Counter-Rocket Artillery Mortar futures

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Counter – Rocket Artillery Mortar (C-RAM) weapons fill a capability need that has evolved since the end of the Cold War. These weapons are intended to shoot down incoming rocket, artillery and mortar rounds. Technologies proposed and developed for this purpose include rapid-fire guns, short range missiles and Directed Energy Weapons (DEW).

The impetus for the development of C-RAM capabilities was the long running harassment campaign conducted by Palestinian militants against the Israeli civilian population in Israel's border regions. They used a range of unguided rocket munitions, from truck launched 'katyusha' style artillery rockets down to man-portable rockets and mortar rounds. Indiscriminate and intended to incite fear in civilians, the campaign produced a range of reactions from the Israelis. The 1982 invasion of Southern Lebanon, intended to drive the Palestinian Liberation Organisation (PLO) from Lebanon, was directly motivated by the PLO's use of that geographical area to launch artillery rockets and artillery fire into Northern Israel. In more recent times harassment attacks using a range of mostly man-portable rockets have continued by the Iranian backed and funded Hezbollah in Lebanon and Hamas in the Palestinian territories. The much publicised series of Israeli attacks on militant leaders and cells, using UAVs or AH-64 Apache helicopters to launch guided weapons, has been another visible response.

The problems of such attacks are not confined to Israel alone. Operations in Afghanistan and especially Iraq since 911 have encountered repeatedly the use of mortars and man portable rockets in attacks on Western military installations. While not particularly effective, and indeed much less effective than suicide bombers with explosive vests. The harassment attacks are also damaging to morale and elicit disproportionate responses from media observers, many of whom play the 'ambulance chasing' game in war zones or areas with insurgent activity.

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C-RAM Phalanx is a land based derivative of the naval CIWS.

While Western thinking in this area is driven mostly by the imperative of protecting military and civilian personnel and facilities from often primitive unguided weapons, a parallel evolution is underway in Russian thinking about technological strategy, driven by an entirely different imperative. In Russia, considerable development effort has been invested since 1992 to develop Counter Precision Guided Munition (C-PGM) weapon systems. The imperative was the observation in 1991 of how the Iraqi air defence system, largely supplied by the Soviets, was fatally crippled in a matter of hours and wholly annihilated in a matter of days by a deluge of US and British Precision Guided Weapons. In subsequent air campaigns, including the NATO effort against Russia's traditional ally Serbia, vast damage was rapidly inflicted against key assets by the massed delivery of smart weapons. The latter included guided bombs, anti-radiation missiles, tactical missiles and cruise missiles.

During the 1990s Russian operational analysts argued that the best approach to dealing with incoming Western PGMs was to shoot them down using short range SAM-fire or gunfire. The intent was to evolve and adapt existing Russian point defence weapons for this purpose. More than a decade later Russian industry is offering two specific products optimised for exactly this purpose.

From a technological strategy perspective, there is little practical difference between the Russian C-PGM role requirement and the Western C-RAM role requirement. Both are centred in the idea of killing inbound projectile fire as a means of protecting fixed or mobile assets in a theatre of operations.

The Russian requirement offers greater latitude in the 'cost per shot' parameter, as the PGMs to be killed are in the unit cost range between US$10,000 up to US$2,000,000, compared to the hundreds-of-dollars cost of an insurgent unguided rocket. However, the idea of measuring cost per shot in defeating an incoming weapon is a classical Lanchester's Linear/Square Law measure centred in attrition warfare between opposing peer competitor industrialised opponents. What it says is that in a protracted attrition based conflict, all else being equal, the side that can produce and deliver more munitions cheaper is the side that will prevail. In this symmetrical model, it's assumed that two shots need to be fired by a C-PGM system to kill an incoming PGM with high confidence. The break-even point is when neither side has an advantage: when the 'cost per shot' of the C-PGM system is less than half the cost of the PGM being killed. If the PGM is a smart bomb, the Russian model is viable at a cost-per-shot" of around

Russian 96K6 Pantsyr S-1E C-PGM SPAAGM system.

Russian 9A331MK Tor M2E C-PGM SAM system.

The Chinese LD-2000 SPAAGM, base on the Dutch 30 mm Goalkeeper, has considerable but yet to be fully developed potential as a C-RAM/C-PGM system. The LD-2000 has been integrated with a cloned Chinese TPQ-36 Counter Battery Radar.

US$5000, whereas if the PGM is a top-end cruise missile, it would still be viable at a cost-per-shot of US$1,000,000.

The symmetrical model for C-PGM operations has a built-in assumption, which is that the asset being defended justifies the procurement cost of a C-PGM system to defend it, and that the recurring maintenance, operating and expended munitions costs are justified to defend the asset. Multimillion dollar military installations, radar systems, long range SAM batteries, airfields hosting hundreds of millions of dollars in parked aircraft, military depots, warehouses, storage yards and ports are all targets that easily justify the cost of deploying a C-PGM or C-RAM system.

In counter-insurgency operations, which are inherently asymmetrical in nature, the Lanchestrian attrition economy logic often collapses, since it is exceedingly difficult to match the delivery cost of an opponent who gets much of his capability in the form of unpaid volunteer time, and foreign military aid from nations like Iran. The logic is then centred on the risk model, and this means in the simplest of terms "what is the damage I suffer if I do not defend this asset?" For unguided low-damage-effect man-portable projectiles, where the damage effect is often more psychological than material, even an objective and measurable assessment of damage can be difficult.

The only way in which the Lanchestrian attrition economy logic can be made to work for C-RAM in a COIN environment is when the cost per shot can be driven down to hundreds of dollars or less. That consideration has ended up becoming a driver in Western reasoning behind C-RAM system development, and the reason why electrically pumped High Energy Lasers (HEL) have become the favoured technology, as the recurring component of the cost per shot is the cost of the diesel fuel or aviation grade kerosene consumed to power the weapon system through the engagement. For a fixed installation feeding off the local electricity grid, this cost component boils down to the kilowatt-hours of grid electricity burned and recurring maintenance cost of a mains power converter if required.

In the longer term it is inevitable that Western C-RAM requirements and needs will become indistinguishable from Russian C-PGM requirements and needs. This is for a number of good reasons.

Western C-RAM systems will have to evolve capabilities to kill incoming PGMs. In part this reflects the reality that PGMs are no longer a weapons technology exclusive to Western nations, as Russia and China have exported and increasingly so will export a diverse range of PGMs into a globalised market. These range from land attack optimised air/sea/sub/land launched cruise missiles at the top end, through guided bombs, down to guided artillery shells, mortar rounds and rockets at the bottom end. Any nation with the cash will be able to procure any quantity of guided munitions in a globalised market.

The disquiet that erupted recently when the Hezbollah insurgents employed a Chinese-built Iranian supplied guided anti-shipping missile launched off the back of a commercial 4WD against an Israeli gunboat is a significant development. Cave-dwelling AKM armed insurgents are not expected to shoot sophisticated high technology PGMs like anti-shipping missiles, yet they did.

In a long term globalised weapons market it will be impossible to prevent insurgents acquiring terminally guided mortar rounds and artillery rockets. With high accuracy these will become the weapon of choice for insurgents intent on standoff harassment attacks.

Western C-RAM systems will inevitably have to evolve to become equally effective against these PGMs, as they are effective against unguided munitions.

The flipside of this evolutionary process is the declining cost and increasing capability of PGMs, especially Western weapons which are being made smaller, smarter and more lethal, to permit single delivery systems to attack more aimpoints in a single delivery. Good examples are artillery rockets or cluster bombs dispensing multiple smart terminally guided submunitions, or fighter aircraft dropping eight GBU-39/B Small Diameter Bombs rather than the traditional pair of 1,000 lb or 2,000 lb smart bombs.

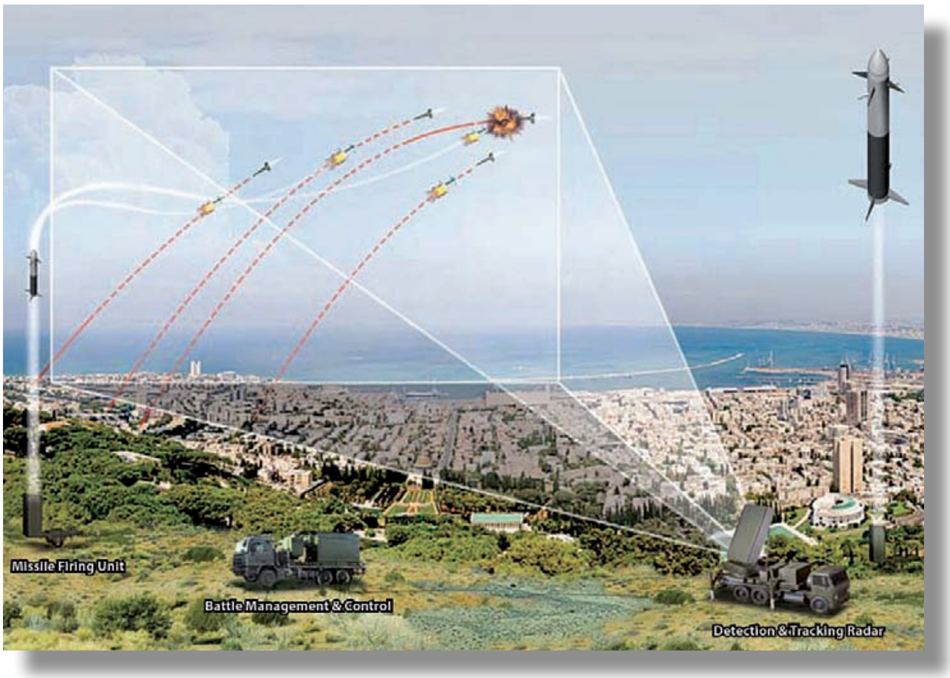
This evolutionary trend will inevitably drive Russian industry toward solutions and designs with minimal cost per shot, as has been observed in Western C-RAM evolution.

At some point the Western C-RAM and Russian C-PGM models will converge, as the requirements will drive designs into a similar cost per shot and target acquisition and tracking capability brackets.

The subject of target acquisition and tracking capabilities in C-RAM versus C-PGM systems is also relevant.

For a typical C-RAM system the target is a subsonic or supersonic unguided projectile flying a simple ballistic trajectory. It is a relatively low signature target in the infrared and upper microwave radar bands. More than often only small numbers or single shots will be fired allowing reattack by the C-RAM weapon if the first attempt fails. The target is relatively slow and predictable in flightpath but physically small, making it hard to track accurately and hard to hit.

For a typical C-PGM system, the target is a subsonic or supersonic guided projectile apt to be flying a complex guided trajectory, possibly designed to



The controversial Rafael Iron Dome C-RAM system is conceptually closest to the Russian Tor M2E, but optimised for C-RAM.

The US Army's new C-RAM Phalanx combines the existing naval CIWS system with existing CBR radar.

THEL Deuterium Fluoride laser demonstrator beam director.

frustrate tracking by low altitude terrain following but certainly designed to impact the target with an optimal trajectory and impact angle. The target's signature is apt to be intentionally low, especially in the X- and Ku-bands used for engagement radars. Whether Western or Russian doctrine is followed, the weapon is apt to be used in concurrent multiple round salvoes, so a C-PGM system will be presented with multiple concurrent targets, but also with very short times to acquire, track and engage, denying time for reattack if an initial shot fails to kill. PGMs, especially missiles, typically being much larger than artillery and mortar rounds and comparable to Katyusha rockets in size will be easier to inflict damage upon.

Target tracking and acquisition capability needs are sufficiently different in current Western C-RAM and Russian C-PGM designs, reflected in different basic technologies used. A Western C-RAM system will use an adaptation or variant of an existing Counter Battery Radar (CBR) to perform initial acquisition and then tracking of the inbound round, upon which a fine-tracking sensor such as a radar or optical tracker will be cued to engage the target. A Russian C-PGM system will, on the other hand, use derivatives of existing air defence weapons for acquisition and tracking, reflected in the use of Passive Electronically Steered Array (PESA) -band radar technology, based on fighter radar technology, for both existing C-PGM system designs. ESA radars provide the valuable capability to concurrently track up to dozens of targets within a narrow sector of interest.

In the longer term, we can expect acquisition and tracking systems to converge on high power AESA radar technology, in the X/Ku-bands coupled with infrared/optical trackers.

The future of the weapons component of C-RAM/C-PGM systems is less clear. Laser weapons, especially electrically pumped lasers, offer exceptionally low cost per shot, and almost unlimited 'magazine depth', which will be attractive for all applications. This advantage must be balanced against higher procurement costs and the need to 'dwell' the weapon on a target until burn-through of the skin or casing can be effected. The latter will be an issue for defeating saturation attacks. The inability of lasers to penetrate cloud, haze, dust and fog is another unavoidable limitation.

Guided missiles, exemplified by the Russian Tor M2E and Pantsyr S1 C-PGM SAM systems, will be primarily challenged in the areas of cost per shot and magazine depth, as are all SAM systems. Achieving significant cost and size reductions for this class of weapon will be challenging, as propellant and explosive payload chemistry of the day set hard limits. Such weapons are insensitive to adverse optical conditions, as they are remotely guided by microwave radar.

Gatling guns and revolver cannon fall in between the extremities of lasers and SAMs, whether we consider cost per shot or magazine depth, with adverse weather penetration and tracking capabilities determined largely by the sensor package employed.

What is however abundantly clear is that the market for C-RAM/C-PGM systems will expand strongly over the coming decade.