Anti-Tank Guided Missiles:
A Technology Perspective

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The introduction of tanks in combat changed the concept of wars during World Wars I and II. Since then, armies have been in continuous search of suitable solutions to defeat the armoured threat of their respective adversaries. With advancement of technology and capability of modern tanks, the anti-tank weapons continue to improve to defeat the most potent threats. Many countries have undertaken the research and development (R&D) of anti-tank guided missiles (ATGM). Various types of technologies have been analysed by scientists the world over to develop the most suitable solutions for the soldiers. The maturity of various technologies and combat experiences of the soldiers have led to the development of various types of ATGM solutions in the world. US industry and R&D agencies have certainly taken the lead in providing very capable ATGM solutions to the soldiers.

US Army Advanced Anti-tank Weapon System – Medium (AAWS-M) Development

In the late 1980s, the US Army and Marine Corps faced the obsolescence of the medium-range anti-tank system called the Dragon. To fulfill their requirement for a replacement system, the Services comprehensively evaluated the technical and operational suitability of three differing technologies for its replacement missile system:

- Laser beam-riding (man-the-loop).
- Fibre-optic guided (fire-and-adjust).
- Imaging infrared (fire-and-forget).

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The first technology evaluated was a beam rider approach in which the missile flies within the laser beam pointed at the target by the gunner. The army saw two distinct disadvantages with this type of technology. The first was that the gunner was tethered to the firing post and had to hold the laser beam precisely on the target throughout the missile's time of flight. In this position, the gunner was extremely vulnerable to counter-fire. Both his survivability and his operational effectiveness were severely compromised by the requirement to mark the target with his laser for extended times after his launch signature. The second major disadvantage to a laser beam rider system is that the wavelengths of typical lasers used to mark the targets are easily detected by most modern tanks with thermal imaging forward-looking infrared (FLIR) systems built into their fire control systems (FCS). Tanks equipped with these FLIR systems can take quick and effective counter-measures to the beam rider system. The tank can immediately deploy effective smoke screens and/or bring effective counter-fire against the gunner, either putting the gunner out of commission or causing him to take cover and lose the proper target designation. All these actions can easily be accomplished within the typical time of flight of a missile engagement. For these reasons, the US Army did not select the beam rider technology for its medium range anti-tank requirement.

France, Germany and the UK initiated development of the laser beam rider TRIGAT-medium range (MR) anti-tank system in 1988, but many of the countries involved with TRIGAT-MR became disillusioned with the laser beam rider technology, and technical, schedule and cost problems eventually killed the programme.

The second technology evaluated by the US Army in the pursuit of its medium range anti-tank requirement was a fibre-optic guided missile. There are several major disadvantages with this system technology as well. First and foremost is that the gunner has to remain tethered to the missile throughout the time of flight of the missile. Although this system technology is a passive one, if the launch can be detected, which is becoming ever easier to do with modern technology, the gunner is susceptible to effective counter-fire similar to the previously discussed beam rider technology. Another serious issue is that the system's operational effectiveness is highly dependent on the gunner's training. Not only is the initial training important when the system is initially fielded, but sustainment training is also very critical and it is much like the TOW (tube-launched, optically-tracked, wire command data link, guided missile) and the Dragon systems in that regard. Gunner skill and effectiveness are directly proportional to the amount of quality

training received. In the stress and fog of battle, this can become a decisively negative issue for such a system. Additionally, the US Army concluded that from a life-cycle perspective, the cost increases considerably when the gunner is tethered to the missile because training requires gunner precision until missile target impact. Unlike true fire-and-forget where training is to trigger pull, the fibre-optic and laser beam rider require gunner precision until missile impact, therefore, requiring intensive training and frequent live firings to validate training and gunner proficiency. A key advantage of true fire-and-forget is that the impact of training on gunner performance is greatly reduced. While remaining stealthy prior to the launch signature, the gunner simply locks the seeker onto the target and fires the missile. At that point, the missile's onboard technology takes over to successfully complete the mission.

Yet another major disadvantage of the fibre-optic systems is that the gunner is not only tethered to the missile by the fibre but is also tethered to a tripod-mounted firing post which contains the means to display a stable image to the gunner and give the gunner the needed controls to guide the missile to the target. This makes the system much less portable in those instances when the operational requirements of the evolving mission require that the gunner manoeuvre with the system, especially in the urban environment.

In addition to the major detractors discussed above, there are fundamental engineering trade-offs required by fibre/wire guided missiles that degrade operational effectiveness. To play out the fibre from the back of the missile, the rocket motor cannot be located at its most efficient position at the rear of the missile. Therefore, a bifurcated rocket motor located at or near the centre of the mass of the missile must be used. This engineering trade-off usually requires the main charge warhead to be placed behind the rocket motor. This seriously degrades the main charge warhead performance by requiring the warhead jet to fight its way through the rocket motor, guidance electronics, and the imaging seeker before it can attack the armour of the tank. Such a design suffers from an inherent loss in warhead effectiveness for the system. This puts greater stress on the gunner's choice of attack point on the target (the gunner must avoid the heavily armoured parts of the tank). This problem also reduces system effectiveness against non-tank type urban targets.

Another disadvantage of bifurcated rocket motors is that they cannot incorporate thrust vector control (TVS) technology. TVC provides aerodynamic control at the low velocity launch stage. By maintaining aerodynamic control at low velocities, the missile can lock onto targets at a much shorter minimum

range than non-TVC systems. Short minimum range (less than 100 metres) can be a critical capability on today's urban battlefield.

"Fire-and-forget" means the soldier locks the missile seeker onto the target and fires the weapon. The missile automatically tracks the target from weapon launch through fly-out and target impact. The missile autonomously flies to the target. After missile launch, the soldier is free to immediately take cover, reposition, and/or reload to engage another target. Fire-and-forget systems achieve maximum gunner survivability because the gunner does not continuously track the target or guide the missile during missile fly-out; and exposure to hostile fire is minimal.

Ultimately, the US Army invested in fire-and-forget technology because it provided the best combination of lightweight, high firepower and soldier survivability. Soldier survivability was a key factor in the decision of the French Ministry of Defence (MoD) earlier this year to replace its wire guided MILAN system in Afghanistan with the US Army Javelin close combat weapon system. In addition to the optimum use of modern technology, there are many other attributes which make the ATGM favorable to the users. Some of the additional factors which add value to the ATGM solution are as given below.

Miscellaneous Issues

Gunner Survivability Short and medium range anti-tank system gunners are subject to counter-fire from both the weapons on their target tanks and fighting vehicles and enemy infantry. Fire-and-forget is the most important operational capability to protect short and medium range infantry anti-tank systems, however, other features which decrease the likelihood of detection are also key to gunner survivability.

- Low smoke/no smoke rocket motors decrease the launch signature of the missile, making it harder for enemy forces to locate the gunner.
- Fire from enclosure capability enables the gunner to fire from inside a building or fighting position so that he is not seen before firing and is under cover after firing.
- When a gunner takes on a main battle tank within range of the tank's main gun, he needs to be confident that he will kill the target. A precursor warhead to defeat reactive armour and a main charge warhead large enough to penetrate the frontal armour are critical to the "one shot, one kill" capability.

Resistance to Counter-Measures and Battlefield Obscurants Top attack minimises the vulnerability of anti-tank missiles to advanced counter-measure systems such as active protection systems and defence-aid-suites. The direct attack mode increases flexibility to engage non-traditional targets such as a cave or a specific window in a large building with optimal blast effect.

All weather capability is a key requirement for modern ATGM systems. Medium wave infrared (MWIR) and long wave infrared (LWIR) systems each have advantages under different circumstances; however, LWIR is far more effective than MWIR against counter-measures such as smoke and flares. LWIR is also better able to penetrate typical battlefield obscurants such as dust and smoke.

Training Killing the target is a combination of the system's technical capability and the gunner's skill. Systems that utilise technology to reduce demands on the gunner, coupled with training devices which realistically simulate actual operation, increase the probability of mission success. Systems that are simple to operate both reduce the time required for a gunner to become qualified and maintain proficiency and also increase the probability of hit when the gunner is subjected to the stress of combat. The decision of some armies to favour fire-and-forget systems recognises the advantages of relying on technology to increase the probability of hit and reduce the time and expense of gunner training.

Life-Cycle Support/Reliability The cost to maintain a system over the decades of its service life can exceed the initial acquisition cost. The cost to maintain and repair the hardware and the cost to train gunners and maintain proficiency spread over many years is a major investment. A system that relies on technology to simplify the gunner's role reduces the training time required and may enable a gunner to be trained on classroom trainers, and eliminate or reduce the number of missile training rounds fired.

Most modern ATGM rounds do not require maintenance. If stored in the prescribed conditions, they will be reliable for many years. The firing posts, or command launch units (CLU) as they are usually called today, and training devices require maintenance and repair. Since the CLU is typically used to both fire the missile and as a surveillance device, it is subject to many hours of use in the field, sometimes under extreme conditions. The number of hours of operation between failures that require repair, the life of its replaceable batteries, and the cost and turnaround time to complete a repair all contribute to both the life-cycle cost and mission success and should be considered when selecting a new ATGM system.

Conclusion

Soldiers always look for the best available weapon systems to have an edge over adversaries. ATGMs would continue to be relevant to soldiers not only in conventional warfare but in counter-insurgency type of operations as well. Since low intensity and urban warfare does not seem to have an end in the near future, it is better to equip the soldiers with the kind of weapon systems which would be relevant for all types of war scenarios. The selection of a suitable type of ATGM is critical for enhancing the war-fighting capability of the soldiers.