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Countering Mobile Missiles:
Holding the Entire Launch Cycle at Risk

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Abstract

A major threat confronting modern U.S. and allied forces around the world is the evolution of potent anti-access/area denial (A2/AD) environments, constructed and enhanced by potential adversaries. At the heart of many of these A2/AD environments is a key capability—the mobile theater ballistic missile (TBM), capable of striking targets across a battlefield or area of operations. Following the use of Scud mobile missiles in the 1991 Gulf War, mobile TBMs as a class have grown more capable and proliferated to numerous countries. This has expanded the threat to U.S. and coalition operations around the world. While a great amount of attention has, appropriately, been focused on active missile defense, modern air forces must complement missile defenses with a full-spectrum response that includes efforts to interdict TBMs before and after launch. This paper aims to explore the means to accomplish this mission within current capabilities.

Introduction: The TBM Threat, Then and Now

The development of ever-more-sophisticated theater ballistic missiles (TBMs) by both near peer and regional militaries around the world represents an increasingly complex challenge for American planners and the defense industry, insofar as developing and deploying effective countermeasures to these weapons. Great strides have been made in the development of more effective missile defense systems to counter the TBM threat. But, with increasingly sophisticated capabilities being developed today by peer and near-peer competitors, it is becoming increasingly evident that missile defense, while essential, may no longer be sufficient. The solution to this threat needs to attack the source, with actions that can be directed at TBM capabilities both before and after launch as part of an overall theater strategy to limit the effectiveness of these weapons.

Since 1991, various concepts have been proposed for countering TBMs with air attacks. One 2002 Air War College analysis advocated for the establishment of a standing capability for counter-air operations against theater missile threats, with the F-22 Raptor playing a lead role, working with E-3 AWACS, E-8 JSTARS, and spaced-based cuing.

TBMs are not a new phenomenon, but they have proved an elusive threat that has grown more mobile and capable over time. The first real American combat experience with the TBM threat occurred during Operation Desert Storm in 1991, when some 88 modified Scud tactical ballistic missiles were fired by Iraq against targets in Israel and Saudi Arabia.[1] In addition to the deployment of the MIM-104 Patriot missile system to Israel and Saudi Arabia, U.S. and coalition forces mounted an intensive effort to find and destroy Iraqi missile transporter-erector-launchers (TELs). These efforts, however, were not notably successful. Of the 88 missiles fired by Iraq, coalition forces observed the launch of 44 of them, and in only eight cases were coalition aircraft able to identify and get close enough to expend weapons against Scud TELs. Even so, there were no confirmed reports of TELs destroyed by these attacks.

Following the Gulf War, missile defense efforts accelerated due to this lack of success against Scuds. Since 1991, various concepts have been proposed for countering TBMs with air attacks. One 2002 Air War College analysis advocated for the establishment of a standing capability for counter-air operations against theater missile threats, with the F-22 Raptor playing a lead role, working with E-3 AWACS, E-8 JSTARS, and spaced-based cuing.[2] Another study by the RAND Corporation recommended a number of air attack options against TBMs, but noted the vulnerability of many intelligence, surveillance, and reconnaissance (ISR) platforms, and recommended consideration for using penetrating, low observable ISR platforms against these threats.[3] One 2006 analysis by a USAF missile officer advocated for persistent surveillance, better use of layered sensors, integration of ISR and strike platforms, and reliance on ground moving target indication (GMTI) radar and automatic target recognition (ATR) sensors to better attack the mobile missile threat.[4] The general consensus of these works and others on this topic, following Operation Desert Storm to the present day, is that there is no single solution to the problem of countering mobile TBMs. A more comprehensive strategy is clearly needed to be effective in countering the mobile TBM threat to U.S. and allied forces. The remainder of this analysis then will decompose the TBM launch cycle into its component parts, and then discuss potential vulnerabilities, with an eye to exploring some attack options at each stage.

TBMs as Complex Target Systems

To better counter this threat, it must be understood in its proper context—a TBM is a weapon system, not just a missile. The launch of a TBM is the last step in a series of technical and logistical activities undertaken by a large and complex infrastructure. Success in defeating the TBM threat must seek to exploit the vulnerabilities of this system throughout the lifecycle of each missile launch. This approach presents opportunities to attack the TBM system before the first missile is launched, to intercept it during its flight phase, and to attack its ground components (once again) after the missile has been launched.

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In so doing, it is essential to understand the TBM launcher as one element of a complex "system of systems." A Russian SS-26 Iskander missile brigade, for example, features some 50 vehicles, including transporter-erector-launchers (TELs), missile transporter-loaders, plus a number of miscellaneous vehicles for command and control (C2), communications, and maintenance.[5,6] A military unit of this size, in the field, will present numerous signatures across many intelligence categories. While many of these individual signatures may not be unique, in the aggregate they can be used to identify, delimit, and locate key target elements.

Intelligence preparation of the battlespace (IPB) is a key element in delimiting potential search areas to drive collection by various ISR sensors.[7] IPB for counter-TBM operations must consider terrain, trafficability, the range of enemy TBM systems and the range of U.S. and allied missiles, artillery, and rocket systems that could threaten enemy missile systems. These factors will also affect the minimum and maximum distances of potential threat TBM locations. While intelligence preparation would not necessarily identify precise locations of TBMs in the field (or their supporting infrastructure) IPB does serve to delimit the search areas, thus optimizing sensor tasking and data fusion. It should be noted that while TBMs would be expected to deploy to exercise sites in peacetime training, it is likely that they will also have designated wartime deployment locations that would not be used in peacetime. While information concerning peacetime deployment and training locations is useful, it is not likely a predictor of probable wartime deployment locations for TBM launchers. Some of the key considerations for IPB with respect to TBMs include:

- **Doctrinal templates:** Modern militaries tend to array their forces in the field in structured ways, whether preparing for attack or during an attack, and this guides the positioning of maneuver forces as well as artillery, air defenses, and mobile missiles.

- **Distance from opposing fires:** A TBM fire unit would normally be located at a place on the battlefield that is beyond the range of the artillery of the opposing force. If the theater missiles of the attacking force outrange the TBMs of the opposing force, the attacking force may well seek to situate their TBMs, at least in the initial phases, beyond range of opposing TBMs—but within range of their own TBMs.

- **Road and terrain considerations:** Although TBM launchers are typically designed for both road mobile and offroad mobility, launch sites and reload sites are likely to be near existing roads to facilitate rapid egress following expenditure of their missile loads. Because of this, both terrain and existing road structures should be considered in any trafficability study that seeks to identify likely TBM launch areas.

- **Tactical communications:** Deployed TBMs, at least during the pre-hostilities phase of a conflict, would be expected to maintain radio silence and remain in receive mode. Certainly, landlines could be used as a secondary means of communication, but minimizing electronic emissions would be a prudent measure to undertake pre-hostilities and should be assumed.

Detection and identification require the correlation of signatures to the TBM itself, which implies that peacetime intelligence collection and analysis is able to resolve the TBM's various signatures. In the field, at least initially, a TBM brigade would likely take measures to minimize communications and other detectable signatures. However, once operations begin, communications will be necessary and would become part of the signature library for this complex target system. To the extent that signatures can be addressed and explored in an unclassified setting, consideration should be given to the following signatures and analytic techniques associated with TBM elements in garrison and when deployed:

- **Electronic intelligence (ELINT)**: Properties of various signals and electronic emissions would be analyzed to determine if any emission or combination of emissions uniquely identifies the deployed TBM system.

- **Electro-optical (EO) sensing:** EO imaging, including full motion video (FMV), would be employed when conditions permit detection in visible light bands and would be used to detect unique equipment, if visible, as well as indications of increased traffic and other activity at suspect missile sites.

- **Synthetic aperture radar (SAR)**: SAR would be employed when conditions are not favorable for EO systems. SAR and moving target indication sensors would also detect movement of vehicles and denote high traffic areas.

- **Multi-spectral and hyperspectral imaging (MSI/HIS):** In addition to imaging in non-EO bands, MSI/HSI may detect unique spectral signatures, if these have been previously observed, and correlate them to TBM units or elements.

- **Publicly available information (PAI) or open source intelligence (OSINT):** This underappreciated source of information is becoming ever more valuable with regard to adversary capabilities and operations. With millions of sensors now operating in handheld mobile devices, which then transmit this information via ubiquitous social media applications, potentially valuable information can be collected and analyzed from these sources by skilled analysts.

- **Artificial intelligence-driven big data analysis**: This technique makes sense out of seemingly unrelated, disparate data, and would support use of algorithmic warfare techniques to use in counter-TBM operations.[8]

Understanding the Life Cycle of a TBM Launch

In its purest essence, the life cycle of a TBM launch consists of moving to launch position, launching, reloading or repositioning, and displacing to replenish missile loads. This paper will leave it to other experts to discuss the various means of intercepting TBMs during the flight phase, and there have been some interesting concepts explored in this area.[9] This analysis though focuses on actions to take during the "left of launch" phase that precedes the launch cycle, and the "right of launch" phase, where replenishment and redeployment of TBM launchers normally occurs. If the assumption is made that U.S. and allied forces cannot pre-emptively attack TBMs before hostilities, the remaining options are to actively target a missile launch in flight, to be followed by "right of launch" solutions aiming to destroy egressing TBM launchers or their reserve missile stocks. Left of launch attacks would be applied to either TBM launchers that did not fire in initial engagements or at freshly replenished TBMs returning to missile launch areas. Fundamentally, the target elements for kinetic attacks on a typical TBM brigade would consist of:

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- Mobile TBM launchers.
- Missile transporter/reloader vehicles.
- Deployed brigade-level C2, communications, and logistical elements.
- Permanent TBM garrisons in rear areas.

The TBM launcher essentially has two options for reloading after expending its initial missile—either reload in place, which would require positioning of missile loaders with each TEL, or rapidly displace to a second designated location to link up with a missile loader, reload, and fire again. Once the launcher's basic load and reload missiles are expended, the firing units must displace once again for survivability and reloads must be provided from a deployed brigade. While initial counter-TBM attacks would be focused on mobile launchers, as the offensive counter-air (OCA) campaign evolves, additional pressure could be placed on the TBM brigade C2 and reload capabilities as well.

Contending with the A2/AD Environment

Even with good target intelligence, conducting an air attack against a mobile TBM launcher in an anti-access, area denial (A2/AD) environment is a daunting challenge. These threat environments are defined by the ranges of offensive and defensive missiles in the opposing force, and these weapons' associated sensors and networks.

In a European conflict involving NATO forces and Russia for example, the European A2/AD environment would be defined by the offensive range of the Iskander-M TBM (approximately 350 km, or 217 miles) and the defensive range of the S-400 surface-to-air (SAM) missile system (also known by its NATO designation, the SA-21). The S-400 system features an air defense range in excess of 400 km (around 250 miles), is an iterative improvement on the S-300 (SA-10) system of SAMs, and is widely believed to be one of the most potent modern air defense weapon systems.[10, 11] Reports have also emerged about the development and impending deployment of a more refined missile system, the S-500, with maximum effective ranges exceeding 400 km (250 miles) against airborne targets and 600 km (372 miles) against ballistic missiles.[12]

The A2/AD environment, especially with respect to defensive missile umbrellas, has the net effect of pushing back U.S. and allied airborne surveillance and reconnaissance platforms, which poses a problem for traditional manned ISR aircraft. Electro-optical (EO) sensors on high-altitude platforms have an effective range of around 120 km (75 miles) against ground targets.[13] Synthetic aperture radars and SARs with moving target indicator sensors on medium to high-altitude platforms have an effective detection range of between 175 and 180 km (up to 112 miles).[14,15] In short, unless mobile TBM launchers unwisely set up initial positions within a 50-100km (31-62 mile) area near the front line of the initial phases of combat, they may not be detected by standoff airborne surveillance and reconnaissance assets once conflict is under way.

In the hostile environment of A2/AD defenses in future combat scenarios, initial offensive operations against TBMs would likely be conducted early in the campaign at a time when enemy air and missile defenses are at their highest state of readiness.

In order to preclude this eventuality, several actions should be taken both before combat and after. First, as noted, the application of rigorous intelligence preparation before combat begins to identify actual or probable TBM locations, and is essential. Second, because of the lethality of A2/AD environments to large, standoff airborne sensor platforms in the early stages of air combat, more emphasis must be placed on employing alternative means of imagery collection. This would require the employment of space-based sensors to support tactical operations. While the capabilities of military space-based systems are beyond the scope of this paper, it should be noted that even commercial satellites now offer imaging capabilities and periodicity rates with significant military utility. For example, commercial small satellite constellations are approaching one half meter of resolution, with coverage gaps on the order of one to 10 minutes.[16] These capabilities, coupled with missile launch detection by U.S. military and intelligence systems, could be employed to direct the actions of combat aircraft to attack TBM launchers and other key TBM-related equipment.

Offensive Counter-Air Operations Against TBMs

Air operations to counter TBMs would be integrated into larger offensive counter-air operations (OCAs) for the air component commander of a campaign.[17] In doctrinal terms, the preferred approach to counter air operations against mobile TBMs is to attack them before they can deploy to forward area concealment sites.[18] However, as previously discussed, this may not be possible and planners must assume that OCA operations would be conducted in response to an attack rather than pre-empting an attack. The remainder of the discussion of OCA in this paper proceeds from the assumption that the enemy strikes first.

Whether OCA operations against mobile TBMs are conducted left of launch or right of launch, the twin challenges continue to be locating and targeting mobile TBMs in a high-threat environment. In the hostile environment of A2/AD defenses in future combat scenarios, initial offensive operations against TBMs would likely be conducted early in a campaign at a time when enemy air and missile defenses are at their highest state of readiness. Strike packages targeting mobile TBM units would ideally consist of attack, air superiority, and defense suppression fighter aircraft, supported by overhead, standoff weapons and penetrating ISR aircraft and capabilities. Penetrating ISR assets equipped with FMV sensors could potentially support terminal search and acquisition of mobile TBMs. Sensor data from these sources would be employed to direct strike packages to TBM targets. The combined defense suppression and precision strike capability of fighter packages would enable both defense penetration and TBM destruction or suppression.

There are, of course, some challenges that need to be addressed. Because of the lethality of the A2/AD environment in the early stages of combat, penetrating strike packages would be most effective if constituted with fifth-generation aircraft for the greatest odds of survivability. However, these aircraft are in short supply in the U.S. inventory today, and are only operated by a few well-equipped allied militaries at present. The air forces of the NATO alliance, for example, consist predominantly of fourth-generation fighter aircraft. Moreover, defense suppression resources in NATO are present only available in limited numbers.[19] This dynamic is steadily shifting though, since several NATO nations have begun taking delivery of F-35 aircraft and other member states are laying out plans to cooperate in the development of a new European low-observable fighter aircraft.[20] If these trends continue to fruition, the capability gap should resolve itself over time with regard to NATO allies.

Mobile TBMs, particularly as a part of an expanding A2/AD environment, constitute a unique threat to the United States and its allies that must be addressed with both advanced technology and well-developed operational art.

Penetrating ISR would normally operate independently of a strike package, but it must be survivable in an A2/AD environment if it is to support OCA missions in hostile airspace. The current generation of RPAs now in operation, such as the MQ-9 Reaper, are highly vulnerable in A2/AD environments, which would argue for the development and deployment of penetrating ISR platforms capable of surviving and operating in high-threat environments. Development of these capabilities is in fact called for in U.S. Air Force plans for future ISR platforms, and the service appears to be moving rapidly to invest in this area over the long term.[21]

Conclusion

Mobile TBMs, particularly as a part of an expanding A2/AD environment, constitute a unique threat to the United States and its allies that must be addressed with both advanced technology and well-developed operational art. Defeating mobile TBM threats require the development of advanced missile defense systems capable of destroying incoming missiles in flight. Missile defense is an essential tool to defeating these threats, but a more comprehensive solution depends on the application of airpower, both to the left and right of launch, and against all target elements of mobile TBMs in order to present the most comprehensive defense against these weapons. ✪

Endnotes

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