomb Israeli forces, and quickly escape back to Egypt. The HAWK missiles employed by Israel proved to be as inefficient in this context as they had been in Vietnam. The Israeli's interim solution was to dismount 20 mm guns from old fighters and place them on Second World War vintage armoured half-track vehicles, although the arrangement lacked any radar or guidance system.

Before 1971, Israeli anti-aircraft guns, mobile and towed, came under the command of the Army while the HAWK missiles came under the Air Force. In 1971 all were united under the Air Force within a new Anti-Aircraft Command. Two years later, in the Yom Kippur War of 1973, the Command played an important role. At that time the Israeli Air Force took heavy losses from new Soviet mobile, surface to air missile units (SAM 6), employed by Egyptian and Syrian forces. Nevertheless, the new Anti-Aircraft Command with its guns and HAWKs, downed a considerable number of enemy planes.[7]

The 1973 War led to the arrival from the USA, of the first VADS and mobile Chaparrals. Two VADS battalions were formed, a moderate part of the total number of anti-aircraft gun-based battalions. The VAD'S firing rate and mobility were of course considerably higher than those of the double barrelled 20 mm guns on the half-tracks. Before 1982 the VADS units practiced for open terrain combat and anti-aircraft tasks and urban fighting was neither expected nor practiced, so a proper doctrine for VADS use had to be devised in the midst of the first phase of the 1982 War.

[7]Lt. Gal Winter, 'Another return of tactical anti-aircraft? The renewed need for air for the ground forces', *Between the Poles*, Volume, Vol. 37 (2022), (Website in Hebrew, translatable to English, the Dado Centre in the General Staff https://www.idf.il/79825, Accessed 19-December-2022)

Battalion 947 Preparations for War

The VADS Battalion 947 was engaged in heavy urban fighting on the coastal road in 1982 and in the first and only VADS downing of a jet plane, a MiG-21. The battalion had four VADS batteries A, B, C, D and a fifth battery, of crews with Redeye shoulder fired manpad type missiles. Each VADS battery had three sections with each section having two VADS, so each battery had six VADS. Altogether, the battalion had twenty-four VADS.[8]

The battalion commander in 1982, now Col. (Ret.) Israel Sar-El, recently recalled that he foresaw the coming of war in early 1982 and had his battalion practice intensively for four months. He also lobbied for more practice ammunition and practice grounds, and for the inclusion of his battalion, which was a part of the Air Force, in the Army's ground combat plans for war.[9] In the US, the VADS units were a part of the US Army and were integrated with the Army's ground forces.

The First Phase of the War in Lebanon

The 1982 Lebanon war began its first phase on June 5 with Israeli forces crossing the border on June 6, 1982. They moved northward on the coastal road and in parallel, northward in the more eastern, valleys and mountains. The aim was to engage with Palestinian forces, although Syrian army tank divisions and commando units had already been present in Lebanon for some years. Since Israel and Syria had a history of confrontation a clash was inevitable and expected. The joint Palestinian-Syrian resistance was intensive, especially in the coastal urban areas, leading to heavy human loss on both sides, and of local civilians. The first cease fire was made on June 13, 1982, when Israeli forces were south of the Beirut-Damascus highway and on the outskirts of Beirut.

Israeli anti-aircraft success was patchy, with the VADS downing a MiG-21, the Redeye units downing a MiG-23, and the HAWKs downing a more modern MiG-25.[10] This

[8]The choice of the 947 story is due to its MiG-21 downing which was discussed during 2021-2022 with one of its officers, Yoav Venkert, and because the 947 story had been publicised by its 1982 battalion commander.

[9]Speaking to a 2022 gathering of retired and young officers, commemorating the Anti-Aircraft Command part in 1982.

[10]M163 VADS, (Hamichlol Encyclopaedia Website in Hebrew Translatable to English https://www.hamichlol.org.il/M163_VADS, Accessed 25-December-2022); M163 VADS, (Wikipedia https://en.wikipedia.org/wiki/M163_VADS#cite_note-9, quoting Israeli air-force website, accessed 26-December 2022); Tony Cullen, Christopher F. Foss, eds. *Jane's,* p.97 (although the VADS were said there to down several planes including a Sukhoi SU-7 fighter bomber); The Heritage Centre of the Air Defense

was a small number compared to the previous 1973 Yom Kippur War. One reason was the June 9 operation by the Israeli Air Force (IAF) which had crippled the Syrian air defence system. The IAF also shot down 86 Syrian aircraft in air-to-air combat without the loss of a single IAF plane.

The Shooting Down of a Syrian Mig-21

On the first day of the ground war, Battery A of VADS Battalion 947 joined the rear of Battalion 13 of the "Golani" infantry brigade. It took only a day or two for the ground commanders to realise the potential of the VADS batteries. One example was Battery A which was a few kilometres into Lebanon on June 6 when they were met by enemy jeeps with guns and Rocket Propelled Grenades (RPG). That night, as told by Lieutenant Col. (Reserve) Yoav Venkert, a VADS section officer in Battery A had his VADS parked together with the tanks and mechanised infantry APCs in two columns, while preparing for a night stay. At dark, they were attacked by mobile enemy units. The Israeli infantry and the tanks' 0.5 inch and 0.3 inch machine guns were not adequate for this skirmish. The Golani brigade commander then instructed the VADS to move forward to accompany his frontal forces. The VADS were placed behind the leading tanks which would sustain the first anti-tank barrage after which the VADS behind would target the enemy rocket firing units. This arrangement was used because the VADS armoured personnel carriers, unlike the tanks were very vulnerable to RPGs and mortar shells. In addition, the VADS crews had to stay with their vehicle to fire back, with the gunner and the commander having to stay above the VADS top, making them even more vulnerable. In contrast, the mechanised infantry soldiers in APCs, could leave their APCs when fired upon and take ground cover. As tank protection was not always available, or effective, several VADS were hit, with the VADS crews suffering casualties.

Several of the units using the twin 20 mm guns mounted on half-tracks participated in fighting in the mountainous areas and were asked to support ground forces, in the same manner as the VADS on the coast road but were found to be far less effective.[11]

During the War and afterwards some have termed the VADS to be a 'Cinderella', helping unexpectedly, and especially so in urban combat, and Battalion 947 was highly decorated after the War.

Corps (Website in Hebrew, translatable to English http://airdefense-center.org.il/ ,Accessed 24-December-2022).

[11]Col. (Ret.) Israel Sar-El discussion with Dr. Uri Milstein on the Battalion 947 role in the fighting South of Beirut (In Hebrew in https://youtu.be/dZdWniWTwHw ,Accessed 24 December 2022).

VADS Downing of a Jet Fighter

Although the use of VADS in the ground fighting was the one most expected, the anti-aircraft role was not neglected, so one or more observers were always on the lookout for attacking aircraft. At midday on June 10, while Israeli forces were moving north towards Beirut on the coastal highway, a few kilometres south of Beirut, Battery A of 947 took part in a local and intensive battle against opposing tanks and commandos. In the midst of this action, an observer spotted three Syrian MiG-21 approaching. The first to give the firing command was Officer Yoav Venkert of the VADS section, making the initial hit on one of the planes. Soon the whole of Battery A and a neighbouring VADS battery joined in, and the plane was seen to crash into the sea. The other two aircraft turned away. The momentary use of the batteries against the Mig-21 was used by the opposing forces to target the VADS. One of their soldiers even climbed onto one of the VADS. Here can be seen a situation where the original dual purpose use of the VADS was a problem. A short while later the VADS resumed their ground mission.

The alertness of the observers was a key factor in the shooting down of the Mig-21 but no less important, were other, favourable, circumstances. One source lists the ideal circumstances for the use of VADS:

> According to the (US) Army, the Vulcan system (VADS) had very limited effectiveness. For Vulcan to be effective, the target must be hovering or flying a non-manoeuvring course towards the gun and be within a range of 1,000 meters. Vulcan provided only a low degree of suppression against manoeuvring threats.[12]

In the specific incident described above the Syrian aircraft were reportedly flying at such favourable conditions, at a range within 1000 meters, at a low altitude, on a straight course and at low angles with little manoeuvring.

The Aftermath & The Re-Appearance of VADS

Major improvements to VADS 1960s technology were made in the US and Israel after 1984, with better electronics and the addition of manpad type missiles to the VADS vehicles. But by 2010 all VADS had been retired from use.[13] The VADS Battalion 947 for example was turned from a VADS based unit to an Iron Dome unit. The Iron Dome system, co-developed with the US, was designed to intercept and destroy short-range rockets and artillery shells.

[12]M163 / M167 VADS Vulcan Air Defence System (Global Security Org. Website)
[13]Tony Cullen, Christopher F. Foss, eds. *Jane's Land-Based Air Defence 1992-93,* (UK, Surrey, Jane's Information Group,1992, 5th Ed), pp. 97-98.

Before the current Russian-Ukrainian War, the use of so called 'suicide drones' was demonstrated in the Second Nagorno-Karabakh War of 2020 when Azeri drones were reported to have destroyed many Armenian anti-aircraft batteries, tanks and vehicles.[14]

This new threat has resulted in the reappearance of VADS type systems to provide ground units with a local, immediate and inexpensive defence. German Gepards have been supplied to Ukraine and are reported to be effective against Iranian-made Shahed-136 drones. The Soviet era Shilka is also reported as being used by the Russians and Ukraine against ground and aerial targets.

Conclusion

During the 1982 Lebanon War the VADS units were again shown to be useful in ground combat, as had been the case in Vietnam.

The 1982 shooting down of a Mig-21 did not alter the belief that VADS was an ineffective system for defence against fast jets. But that downing did demonstrate that a less cutting-edge technology can still be useful under certain circumstances. The alertness of the VADS observers in the midst of ground fighting was essential to that owning which took place under ideal conditions for what was a piece of 1960s technology. .

Improvements to VADS were made in the US and Israel after 1984 and may have helped extend the use of the VADS, but by the 1990s had not prevented their withdrawal from service.

The recent and fairly unexpected resurgence in the use of gun based systems such as VADS against drones shows that old technology and weapons systems may find a second application not foreseen by the original designers.

[14]Lt. Gal Winter, 'Another return..'