Taking aim: maritime ballistic missile defence in a UK context

As the United Kingdom’s next Strategic Defence and Security Review approaches, the question of what role the country might play in ballistic missile defence is back on the agenda. Richard Scott examines the maritime dimension to this debate.
ASD15 marks a milestone test event for the MTMD Forum. Moreover, it will occur at a time when the missile defence debate in the United Kingdom is likely to be in full swing as a newly elected government works through the next Strategic Defence and Security Review (SDSR). Indeed, there is a sense that ballistic missile defence (BMD) is already rising up the agenda: if not quite the elephant in the room, then it is unquestionably one pushing at the door.

**Context**

BMD is hardly a new issue for the United Kingdom. It was in September 1944 - more than 70 years ago - that London first came under attack from German V2 rockets fired from occupied Europe. More than 1,000 of these weapons were targeted against London in a campaign that lasted until late March 1945; the attacks only ceased as the rocket launch sites fell to the allied advance across western Europe.

The V2 offensive opened a new chapter in warfare. Launched from fixed sites or mobile trailers, the V2 flew a high altitude (exo-atmospheric) ballistic trajectory to deliver a one-ton conventional explosive payload to a maximum range of about 360 km, arriving with no warning and impacting at three times the speed of sound with devastating effect. Its speed and trajectory made it invulnerable to interception by the air defences of the day.

More recently, it was the Scud offensive of the 1991 Gulf War that re-awoke governments and military commanders to the political and operational risk of short- to medium-range ballistic missile attacks. The material threat that Iraq's Scuds posed to deployed forces served as a catalyst for a number of nations - the United States, foremost - to start thinking seriously about how to acquire theatre BMD capabilities.

The intervening period has seen continued proliferation of missile propulsion, guidance, and payload technologies, the result being that more than 25 nations (including a number of 'states of concern') possess ballistic missiles today. This technological proliferation has seen the development of more advanced threats, bringing extended ranges and improved accuracies.

**Phased Adaptive Approach**

In September 2009 US President Barack Obama announced a new Phased Adaptive Approach (PAA) for missile defence in Europe. Aegis BMD is the cornerstone of this approach, with SM-3 upgrades being phased in to deployed Aegis BMD ships and land-based facilities during the course of this decade.

A first Aegis BMD deployment under Phase 1 of the European PAA began in March 2011 with the deployment of the CG 47 Ticonderoga-class cruiser USS *Monterey* (armed with SM-3 Block IA missiles). The deployment of Phase 2 capabilities began in February 2014, with the delivery of Aegis BMD ships that can fire SM-3 Block 1B missiles (Block 1B missiles were operationally deployed from 2013).

In 2003 Japan took the decision to upgrade its Kongo-class Aegis guided-missile destroyers with a BMD capability. Foreign Military Sales (FMS) cases have been implemented to upgrade all four Kongo ships with Aegis BMD, based around SM-3 Block IA missiles. The MDA states that each installation has been followed
by a flight test to demonstrate operational effectiveness of the BMD equipment and computer programmes.

In 2005, meanwhile, NATO began a programme to establish an Active Layered Theatre Ballistic Missile Defence System (ALTBMD) capability to protect deployed forces. This followed the completion of a two-year feasibility study involving co-operation from eight NATO nations and various NATO projects.

In November 2010, NATO leaders meeting in Lisbon agreed to develop a capability to defend NATO’s European nations against ballistic missile attack. This initiative, reflecting concerns over ballistic missile technology and weapons of mass destruction proliferation, built on the ALTBMD programme’s command, control, and communications capabilities and leverages the European PAA - as a US national contribution - to create a system architecture capable of defending European populations and territory.

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Off the fence?

Yet all the while - and history notwithstanding - missile defence has seemed to be a difficult nettle for the United Kingdom to grasp from a defence policy and planning standpoint. Successive defence reviews since the end of the Cold War have significantly re-shaped and re-purposed the armed forces - but in recent times each and every administration arguably has shied away from formulating a definitive position on BMD.

For example, while the 1998 Strategic Defence Review (SDR) had expeditionary operations at its core, it side-stepped the missile defence issue. A supporting essay noted only that "technologies in this area are changing rapidly and it would, at this stage, be premature to decide on acquiring such a capability".

The government of the day did commit to "monitor developments in the risks posed by ballistic missiles and in the technology available to counter them, participate in NATO studies, and work closely with [the UK's] allies to inform future decisions". This led to the establishment of a three-year research programme known as TRAPP [Technology, Readiness, and Risk Assessment Programme]. Led by the Defence Evaluation and Research Agency, TRAPP was predicated on the defence of UK forces deployed overseas - and expressly not the defence of the United Kingdom itself.

TRAPP studies significantly advanced the UK government’s understanding of the threat, as well as potential BMD options. However, in early 2002 a comprehensive joint memorandum prepared by the Ministry of Defence (MoD) and the Foreign and Commonwealth Office set out the view that, despite threat developments, it was "still premature to decide on acquiring an active ballistic missile defence capability for other deployed forces, for whom we already have considerable capabilities for passive force protection[,] ... or for the defence of the UK".

The 2010 SDSR continued the trend. Undertaken hurriedly by a newly elected Conservative-led coalition, the review acknowledged only an intention to "maintain [the UK's] existing policy of close co-operation with the US and ... other NATO allies on ballistic missile defences" and confirmed support for proposals to expand NATO's role.

There are several reasons that may explain this apparent diffidence. One is that a strong advocacy for missile defence from government might in some way undermine the political case for investment in a renewed strategic nuclear deterrent. Another is that the threat to the UK mainland (as opposed to UK
interests per se) is not perceived to be as immediate as it may be to some other nations in Europe that already fall within range of ballistic missile threats emanating the Middle East region.

The primary reason, however, is funding. Defence spending has come under unprecedented pressure since the late 1990s, with constrictions latterly exacerbated by the enduring impact of the global financial crisis. Furthermore, the main operational effort over the past 12 years has been on countering insurgencies in Afghanistan and Iraq. Resourcing has thus tended to be focused on protected mobility, force protection, tactical ISR, precision engagement, and air manoeuvre on and above the battlefield.

With the pressing priority to cut defence expenditure as part of a wider drive to reduce government spending, along with the main operational focus on Afghanistan, the 2010 SDSR in effect passed over the BMD issue. Today, however, there is a feeling that missile defence can no longer be ignored and that SDSR 2015 will finally see the United Kingdom decide on a policy position. There is already an expectation that BMD will have hooks into the underpinning concepts and doctrine that will provide a framework for policy debates.

**Informing options**

What should be made clear is that the absence of any stated policy on missile defence has not in itself left the United Kingdom ignorant of the BMD threat or without an understanding of the potential means to counter it. The MoD, the individual armed services, and the defence scientific community, together with industry, have over a long period worked to keep abreast of the threat, study and characterise key BMD technologies, perform technical and scientific research and experimentation, and provide advice to inform future policy planning options.

The focal point for this activity over the last decade has been the Missile Defence Centre (MDC). Established in 2003 following signature of a Memorandum of Understanding between the United Kingdom and the United States on joint BMD research, the MDC is an MoD-led government/industry partnership providing technical and scientific input to keep the government informed and updated on BMD-related technologies and architectures; oversee the management of supporting test, experimentation, and demonstration activities; and inform policy development.

The establishment of the MDC built on an enduring relationship between the United Kingdom and United States governments on missile defence. This includes the UK hosting the US Ballistic Missile Early Warning System radar facility at RAF Fylingdales in north Yorkshire and the communications listening station at nearby RAF Menwith Hill, both of which support the BMDS. The relationship also has seen prior collaboration on a range of science, research, and technology development projects. Accordingly, the MDC has forged close links with the MDA.
The Sampson MFR (designated Radar Type 1045 in RN service) is a high-power E-/F-band MFR using dual rotating active arrays and providing primary surveillance and dedicated tracking as part of the MBDA Sea Viper anti-air guided-weapons system. (Richard Scott/NAVYPIX)

Research areas

The MDC's research programme, which stretches back over the past decade, has included a significant maritime component geared towards understanding the potential of the Type 45 in this area. Work has addressed both the contribution to theatre missile defence and a tactical (local area) capability in the face of the emergence and anticipated proliferation of ASBMs.

Under its S&T remit, the MDC has sponsored BMD radar research for a number of years. This recognises that radar is an essential component in a missile defence architecture, providing a capability for autonomous detection, accurate trajectory determination, launch point estimation and impact point prediction, and weapon system cueing (whether organic or non-organic).
A Standard Missile-3 (SM-3) Block 1A interceptor is launched from the Arleigh Burke-class guided-missile destroyer USS Decatur (DDG 73) during FTO-01 in the Pacific Ocean in September 2013. The ship used its Aegis weapon system to track and intercept one medium-range ballistic missile target by THAAD and one MRBM target by Aegis BMD. (US Navy)

UK BMD radar research can in fact be traced back to experiments with the Multifunction Electronically Scanned Adaptive Radar 2 (MESAR2) prototype back in the early 2000s. This was followed by a satellite-tracking modification embodied in the follow-on UK ARTIST (Advanced Radar Technology Integrated Systems Testbed) radar, and more recently, an experimental BMD radar programme based on the Sampson MFR. The latter project has provided the foundation for the Type 45 Science and Technology (TSAT) demonstration programme, undertaken in September 2013, in which Daring successfully detected and tracked two medium-range ballistic missile (MRBM) targets during Flight Test Operational-01 (FTO-01), a US BMDS operational test executed at the Reagan Test Site/Kwajalein Atoll in the Marshall Islands.

Sampson’s ancestry goes back to the MESAR research programme, which itself spawned two demonstrators: the original MESAR1 prototype array, used in three trials programmes in the 1989-95 period, pioneered the development of transmit and receive modules, digital adaptive beamforming techniques, and real-time radar control; the evolved MESAR2 system began development in 1995 and subsequently underwent a two-year trials programme to demonstrate the application of MESAR technology to BMD.

More recently, the trans-Atlantic ARTIST radar research and development programme saw the United States and the United Kingdom fund the design, integration, and side-by-side testing of respective active-array MFR technology demonstrators at the US Surface Combat Systems Center at Wallops Island, Virginia. QinetiQ led the UK ARTIST industry team (which included BAE Systems and Roke Manor Research), with the UK radar building on the earlier MESAR2 demonstrator and the Sampson MFR.
The UK Royal Navy Type 45 destroyer HMS Daring arrives at Pearl Harbor naval base in July 2013. The ship subsequently sailed into the Pacific Ocean to undertake a BMD tracking experiment under the Type 45 S&T programme. The ship's Sampson MFR successfully detected and tracked two MRBM targets during FTO-01. (US Navy)

In 2007 the UK ARTIST team began work with the MDC to develop a satellite tracking capability for implementation in the radar testbed. This embodiment, which necessitated the development of alternative search strategies, radar waveforms, and signal processing, was trialled for the first time in June 2010 with two tracking experiments that used the International Space Station as a 'target of opportunity'.

The UK ARTIST system also participated in the 'Atlantic Trident' 2011 trial in January 2011. 'Atlantic Trident', the US Navy's first fleet BMD exercise to take place in the Atlantic Ocean, saw the launch of a Terrier-Oriole surrogate target vehicle from NASA's Wallops Island Flight Facility to test the surveillance and tracking performance of Aegis BMD ships.

These successful de-risking trials demonstrated the utility of the UK ARTIST testbed as a development platform and prompted the MDC to commit funding for further maturation and trials. Successful satellite tracking experiments, using the MFR Test Facility at BAE Systems' Cowes site, followed in early 2012.

TSAT itself stemmed from an MDA invitation to the RN, received in late 2011, to participate in FTO-01. According to Simon Pavitt, the MDC's director, this complex, multi-layered operational test offered the United Kingdom a real opportunity to evaluate the efficacy of its performance modelling and gather high-quality trials data for further analysis.

"Through our dialogue with the MDA, the US side knew we had been examining BMD and knew that we had done satellite tracking," he told IHS Jane's in a July 2013 interview. "The chance to track a ballistic target is incredibly rare and incredibly difficult to arrange."
The GBP10 million (USD15 million) TSAT programme was funded from the MoD's Chief Scientific Advisor's S&T programme, with MDC leading the delivery of the programme in close concert with industry (BAE Systems and MBDA) and the RN. The key radar objective for the S&T demonstration was to use Sampson, with firmware and software changes embodied, to detect and track MRBMs so as to confirm performance modelling and predictions. TSAT-specific modifications to the Sea Viper C2 system were separately implemented by MBDA; the company undertook a parallel programme of software development using a C2 Demonstrator (utilising the PAAMS Integration Facility, or PIF) established at the company's Filton site.

"Sampson has an inherent flexibility and latent capability that we sought to exploit during the TSAT demonstration," Jonathon Bluestone, BAE Systems' manager for MFR capability development, told IHS Jane's. "That said, there were a number of constraints in terms of time and resources.

"For example, we could not change the baseline logic [of the radar] because that would have needed a greater level of assurance, and hence time .... The ship [also] had to 'switch off' AAW functionality for the duration of the test, running the experimental BMD software build only in a local control mode."

Following an initial feasibility study running through to early 2012, BAE Systems began work to modify the Sampson radar to support TSAT. "We started the formal design in May 2012," Bluestone said, "and had firmware in the [Cowes] reference radar in November that year. The experimental software build, which introduced new waveform types and timing appropriate to the target set, followed in early 2013."

Implementation of the experimental BMD build in the Radar Type 1045 set on Daring followed in March 2013. Alongside performance testing in UK waters, assurance testing was undertaken to confirm that there was no impact on normal operation.

"Another deliverable to the TSAT programme was a Radar Mission Planning [RMP] tool," Bluestone said. "This was required to ensure the best utilisation of the Sampson radar and ultimately to position the ship. So we developed a prototype RMP to create radar configurations based on trajectory, target size, and a range of features and constraints."

MBDA UK, as the Sea Viper system design authority, also played a key role in TSAT by modifying the C2 software to support the BMD mission. To accomplish this, the company in 2012 began work using the PIF already resident at its Filton site. "This S&T activity introduced software changes to explore aspects of threat evaluation and weapon assignment [TEWA] chain associated with [ballistic missile] targets," Dr Phil Jackson, head of concepts and technologies for MBDA, told IHS Jane's.

"What we [MBDA] also did was to integrate and test the [MFR and C2] upgrades developed for TSAT and develop the trial conduct and safety procedures for TSAT on behalf of the MDC," added Dr David McDowell, MBDA's Sea Viper project head and chief engineer. "In this case, we used the procedures from in-service firings on the Hebrides as a baseline."
The experimental BMD software builds in both the MFR and C2 remained latent on board Daring up until the TSAT campaign period. For the live firing event itself, undertaken on 10 September 2013, the ship was positioned several hundred miles north of Kwajalein Atoll, downrange of the two MRBM launch points.

Although the MDC has not permitted the release of detailed metrics, Bluestone said the performance of the modified Sampson radar exceeded expectations in all respects. "Our objective was to acquire both targets as soon as possible after launch and then maintain track as long as possible. We achieved that, tracking both to intercept, [and] demonstrated without doubt that we can reliably detect and track ballistic missiles over significant volumes of space."

MBDA was similarly pleased with the C2 component performance. "Sea Viper successfully generated real-time track data and provided estimates of the launch point and impact point prediction," Jackson said, adding: "More comprehensive post-trials analysis confirmed the fidelity of performance with regard to launch point estimation and impact point prediction.

"So, from our point of view, TSAT was a very successful demonstration, allowing us to capture very good data to support further research at both the sensor and the C2 level. The involvement of an operational Type 45 in a significant test and demonstration exercise provided a unique opportunity to increase the UK's understanding and knowledge in this area."

McDowell added: "Participation in the TSAT exercise enabled the UK to explore the potential capabilities of an evolved [Sea Viper] weapon system against [a] challenging threat set."

Following the success of the TSAT programme, the MoD’s Research and Development Board approved in November 2013 the Type 45 Experimental Concurrency and Cueing (TECC) programme. TECC will be implemented in an as-yet-unidentified Type 45 platform for the MTMD Forum’s ASD15 demonstration this October.

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An Aster 30 missile accelerates skyward after launch from the Type 45 destroyer HMS Daring. The Aster 30 Block 1 missile - which features a dual-role warhead - would provide an initial capability against ASBMs. The follow-on Aster 30 Block 1NT - expected to enter service in the early 2020s - would offer an expanded capability. (MBDA)

**Theatre ticket**

While the IAC option - very much conditioned by the emergence of the ASBM threat - presents itself as an entry point to deliver a tactical capability, some consideration is also being given to a more ambitious BMD upgrade that could deliver a theatre-level defensive capability.
The UK’s NDP team has been tasked to examine the physical integration of the SM-3 and associated Mk 41 VLS into the Type 45 platform. (US Navy)

In October 2014 a pre-feasibility contract was placed by the Maritime Capability area in Navy Command Headquarters on the MoD-led Naval Design Partnering (NDP) team to investigate the physical integration of the Raytheon-developed SM-3 interceptor into the Type 45 platform. The start point for this is the Installation Provision Made in Design (IPMD) originally made in the Type 45 design for two eight-cell, strike-length Mk 41 VLS modules in a position abaft the Mk 8 Mod 1 4.5 in gun.
The IPMD had originally been reserved with a view to adding a deep strike capability (in the form of the Tomahawk Block IV land attack missile) into the Type 45 design. This option was not subsequently taken up, but the reserved volume remains within the ship (the space is currently used as a gymnasium).

The NDP study has sought to re-validate the baseline IPMD assumptions on Mk 41 installation and services. It has also examined the issues around the SM-3 launch environment (such as thrust impact and efflux on the deck).

**Conclusion**

Decisions made in the coming months will have important repercussions for the direction that the United Kingdom takes - if any - on missile defence. Given current pressures on defence spending, some will argue that the government - of whatever persuasion or composition - must prioritise other gapped or deficient capabilities, with maritime patrol aircraft an obvious case in point. There are others, however, who will contest that BMD is an issue the United Kingdom can no longer afford to ignore.

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