Missile-Defence Dilemmas

By Dr David Gates

Shortly after coming to office in 2009, President Barack Obama ordered a wholesale review of the USA's rather controversial policy and plans regarding ballistic missile defence that he had inherited from the preceding administration under President George Walker Bush. The resulting *Ballistic Missile Defence Review Report* has led to substantial changes in approach that have ramifications for the defence of, not only North America, but also the whole NATO region and other countries that have linked their security to that of the USA. Not least because of developments in the Middle and Far East, missile defence is in any case one of the greatest and most pressing challenges within the realm of aerospace power. At the same time, however, it is one that is peculiarly fraught with political, technical and operational complexities. This article examines some of the dilemmas inherent in ballistic missile defence especially.

Introduction

It seems probable that in no aspect of aerospace power will millennial technology have a greater part to play than in missile attack and defence. Achieving control of the air in future conflicts will require a capacity to counter, not just the customary threat posed by crewed aircraft, but also that posed by opponents' ballistic and aerodynamic missiles, as well as the latter's cousins, remotely-piloted aerial systems (RPAS). This challenge is also compounded by the simultaneous proliferation of weapons of mass destruction (WMD), for these are as likely, if not more likely, to be delivered by an adversary's aerodynamic or ballistic missiles or RPAS as they are by crewed aircraft. This article will examine some of the dilemmas inherent in ballistic missile defence (BMD) in particular.

In summer, 1944, Britain became the first country to undergo attacks by ballistic and aerodynamic missiles and had to improvise the best shield that the technology of the day permitted. Whereas an integrated defence comprising aircraft, command centres, radar, observers, anti-aircraft guns, barrage-balloons and air-raid shelters already existed in the UK, much of it having been constructed before the Second World War commenced, tactics had to be extemporized to cope with the novel threat posed by the fast, low-flying V-1 'Doodle-bugs', which were quite vulnerable to fire but difficult to spot. By contrast, against the supersonic V-2, the parabolic trajectory of which carried it beyond the atmosphere before it hurtled Earthwards, no active defence was to hand for the immediate protection of targets; counterforce operations, notably air attacks on either the facilities where the missiles were produced and stored or on the rockets themselves, or the overrunning and occupation of their launch-sites, were the only options open to the UK's defenders.

Hitler's V-1s and V-2s indubitably caused appreciable disquiet among the communities they overshadowed. At a juncture when the Allies had finally appeared to be winning the Second World War, these crude rockets gave Germany the capability to mount random, insidious attacks by night or day. Around a third of all the V-1s launched penetrated the UK's defences, while the supersonic V-2 struck with utter impunity.[1] Nevertheless, these *Vergeltungswaffen* - 'retaliation weapons' - were never likely to prove much more than a localized nuisance, not only because of the defence's effectiveness but also because of their primitive design (which made them ineluctably indiscriminate) and, above all, the Nazis' failure to subordinate their employment to a viable political and military strategy. In their attacks on the UK, the Germans' increasingly desperate search for an Achilles' heel in the form of, first, the RAF's airfields during the Battle of Britain and, subsequently, population centres during the Blitz and the V-weapons campaign, underscored the inherent problems in trying to deal an opponent a knockout blow with conventionally-armed airpower alone. As a result, the V-weapons proved comparatively ineffective, killing less than 8,900 people between them - about 20% of the deaths inflicted by manned bombers in the Blitz as a whole.[2] It was never probable that this essentially aimless and comparatively insignificant destruction would cow the hitherto indomitable British. Indeed, the very name *Vergeltungswaffen* suggests that the Germans themselves regarded them more as instruments of denial than of coercion. Certainly, they did not engender terror

to the extent that Hitler had hoped they would. If only by means of the simple expedient of suppressing reports on the bombardment's scale and the casualties it inflicted, the British authorities prevented any widespread panic.[3] In the meantime, Allied counterforce operations steadily eradicated the threat posed by these armaments to the UK.

Unlike so many in Britain, not least because of their geostrategic location and local air and naval supremacy, the cities and towns of the continental USA emerged from the Second World War virtually unscathed. Within a few years, however, the protection afforded America by her relative remoteness and great military power was being undermined. The launch, in 1957, by the USSR of the satellite *Sputnik*, the Cuban Missile Crisis of 1962 and China's acquisition of nuclear weapons shortly after helped spawn the first debate in the USA about BMD. Confronted with Congressional demands for a suitable shield and the initial reluctance of the Soviet Union to commit herself to bilateral negotiations over strategic arsenals, the Defense Secretary of the time, Robert McNamara, grew fearful that the USA would be left with no option other than to try to construct a national anti-ballistic missile (ABM) network. This threatened to be hugely expensive and, moreover, there were concerns as to the impact such a development would have on the Nuclear Non-Proliferation Treaty negotiations. Furthermore, likened to hitting one bullet with another, active BMD seemed as technically challenging as it did financially prohibitive. What had often been a bitter argument eventually ended in a compromise, whereby McNamara, persuaded that the most dependable and, thus, cost-effective way of countering any Soviet defensive web was to build more and better *offensive* missiles, focussed on just that, subordinating active BMD to deterrence.[4] Announced in September, 1967, this decision was echoed by NATO's Nuclear Planning Group the following year, when it rejected the suggestion that a European missile shield should be devised.[5] In the interim, the Russians' deliberations about ABM defences had proceeded in essentially the same direction of those of the Americans.[6] Indeed, anxious to preserve the status quo, notably the mutually assured deterrence upon which the stability of the bipolar international system that they dominated was ultimately founded, both superpowers were in the end content to accept both the ABM Treaty and the Strategic Arms Limitation Treaty (SALT) of 1972, whereby they rather pompously pledged not to do what neither of them had any real desire to do anyway. There can be no question that the costs of the projected ABM defence networks outweighed any advantages that might have stemmed from having them, while SALT 1 left both sides with the liberty and resources to refine and expand their nuclear arsenals in a more selective fashion, notably through the procurement of survivable second-strike systems.[7]

The ABM Treaty was destined to survive for thirty years. The Americans' *Safeguard* BMD system, which was built to protect *Minuteman* missile silos from pre-emptive attack, remained in service from 1969 until 1975. The A-135, a modified two-tier system of the old Soviet *Galosh* BMD network, which was designed to protect Moscow and its environs, is still in being. In short, both superpowers used the very limited scope for BMD left them under the ABM Treaty to reinforce deterrence. Indeed, as early as 1946, one of the USA's most promising military thinkers, Bernard Brodie (1910-1978), who is perhaps best remembered for his book *Strategy in*

the Missile Age (1959), a staunch endorsement of the acquirement of survivable second-strike capabilities, had written: 'Thus far, the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them.'[8]

Yet sooner or later there were bound to be those who were dissatisfied with 'the balance of terror.' In 1983, with the deployment of sophisticated intermediate range missiles in Europe exacerbating East-West tensions, US President Ronald Reagan proposed an alternative security arrangement, the Strategic Defense Initiative (often pejoratively referred to as 'Star Wars'), which, critics argued, undermined deterrence by compromising the effectiveness of the Soviet strategic forces through the development and deployment of unparalleled BMD capabilities, many of which would be aboard platforms based in space. There were soon calls for a European Defence Initiative, too, with commensurately more modest suggestions for the enhancement of NATO's existing air-defences so that they would be able to counter aerodynamic and 'theatre' ballistic missiles.[9]

Neither the Strategic Defense Initiative, as it was originally envisaged by Reagan, or the European Defence Initiative ever came to fruition. Nevertheless, many of the operational concepts and technological innovations these ideas inspired survived the Cold War's end. The 'balance of terror' had, in the meantime, steadily become rather more complicated. Notwithstanding the 1968 Non-Proliferation Treaty, other states aspired to join the nuclear club and many sought and acquired other WMD, notably chemical and biological armaments. In recent years, apprehension in this regard over, firstly, Iraq and, subsequently, Iran has been to the fore, but the atomic test conducted by the People's Republic of China in 1964 was an alarming development for both superpowers. In fact, the USA considered mounting a preventive attack on the Chinese research and development facilities, while, within five years, observers were speculating that the USSR was facing her last opportunity to destroy Beijing's nuclear capabilities without incurring unaffordable costs herself. Having initially hoped to control China's acquisition of nuclear arms through the Test Ban Treaty and through cooperation with the USA, the Russians were eventually reduced to contemplating a preventive attack against the Chinese nuclear plant at Lop Nor in 1969.[10] This drastic option was eventually rejected, leaving the Kremlin worrying about a growing and increasingly sophisticated Chinese arsenal, including nuclear weaponry, along the Sino-Soviet frontier. Amidst the deepening rapprochement between China and the USA that was coincident with and influenced by the end of the Vietnam War, the Russians became ever more fearful that Beijing might get its hands on Western aerospace technology that might weaken the USSR's strategic position still further.[11]

There are obvious pitfalls surrounding preventive strikes, namely those attacks intended to stop the acquisition of a particular capability. Nevertheless, these have been resorted to on occasion, notably the Israelis' destruction of the Iraqi nuclear facility at Osirak in 1981[12] and Operation 'Desert Fox' in 1998, whereby British and American air power razed buildings in Iraq that were thought to be being used for the clandestine production of WMD. Indeed, the

invasion of Iraq five years later was arguably the grandest preventive operation ever mounted. In view of the enormous difficulties involved in intercepting a missile once it is in flight, the temptation to try to avoid the need for this through either preventive or pre-emptive attacks is considerable. However, it is only to be anticipated that future counterforce operations will encounter greater endeavours to thwart them. This could be achieved by various deception techniques, by enhancing the defences, concealment or mobility of possible targets, by dispersing them or by granting them greater operational independence. In any event, not only do pre-emptive blows call for an intelligence-gathering and dissemination mechanism that is almost infallible, they also constitute a questionable policy, from both a legal and moral standpoint, that can all too easily prove counterproductive as well.[13] What exactly is to be pre-empted and what is expected to ensue? Can pre-emption be reconciled with the right to self-defence?

Such were and are the sheer size and sophistication of the Russians' missile inventory that, since Reagan's abortive SDI, no serious proposals for countering these forces through universal, active-defence measures have been given much thought (in public, at least!). Nevertheless, the attempts by NATO in general and the USA in particular to counter more-manageable threats have predictably aroused suspicions in Moscow and Beijing alike. With the end of the Cold War, the rationale for missile-defence altered: tactical protection for deployed forces was increasingly seen as essential; some capacity for destroying missiles launched in error or by accident was regarded as desirable; the insidious danger that non-state actors, who would not be susceptible to deterrence, might acquire WMD and some means for delivering them remotely was also seen to be growing; and there was a clutch of 'rogue' states - North Korea, Iran, Libya and Iraq - that appeared bent on upsetting the apple-cart by obtaining WMD and missile-technology through fair means or foul. The response of George W. Bush's administration to these looming dangers included: the rescinding of the ABM Treaty; the invasion and occupation of Iraq in 2003; the rather hasty development and deployment of ground-based interceptors (GBI) at Fort Greely, Alaska, and Vandenberg Air Force Base, California; and plans for an array of ten such interceptors at Koszalin, Poland, which would be supported by a single, large, static radar in the Brdy district of the Czech Republic.

In fact, the justification for some Western capacity for active missile-defence began to change before the Cold War's end. Even as the threat from the crumbling Soviet Union receded, new dangers were looming on the horizon. The bombardment of Israeli and Saudi cities by Iraqi ballistic missiles during the Gulf War of 1991 seemed a harbinger of things to come. The immediate reaction to these developments included extensive counterforce operations - the so-called 'great Scud Hunt' - and the hasty deployment of American *Patriot* (PAC-2) air-defence units to give some protection to vulnerable nodes. (The *Patriot* had essentially been designed as an anti-aircraft weapon and had to be rushed from testing into emergency production.) Although, at the time, great claims were made about its performance in countering the Scuds, subsequent analysis suggested that very few, if any, incoming rockets were successfully intercepted.[14] Re-entering the Earth's atmosphere had evidently proved a greater danger to

the *Al-Hussein* variant especially than had active defence measures such as the *Patriot*, which, among other problems, had difficulty distinguishing between the warhead and other larger pieces of debris from disintegrating missiles.

Although the damage inflicted by the Scuds was far more psychological than physical, it did have considerable effect, not least within some of the USA's political and military circles. Whereas, largely because of the high degree of control of the air enjoyed by her armed forces during the intervening period, the USA had not lost a single soldier to aerial attack for almost 40 years,[15] during the Gulf War 28 perished and 97 were injured in a single incident when, as much by accident as design, one of Saddam Hussein's rickety missiles fell on their barracks in Dhahran.[16]

This spurred on America's quest for effective, active defences against missiles. Developing and deploying suitable armaments as quickly as possible was seen as an imperative. Not least because the US Army, Air Force and Navy were all searching for their own solution to perceived problems, a number of potential weapon systems was invested in, notably the Theatre High-Altitude Area-Defence (THAAD) interceptor, improved versions of the existing *Patriot*, the ship-mounted SM-3 Missile, which was linked to the Aegis radar system, and the exotic Airborne laser, which was squeezed into a Boeing airliner. There were also multi-national collaborative ventures, such as the Israeli missile-defence project, which was to yield such weapons as the *Arrow, David's Sling and Iron Dome*, and the European Medium Extended Air-Defence System (MEADS).

These undertakings relied - and, in some cases, still rely - extensively on American financial subsidies, technology-transfers and expertise. The monetary costs alone attached to missile defence have proved, and continue to prove, awesome. Although the Clinton administration was to spend some $25 billion on BMD alone during the fiscal years 1997-2003, this sum was to prove insufficient at times. The USA's annual spending on projects relating to missile defence has averaged almost 2% of the overall defence budget since 2001 and will amount to $9.9 billion in the financial year 2011. It is expected to rise to $10.7 billion in the year after.[17]

Moreover, the new emphasis on active defence has proved irreconcilable with parts of the existing framework of arms-control agreements. The USA duly withdrew from the ABM Treaty in 2002.[18] Faith in the Missile-Technology Control Regime (MTCR) also waned. The MTCR was the next best thing to an international treaty banning trade in missiles and their key components; it sought to dovetail export controls among its numerous members so as to prevent militarily-sensitive technology, materials and know-how from being passed to certain states. In the porous societies of today's world, this approach was unlikely to prevent those bent on acquiring particular capabilities from doing so. Diplomatic efforts to constrain the spread of WMD continue, but there is now an open market in many technologies associated with the cardinal delivery system for such weapons, the missile.

In the meantime, in the face of a threat that is seen to be increasing, both qualitatively and

quantitatively, America's current government 'will continue to reject any negotiated restraints on U.S. ballistic missile defenses.'[19] Many states that already possess missiles are enlarging their inventories; others are deploying missiles that are more sophisticated than their predecessors. The range and accuracy of ballistic missiles is generally improving, bringing ever larger areas of the Earth's surface within their reach and rendering these armaments that much more capable of striking discrete targets. Pre-launch survivability might well increase as potential adversaries strengthen their deception measures and increasingly rely upon mobile, rather than static, platforms. Many states are now using advanced, liquid- or even solid-propellants in their missiles, which reduces launch-times and improves both reliability and the scope for mobility. This, in turn, enhances survivability. Besides attempting to increase their missile units' protection against counterforce operations of the type seen in the 'Great Scud Hunt', some states are also trying to develop technical and operational countermeasures to neutralize active missile-defences, not least the technique of firing salvoes of missiles so as to swamp the monitoring capabilities and firepower of any defensive network.

Moreover, whereas a few states are also believed to be bent on developing nuclear warheads for their ballistic missiles, rather more are seen to be devising chemical or biological payloads, or both. North Korea, for instance, has not disguised her nuclear ambitions and has been endeavouring to perfect a long-range rocket that might deliver such a warhead.[20] The *Taepodong*-1 missile, which first appeared in 1998, has now been joined by the *Taepodong*-2, a variant of which, it is believed, might eventually be capable of reaching parts of the continental USA. Test launches of the *Taepodong*-2 have been dogged by failure, but the same could be said of the development of many other, ultimately serviceable, ballistic missiles. As the proliferation of nuclear arms has itself highlighted, if sufficient resources, including time, are devoted to their solution, even complex technical problems can very often be overcome. It would be imprudent not to assume that, unless there is a substantial change in the course of North Korea's national security strategy, she will possess a viable ICBM by 2020.

In the meantime, countries that are important allies of the West in general and of the USA in particular - some of them, such as South Korea, containing a significant American military presence - are already in reach of North Korean ballistic missiles. Likewise, the exposure of Taiwanese military and civilian centres, not to mention US and allied forces in the region, to attack by ever more numerous and sophisticated Chinese ballistic missiles based along the straits represents 'a growing imbalance of power' that 'particularly concerns' the USA.[21] (China even claims to have successfully tested her own ground-based BMD system in January, 2010.[22]) Similarly, Iran, suspected of clandestinely developing nuclear weaponry, is certainly acquiring ballistic missiles of greater reach than those she has had in the past, while Syria is known to have several hundred Scuds and SS-21 short-range ballistic missiles, all of which are mobile systems. It is believed that Syria also has at least some chemical warheads for use with her Scuds.[23] Cyprus - where Britain has sovereign bases - and much of Turkey, Israel and Iraq can be reached by such missiles, whereas the latest variant of Iran's *Shahab*-3 is thought to have a range of all of 2,000 kilometres.[24] Most of the Balkan Peninsula, which, since the Gulf War of

1991, has become NATO territory, thereby lies within striking distance. Iran's ally, Hezbollah, which has made ever more use of rocket systems of various types, is widely believed to have amassed some 40,000 such devices, mostly short-range armaments, with which to saturate Israel's defences.[25] As a recent American report on BMD concluded: 'Such capabilities could be significant sources of military advantage during a conflict. But they may be equally significant in times of relative peace, when they undergird efforts to coerce states near and far.'[26]

Ever since the mid-1990s, NATO has proceeded on the assumption that, within fifteen years, much of the alliance's territory would lie within reach of, not just weaponry possessed by the old adversary, Russia, but also ballistic missiles belonging to potentially hostile states such as Iran. This expectation has partly been fulfilled. Indeed, during the second quinquennium of the 21st Century, growth in the capabilities of North Korea and Iran provoked considerable anxiety in the West, not least in Washington, where fears of a missile attack on the continental USA intensified. On coming into office, President Obama ordered a thorough review of the policy and plans regarding BMD that had been pursued by the preceding administration under President George Bush. Published early in 2010, the resulting report concluded that, thanks to measures that had already been implemented, the USA possessed sufficient capability 'to counter the projected threat from North Korea and Iran for the foreseeable future.'[27] It was therefore proposed that, for the time being, no new ground-based interceptors be added to those that had already been deployed in California and Alaska. Aided by early-warning radars in the UK, Greenland and the continental USA, and by radars mounted on anchored rigs and aboard Aegis cruisers and destroyers, these interceptors might undergo some qualitative refinements, but their number could, it was believed, safely be left at thirty.[28] Moreover, the plans for the deployment of interceptors and a supporting, static radar in Eastern Europe – plans that, predictably, had antagonised the Russians - were likewise discarded.

The challenge had not quite taken on the pace, size and shape that had been expected, underlining the need for a more flexible, adaptive approach to the quandary of BMD than that taken by the Bush administration. Nevertheless, substantial and expanding dangers abounded. As Robert Gates, the US Secretary of Defense, observed at the beginning of 2010:

> *'The protection of the United States from the threat of ballistic missile attack is a critical national security priority. The threat to our deployed military forces and to our allies and partners is growing rapidly. This threat has significant implications for our ability to project power abroad, to prevent and deter future conflicts, and to prevail should deterrence fail.'*[29]

Rather than trying to neutralize this threat through an integrated missile-defence architecture that integrates allies into a uniform, global structure, the USA was henceforth to pursue 'regional structures sharing common assets that are relevant and robust because they are tailored to the unique requirements and opportunities within each region.'[30] In the case of the NATO area, a 'phased, adaptive approach' was envisaged, whereby, focussing on real, emerging threats and relying on tried and tested solutions, successively better, interoperable and more

numerous capabilities would be deployed in four phases that would stretch as far into the future as 2020. Protection from attack by ballistic missiles would thereby gradually be extended to cover, not just deployed forces, but also entire countries and populations.

The first of these phases has already begun. Aegis cruisers, armed with SM-3 (Block 1A) interceptors and deployed on six-month tours in European waters, will supplement European and American *Patriot* PAC-3 batteries and long-range sensors such as the AN/TPY-2 high-resolution radar (Army and Navy Transportable Radar Surveillance System). The North Atlantic Council is finalizing appropriate missile-defence consultation and control arrangements. During the programme's second phase, a more capable version of the SM-3 (the Block 1-B) will be introduced, together with better sensors so as to expand the defensive 'envelope' against short- and medium-range missiles. Likewise, the *Patriot* Missile Segment Enhancement (PAC-3 MSE) programme will yield an interceptor that is faster and more agile than its predecessors. (This will also serve as the interceptor component in the MEADS.) A re-locatable land version of the SM-3, provisionally dubbed 'Aegis ashore', is also being perfected to complement THAAD and *Patriot* batteries from 2015 onwards. Still more capable versions of the SM-3, the Block 2-A and Block 2-B, are envisaged and are expected to enter service in phases three and four, respectively.[31]

Prior to this, the depth of NATO's defences will be bolstered through the introduction of a fleet of RPAS, which will use infrared sensors to detect and track multiple targets. The ability to cue the SM-3 through remote sensor data is also being explored. This will effectively expand the missile's reach by enabling the interceptor to engage targets beyond the range of the Aegis radar. Similarly, it is expected that, between 2015 and 2020, new space-based sensors will be deployed that will be capable of detecting and tracking numerous missiles throughout their flight. This might permit a reduction in the need for terrestrial sensors and in the overall size of defensive networks.[32]

From the preceding, brief survey of the history of missile defence, it can be seen that there are four potential solutions to the fundamental problem. These comprise deterrence and, should that fail, a triad of defensive measures: counterforce, passive defence (which includes arms-control) and active defence.

The performance characteristics of ballistic missiles, aerodynamic missiles, RPAS and crewed aircraft all differ to a greater or lesser degree, necessitating a blend of contrasting defensive systems in any extended air-defence network. However, identifying and achieving the appropriate mixture of the various defensive components in a dynamic, scenario-dependant environment is all but impossible. Military capabilities take years to develop or regenerate once lost, yet political intentions can alter literally overnight. Furthermore, not only do force-balance issues affect each component of the defensive triad, complicating research and procurement decisions as well as operational matters, but also the elements of extended air-defence are as mutually competitive as they are reinforcing.

This exacerbates force-design and strategic-planning difficulties. For example, if arms-control or efficacious counterforce capabilities might reduce if not obviate the need for active defence preparations, then powerful counterforce or active defence capabilities could diminish the requirement for passive defences. Providing an appropriate level of active and passive protection for anything but deployed forces, however, would be dauntingly costly. Just as pure defence could not offer complete protection - furnishing passive defences for entire countries is essentially impracticable and would offer only scanty protection against WMD - so too could active defences be circumvented by unconventional delivery means, including acts of terrorism involving WMD.[33] Under the phased, adaptive approach to extended air-defence, threats are to be addressed in a prioritised fashion that includes consideration of the imminence of the danger and the level of acceptable risk. This approach is, of course, largely guesswork, but it would appear to be the best solution available to the conundrum.

Besides such broader complexities, there are several dilemmas surrounding the tactical operation of missile-defences. Where BMD is concerned, providing one has suitable sensors, decision-making processes and interceptors, it is theoretically possible to strike at a ballistic missile during the boost, mid-course and terminal phases of its trajectory. There are disadvantages and advantages that are peculiar to each of these approaches, necessitating the customizing of defences to each particular set of circumstances. During its boost phase, for example, any missile will present a single target; it will not yet have deployed either any decoys it possesses or, if fitted with more than one payload, its discrete warheads, of which there might be several. Debris from any successful interception will, moreover, fall onto the launch area. On the other hand, an ICBM typically reaches a speed of seven kilometres per second within 250 seconds of being launched. This leaves an opponent very little time - five minutes at most - in which to detect the launch, plot an interception and unleash an interceptor. The latter missile will then have to cover the intervening distance with tremendous speed if the target is not to evade it. All of this demands early detection, which requires good sensors (not least satellite-based systems), ideally of contrasting types, and very rapid decision-making mechanisms.

The mid-course phase of a missile's flight, by contrast, offers a relatively large window of opportunity for interceptions, perhaps as much as twenty-five minutes. During this period, various sensors, such as radars and space-based tracking systems, can guide ground-based interceptors to the target. However, there is now a chance that their quarry will be obscured by decoys, such as balloons made from polyethylene terephthalate. Whereas the more adept sensors can discriminate between these and real warheads, decoys are steadily becoming more sophisticated.

Finally, an interception might be attempted during the terminal, re-entry phase of a missile's flight. This period might last no more than a minute, leaving the defender with very little time in which to use his firepower. Protective systems thus have to be situated in the vicinity of the target and need to be able to track and intercept incoming missiles with extraordinary precision. Decoys are unlikely to complicate matters at this stage, since they usually burn up

on entering the Earth's atmosphere. Any debris from intercepted missiles will of course fall onto the target area and might thereby inflict some damage.

Last but by no means least are the difficulties inherent in achieving an interception. Likened to hitting one bullet with another, BMD calls for extraordinary precision; a split second or an angle of a fraction of a degree can make all the difference between success and failure. Rather than employing proximity fuses, interceptors such as *Patriot* (PAC-3), THAAD and the SM-3 ultimately depend upon 'kinetic kills', whereby a collision between the incoming missile and defensive projectiles, the final trajectory of which is adjusted by sophisticated, organic sensors and guidance systems, is engineered. BMD is thus essentially a sequential process; if a single link in the chain fails, then the chain as a whole is compromised. During its development, the THAAD missile, for instance, once failed five consecutive tests for five different reasons, while, as recently as December, 2010, a GBI, which was launched from California and guided by a sea-based X-band radar, failed to destroy a target missile fired from the Marshall Islands; the exo-atmospheric kill-vehicle released by the GBI rocket did not find its prey.

That said, many years of investment, testing and refinement have begun to pay dividends. Indeed, better, more cost-effective technology is one of the considerations that have helped bring about the change in American policy that has occurred of late. These exotic weapons are more dependable than ever before. Whereas in the past the perceived urgency of the situation led to some development and deployment programmes occurring simultaneously, the US government's approach is now one of 'fly before you buy.'

Whether tried and tested BMD armaments and supporting sensors can be produced and afforded in sufficient quantities to satisfy the growing demand for them remains to be seen. And this is just one of several overlapping complexities concerning the density of any defensive network alone. For instance, confronted with the possibility that, as occurred in 2006, hundreds of short-range rockets might be fired into her territory by Hezbollah, Israel, with American assistance, is investing in *Iron Dome* batteries. Each of these has radars capable of tracking several targets simultaneously and twenty interceptors. Will this firepower prove sufficient to deal with the potential volume of incoming projectiles? If not, on what are these defensive assets to be focussed? It is becoming increasingly clear that the priority is to protect military capabilities, not least counterforce capabilities, rather than, say, population centres.

Several quandaries bedevil the USA's latest policy regarding missile defence. Among these are: the need to find sufficient funds to pay for capabilities over the long term; to ensure that new technology is proven before deployment; to protect the homeland while finding sufficient resources to defend against regional missile threats to US forces as well as, where appropriate, their allies and partners; to make certain that capabilities are sufficiently flexible to adapt as threats change; and to achieve expanded international cooperation over missile defence while not jeopardizing the strategic balance between the world's major powers, notably NATO, Russia and China. As far as regional BMD is concerned, there is a further need to customize

capabilities to meet the peculiar deterrence and defence requirements of each theatre, the characteristics of which vary appreciably in terms of geography, the scale of the perceived threat and its rate of growth, and the breadth and depth of the relationship between the USA's armed forces and the 'host' military. As the potential, global demand for missile-defence assets might well exceed supply, it is also felt necessary to develop systems that are mobile and can be relocated to counter shifting and evolving threats.

According to *The Ballistic Missile Defence Review Report* of 2010, the USA 'seeks to create an environment in which 'the development, acquisition, deployment and use of ballistic missiles by regional adversaries can be deterred, principally by eliminating their confidence in the effectiveness of such attacks.'[34] Much of the disquiet aroused in recent years in the USA in particular and in the West in general by ballistic missiles has stemmed from events in Iran. To date, diplomatic sanctions and deterrence have been to the fore in trying to deal with what could all too easily become one of the greatest political and military dilemmas of our time. It is clear that faith in the eventual success of these endeavours is faltering and more emphasis is being placed on preparations for active BMD by NATO, Israel and several members of the Gulf Cooperation Council that have bilateral arrangements with the USA.[35] Whilst a greater capacity for active defence might bolster deterrence, it will be interesting to see what role, if any, the other components of the defensive triad are allotted in the ultimate resolution of this quandary.

Notes

[1] Whereas 1,054 V-2s struck Britain, about 10,000 V-1s were unleashed against her, mostly from surface sites, though a few were launched from aircraft. In all, 7,488 reached Britain, 3,531 eluding the defences. See: I.C.B. Dear and M.R.D. Foot, *The Oxford Companion to the Second World War* (Oxford, 1995), pp. 1,249-53.
[2] See: ibid. pp. 138-40; B. Ford, *German Secret Weapons: Blueprint for Mars* (London, 1970), pp. 104-11; and B. Collier, *The Defence of the United Kingdom* (London, 1957), pp. 527-8.
[3] R.V. Jones, *Most Secret War* (London, 1978), pp. 523-75.
[4] See: 'Arms Control and Disarmament', *Foreign Relations of the United States 1964-68* (Washington DC, 1997), 282-4, 286-8, 407-17, 421-23, 426-9, 499-502, 512-15, 653-7, 659-61,669-72, 674-80, 704-13, 744-7 and passim.
[5] M. Rühle, 'Preserving the Deterrent: A Missile Defence for Europe,' *Occasional Paper 21* (Institute for European Defence and Strategic Studies, London, 1986), p. 7.
[6] See C. Bluth, *Soviet Strategic Arms Policy Before SALT* ((Cambridge, 1992), pp. 199-218.
[7] See: C. Bluth, op. cit., pp. 199-218; J.J. Stone, 'The Case Against Missile Defence,' *Adelphi Paper* 47 (International Institute for Strategic Studies, London, 1968); and J. Voas, 'Soviet Attitudes Towards Ballistic Missile Defence and the ABM Treaty,' *Adelphi Paper* 255 (International Institute for Strategic Studies, London, 1990).
[8] B. Brodie (editor), *The Absolute Weapon* (New York, 1946), p. 76.
[9] See: C. Bertram, 'Strategic Defence in Europe,' *Nato's Sixteen Nations* 31/3, (June, 1986), 28-30;

D.L. Hafner and J. Roper, (editors), *ATBMs and Western Security: Missile Defenses For Europe* (Cambridge MA, 1988); D.S. Sorenson, 'Ballistic Missile Defence for Europe,' *Comparative Strategy*, 5/2 (1985), 159-78.

[10] See: R. Foot, *The Practice of Power: US Relations With China Since 1949* (Oxford, 1995), pp. 128-9, 133, 176, 178-81, 188-93.

[11] C.J. Bartlett, *The Global Conflict* (London, 1994), pp. 349, 365-6; Foot, *op. cit*., p. 138-9.

[12] For a survey of such attacks on nuclear facilities, see: S.E. Kreps and M. Fuhrmann, 'Attacking the Atom: Does Bombing Nuclear Facilities Affect Proliferation?' *Journal of Strategic Studies*, 34/2 (2011), 161-87.

[13] See, for instance, S. Condron, 'Justification for Unilateral Action in Response to the Iraqi Threat: A Critical Analysis of Operation Desert Fox,' *Military Law Review*, 115 (1999).

[14] See Activities of the House Committee on Government Operations, 'Performance of the Patriot', *Congressional Record*, House of Representatives, 102nd Congress, 1st and 2nd sessions,, 1991-92 (Washington DC, 1992), pp. 179-85; T. Postol. 'Lessons of the Gulf War Experience with Patriot', *International Security*, XVI/3 (1991) 119-71; T. Postol and R. Stein, 'Patriot Experience in the Gulf War', *International Security*XVII/1 (1992), 199-240.

[15] P.S. Meilinger, *Ten Propositions Regarding Air Power* (Washington, 1995), pp. 4-5.

[16] These figures constituted 36% and 34% of all the US Army's fatalities and wounded, respectively.

[17] See: W. Ferster, 'US Missile Defense Faces Funding Deficit,' *Defense News*, 13/19 (May, 1998), 3, 27; US Department of Defense, Office of the Assistant Secretary of Defense (Public Affairs), *News Release* 084-10, (Washington DC), 1 February, 2010; Office of the Under Secretary of Defense (Comptroller), US Department of Defense, *Fiscal Year 2012: Budget Request: Overview* (Washington DC, 2011), section 4-9.

[18] There is also some concern for the future of the Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (1967), which calls for the peaceful use of space. Some ballistic missile interceptors can reach satellites in low -earth orbit. Will satellite constellations come to be protected by space-based defences, thereby militarizing space?

[19] US Department of Defense, *Ballistic Missile Defence Review Report* (Hereafter *BMDRR*), (Washington DC, 2010), p. 34.

[20] International Institute for Strategic Studies, *The Military Balance 2011: The Annual Assessment of Global Military Capabilities and Defence Economics* (Hereafter *Military Balance 2011*), (London, 2011), pp.249-50.

[21] *BMDRR*, p. 7.

[22] Ibid., pp. 12-13. For a broader survey of Chinese capabilities, see: *The Military Balance 2011*, pp. 230-36, particularly p. 230.

[23] See: *Military Balance 2011*, pp. 330-32.

[24] See: *Ibid*., pp. 309-11.

[25] For a discussion of this and related problems, see S. Kainikara and R. Parkin, *Pathways to Victory: Observations from the 2006 Israel-Hezbollah Conflict* (Air Power Development Centre, Tuggeranong, 2007); and A. Stav (editor), *The Threat of Ballistic Missiles in the Middle East: Active Defense and Counter-Measures* (Brighton, 2004).

[26] *BMDRR*, p. iii.
[27] *Ibid*. p. iv.
[28] *Ibid*., pp. 15-16.
[29] *Ibid*. p. i.
[30] *Ibid*., p. 23.
[31] *Ibid*. pp. 20-23.
[32] *Ibid*. pp. v, 21.
[33] For some of the complexities surrounding this issue, see: A.J. Mauroni, 'A Counter-WMD Strategy for the Future,' *Parameters: US Army War College Quarterly*, XXXX/2 (2010), 58-73.
[34] *BMDRR*, p. vi.
[35] *Ibid*., pp. 5-6, 33-34. Also see: International Institute for *Strategic Studies, Strategic Survey 2010: The Annual Review of World Affairs* (Abingdon, 2010), pp. 242-45.