Proliferation Papers

Addressing the Cruise Missile Threat: Defense and Diplomatic Responses

In collaboration with the Atomic Energy Commission (CEA)

Dennis Gormley

Spring 2002

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Security Studies Department

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Though it has long been a concern for security experts, proliferation has truly become an important political issue over the last decade, marked simultaneously by the nuclearization of South Asia, the strengthening of international regimes (TNP, CW, MTCR) and the discovery of fraud and trafficking, the number and gravity of which have surprised observers and analysts alike (Iraq in 1991, North Korea, Libyan and Iranian programs or the A. Q. Khan networks today).

To further the debate on complex issues that involve technical, regional, and strategic aspects, Ifri's Security Studies Department organizes each year, in collaboration with the Atomic Energy Commission (*Commissariat à l'énergie atomiqe*, CEA), a series of closed seminars dealing with WMD proliferation, disarmament, and non-proliferation. Generally held in English these seminars take the form of a presentation by an international expert. The *Proliferation Papers* is a collection, in the original version, of selected texts from these presentations.

The following text is based on a presentation given by Dennis Gormley at Ifri on April 11st, 2003.

Dennis M. Gormley is a Senior Fellow at the Monterey Institute's Center for Nonproliferation Studies, based at its Washington DC office. His work over the last decade has focused heavily on the strategic implications of cruise missile proliferation. He has written widely on the subject, including two influential monographs, *Dealing with the Threat of Cruise Missiles* (Oxford University Press for IISS, 2001) and *Controlling the Spread of Land-Attack Cruise Missiles* (American Institute for Strategic Cooperation, 1995) with K. Scott McMahon.

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Text established by Marianne Kac-Vergne and Marguerite Collignan

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Introduction

Even though cruise missiles were more prominent instruments of warfare over the last decade, ballistic missiles have dominated the missile proliferation scene. This should come as no surprise. Iraq's use of modified Scud ballistic missiles during the last Persian Gulf War mesmerized the public with lasting images of duels between Iraqi missiles and US Patriot missile defenses. Besides, ballistic missiles based on the ubiquitous Scud have spread widely and, as a potential means of delivering weapons of mass destruction (WMD), they represent significant impediments to US force projection and a potent means of future coercive diplomacy should intercontinental range ballistic missiles (ICBMs) eventually become available to a handful of American adversaries. Land-attack cruise missiles, on the other hand, have not spread widely beyond a few industrialized nations. However, cruise missiles and armed unmanned aerial vehicles (or UAVs) represent the next great missile-proliferation challenge. In the absence of appropriate hedging strategies consisting of a mix of defense and diplomatic initiatives, the widespread proliferation of cruise missiles for land attack is destined to sow unwelcome strategic consequences.

What might these strategic consequences be? The widespread proliferation of land-attack cruise missiles could adversely affect the success of US-led coalitions in projecting force over great distances, as well as homeland security. Regarding force projection, if the use of large numbers of cruise missiles becomes a major feature of military operations in the next two decades, a combination of cruise and ballistic missile attacks could make early entry into regional bases of operation increasingly problematic. Compared to ballistic missiles, cruise missiles greatly enlarge the effective lethal area of chemical and biological attack, and because of their accuracy, even conventionally armed cruise missiles may be able to achieve significant damage on exposed area targets. But even more worrisome is the fact that the low cost of cruise missiles, small airplanes modified to become autonomous vehicles, and other propeller-driven and armed UAVs makes the cost-per-kill arithmetic of theater missile defense stark. Whether a *Patriot* PAC-3 missile costs $5,000,000 or the desired $2,000,000 per copy, the figure compares unfavorably with either a $200,000-per-copy cruise missile or large saturation attacks of $50,000-per-copy modified airplanes. Quite simply, because ballistic and cruise missile defenses depend largely on the same high-cost air-defense interceptors, complementary cruise and ballistic missile attacks, especially saturation ones and those delivering WMD payloads, will present enormous challenges for the defense.

On the homeland defense side, various CIA National Intelligence Estimates (NIEs) have drawn attention to the possibility of covertly converting a commercial container ship into a launching platform for a cruise missile positioned outside a nation's territorial waters. From such locations, such a launch platform could strike virtually any important capital or large military target anywhere around the globe. Indeed, the latest NIE—no doubt influenced by the events of September 11th —argues that this, among several other attack options, is more likely to occur rather than a long-range ballistic missile attack on the US homeland. This is because such alternatives are less costly, easier to acquire, and more reliable than using an ICBM. While this scenario and other non-ICBM threats deserve close scrutiny, it is the conversion of small manned airplanes into weapons-carrying, fully autonomous cruise missiles which causes the most concern. Terrorist use of large commercial airliners on 11 September came as a complete shock to American planners. To be sure, September 11th sparked a whole rash of reforms to cope with the repetition of such an attack. None of the reforms, however, deal with private aviation. Even though small converted aircraft cannot begin to approach the carrying capacity of a jumbo jet's 60 tons of fuel, the mere fact that gasoline, when mixed with air, releases 15 times as much energy as an equal weight of TNT, means that even relatively small aircraft can do significant damage to certain civilian and industrial targets. Such platforms, too, stand as effective means of delivering biological weapons.

What I would like to discuss today are how the cruise missile threat may evolve and what responses seem appropriate in light of the threat's emergence. By way of outline, I will briefly touch on why the barriers to acquiring cruise missiles are falling; then address the various ways a country might choose to acquire such missiles; next examine why the threat hasn't emerged as fully as some analysts had predicted; and finally, discuss both defense and diplomatic responses that might comprise useful hedging strategies to cope with the cruise missile threat.

Nature of the Threat

A. Falling Barriers to Cruise Missile Development

Technological Barriers

Concern about the spread of land-attack cruise missiles is driven by two realities: first, the quantum leap in dual-use technologies supporting cruise-missile development (including satellite navigation and guidance, high-resolution satellite imagery from commercial vendors, unregulated flight management systems for converting aircraft into unmanned aerial vehicles, and digital mapping technologies for mission planning); and second, the fact that the 33-nation Missile Technology Control Regime (MTCR) is much less effective at controlling the spread of cruise missiles and UAVs than ballistic missiles.

The two primary barriers to developing land-attack cruise missiles are access to navigational guidance and propulsion systems. As to the former, as long as highly sophisticated guidance and control technology, such as terrain contour matching (TERCOM) and digital scene matching area correlation (DSMAC) systems, represented the state of the art, there were three important barriers to proliferation. First, the functionality of these technologies depended on maps derived from highly classified overhead reconnaissance satellites. Second, developing a dedicated mapping infrastructure was prohibitively expensive. Third (and perhaps most important) TERCOM and DSMAC were subject to strong export controls. The advent of the global positioning system has had the most profound enabling effect on cruise missile proliferation by essentially obviating the need for such advanced navigational guidance systems. Consider that an accurate stand-alone inertial navigation system for commercial aircraft costs roughly $150,000. Less accurate stand-alone INS cost a third of this, but adding embedded GPS receivers makes them far more accurate than the most expensive stand-alone INS. Thus, for a fraction of the cost, cheap INS with integrated GPS allows the acquiring state to leap ahead 15 years in navigational guidance systems.

As for propulsion requirements, highly efficient advanced propulsion systems, such as turbofan engines, still remain tightly controlled. But there are ways to work around such controls by using unrestricted turbojet engines available from nearly ten industrial nations. Moreover, some countries may wish to convert unarmed UAVs into armed cruise missiles. Such vehicles do not require anything like an advanced gas-turbine engine. With simple reciprocating engines, many of these systems are capable of one-way ranges of over 1,000km.

Export Control Barriers

What about export control barriers, the second reason for growing concern about cruise missile proliferation? Crafted in 1987 by the US and its Group of Seven (G-7) partners, today's 33-nation MTCR is a politically rather than legally binding agreement among member states to restrict the proliferation of rockets, unmanned aerial vehicles and related technologies capable of carrying a payload of 500kg for at least 300km. In 1993, the regime's guidelines were expanded to include missile-delivery systems capable of carrying biological and chemical warheads regardless of payload.

along with an array of support services, to enable the transformation of manned aircraft into Several reasons account for why the MTCR is much more effective at controlling ballistic rather than cruise missiles. First, there is a reasonably solid consensus among members for restricting ballistic missiles, while the same does not yet hold for cruise missiles and other UAVs. Second, because the MTCR does not restrict manned aircraft exports, there are systematic exemptions for all civilian and military aircraft, which can be used to work around many of the regime's restrictions on UAVs. Third, the inherent modularity of cruise missiles makes determining their true range and payload, and trade-offs between the two, difficult, but not impossible. In particular, variations in cruise-missile flight profiles—especially taking advantage of more fuel-efficient flight at higher altitudes—can lead to substantially longer ranges than manufacturers and exporting countries advertise. Finally, the provisions of the MTCR's equipment and technology annex—particularly as it applies to cruise missiles and UAVs—simply have not kept pace with the incredibly rapid changes in technology that characterize today's globalized economy. To take the most egregious example, new aerospace companies have appeared which can provide fully integrated flight management systems, entirely autonomous UAVs.

B. Alternative Sources for Acquiring Cruise Missiles

Unless reforms are made in the way the MTCR currently addresses cruise missile and related technology transfers, a variety of sources will exist to acquire land-attack cruise missiles.

Direct Purchase from Industrial Suppliers

In some ways this avenue is the easiest, and certainly the most worrisome, way to acquire highly sophisticated land-attack cruise missiles from a growing list of industrial-world suppliers, now numbering at least nine. This is where ground rules for determining the true range and payload of cruise missiles are so essential. What little consensus existed with respect to the presumption to deny exports of cruise missiles exceeding the 500kg/300km MTCR threshold was dealt a severe blow by the joint French/United Kingdom decision in 1998 to sell the advanced *Black Shaheen* cruise missile to the UAE. Only time will tell what impact this decision will have on the sales behavior of other more problematic regime members or adherents, most notably Russia and China.

Conversion of Short-range Anti-ship Cruise Missiles into Land-attack Ones

Frequently cited as a major concern because of the huge worldwide inventory of roughly 75,000 anti-ship cruise missiles, this avenue may have much lower potential than first meets the eye. Only a small fraction may have the potential for transformation into land-attack cruise missiles with ranges over 300km. This is because a large fraction of the world's inventory of anti-ship cruise missiles tends to be smaller in volume than their land-attack cousins. They are also densely packed with electronics and software, which leaves little room for changing engines, rearranging the guidance and control systems, and most important, adding fuel for ranges greater than 300km. By contrast, the Russian *Styx* and its Chinese derivative *Silkworm*, probably the third largest class of exported anti-ship cruise missiles, are easier to modify, and because of their roominess and simple design, conversions require less technical skill. A conversion might permit modified *Silkworms* to reach 500 to 700 km, or more, if payload weight was traded off for increased fuel. Were a developing country in the midst of upgrading its anti-ship cruise missiles and had a significant inventory of surplus *Silkworms*, it might consider this route as the most direct path to land-attack capability.

Conversion of Unarmed UAVs, Target and Reconnaissance Drones into Land-attack Cruise Missiles

These are increasingly being used not only in tactical military systems but also in non-military commercial, civilian and scientific applications. Of the 40 nations indigenously producing UAVs today, just over a half are members of the MTCR. Many of these UAVs already come equipped with GPS/INS guidance packages and with fire control systems readily adaptable to pre-programmed flight instructions. Several countries have already successfully converted unarmed UAVs or target drones into land-attack cruise missiles. A recent study of over 600 UAVs found that nearly 80 percent could achieve one-way ranges in excess of 300km, without any modification. Indeed, 65 percent had ranges exceeding 500km, and 36 percent could fly over 1000km. Of course, the payloads of these UAVs would be minimal, yet the aerodynamic flight stability of these vehicles make them well suited to delivering biological agents, or small but highly effective packages of submunitions.

Conversion of small manned kit airplanes into weapons-carrying, fully autonomous cruise missiles

There is a dizzying array of kit airplanes in today's marketplace (by one recent count, nearly 100,000 copies of 425 systems produced by worldwide manufacturers). Their average characteristics include a cruising speed of around 75 knots, a range of 500km, a maximum weight of just fewer than 900 pounds, fuel and payload capacity of 450 pounds, a very short takeoff distance averaging 75 meters, and a beginner build time of around 260 hours. The biggest challenge to converting such manned airplanes into autonomous unmanned systems is flight navigation, but, as noted above, there are now available fully autonomous flight management systems designed to convert manned aircraft into UAVs. But what makes this option most attractive are the low cost (perhaps no more than $50,000 for acquisition of the kit airplane, reciprocating engine, and autonomous flight controls) to achieve such a capability, and the difficulty of detecting such slow-flying planes. Sophisticated lookdown radars on today's legacy systems eliminate slow-moving targets on or near the ground, to prevent their data processing and display systems from being overtaxed. This means that large numbers of propeller-driven kit airplanes flying at under 80 knots would be ignored as potential targets. Thus, this avenue may well represent the "poor man's cruise missile arsenal" of the future, or domestic terrorists' weapon of choice for launch from a concealed location at modest distances from their targets.

Indigenous Cruise-missile Development

Indigenous development is not only the longest route to acquiring militarily significant cruise-missile capabilities, it is also unlikely to lead developing states to true autarky or anything beyond low-tech designs. Foreign assistance is a critical variable affecting the pace and quality of indigenous development.

C. The Difficulty of Calibrating the Threat's Emergence

What complicates the predictability of the cruise-missile threat's evolution is a diverse set of crosscutting motivations and constraints facing proliferating states. Perhaps the strongest motivating factor is the decided advantage of land-attack cruise missiles over ballistic missiles or even manned aircraft in achieving military objectives. Indeed, their capacity for precise delivery makes them the weapon of choice not only for biological and chemical attacks, but also for conventional ones. Regional states facing any US-led coalition cannot expect to see their aircraft survive much beyond the first blow of any campaign. Yet cruise missiles launched from a variety of survivable platforms would enable such a state to mount a strategic air campaign with cruise (and ballistic) missiles without achieving air superiority. In this connection, military effectiveness interacts closely with the growing vulnerability of Western-style force projection, especially its dependence on short-legged aircraft operating out of a few forward bases. The fact that the cost of even advanced cruise missiles is less than that of ballistic missiles, and that large numbers of converted kit airplanes and UAVs could conceivably become affordable for proliferating states, adds to their attraction.

Third-world motivations for acquiring large inventories of anti-ship cruise missiles, beginning in the 1960s, may shed light on what may occur in the future with their land-attack brethren. Despite their significant expense (typically around $800,000), about 40 developing nations came to see such missiles as yielding a high payoff in the absence of the prestige and operational utility of large military establishments. Only one accurately positioned anti-ship cruise missile could potentially achieve strategic results even against a major industrial power. Argentina's use of only a few French *Exocet* cruise missiles in the Falklands War against the British Royal Navy furnishes but one example.

But these strong motivations must be tempered by an equally compelling set of constraints. However much the prestige value of cruise missiles may have risen since the Persian Gulf War, the acquisition of ballistic missiles spurs a proliferating state down the path toward possessing an intercontinental-range missile. Although a regional adversary of the US could, without detection, use cruise missiles earmarked for regional warfighting to attack US territory from an offshore vessel, the deterrent value of such an option pales in comparison to possession of an ICBM. Another possible constraining factor is the doctrinal and bureaucratic difficulty of fully integrating cruise missiles into third-world force structures dominated by aircraft, tanks, and ships. Moreover, the underlying dual-use technologies supporting either indigenous or conversion programs are relatively new: cheap and widely available GPS/INS systems are less than a decade old; the commercial market for high-resolution satellite imagery is just beginning to mature; and subsidiary aerospace industries specializing in autonomous flight management systems for manned aircraft are a recent phenomenon. But perhaps the most important reason why cruise missiles have yet to spread widely is the absence of effective layered defenses, including counterforce capabilities, against ballistic missiles. Not until after 2007 will such defenses begin to be effectively deployed.

Possible Responses

A. Defenses Against Cruise Missiles

Protecting oneself against today's land-attack cruise missiles is more complicated than the kind of challenge that Britain faced against German V-1 cruise missiles for two reasons: (1) most of today's missiles have sleek aerodynamic designs (and in many cases, are intentionally stealthy) and therefore more difficult to detect than their predecessors; and (2) they can be designed to fly essentially earth-hugging flight profiles, using terrain features to avoid detection. Both airborne and ground-based surveillance radars are greatly taxed by these twin realities. Reduced radar observability means that the defense has less time to react. Low flight complicates airborne surveillance due to ground clutter (or radar returns from objects on the ground other than the target), which results in very high noise rates and insufficient signals from the real target to detect its presence. For ground-based radars, the earth's curvature constrains the detection distance at which low-flying targets can be detected to just tens of kilometers.

Responding to the manned aircraft threat, the US alone has invested many tens of billions of dollars in theater air defenses, comprising fighter-based air-to-air missiles, airborne surveillance aircraft, surface-to-air missiles (SAMs), and battle management command, control, and communications systems. Some of today's theater air defenses have substantial capability against large land-attack cruise missiles flying relatively high flight profiles. But once cruise missiles fly low, or worse, add stealthy features or employ end-game countermeasures (decoys or jammers), severe difficulties arise. Even against highly observable cruise missiles flying relatively high flight profiles, radars could mistake friendly aircraft returning to their bases for these targets and inadvertently shoot them down. Further, by adding ballistic missiles to this threat picture, ground-based theater defenses would be doubly stressed to try and cope with both high- and low-angle missile threats.

The emergence of large numbers of weapons-carrying unmanned aerial vehicles (UAVs) flying at very slow speeds also threatens the utility of legacy air defense systems. Today's expensive air defense systems were designed to detect high-performance Soviet air threats flying at high speeds. As previously noted, sophisticated look-down radars eliminate slow-moving targets on or near the ground in order to prevent their data processing and display systems from being overly taxed. Thus, large numbers of propeller-driven UAVs flying at speeds under 80 knots would be ignored as potential targets. Although ground-based SAM radars could detect such slow-flying threats, the limited radar horizon of ground-based radars combined with large raid size means that SAMs could be quickly overwhelmed and their missile inventories rapidly depleted.

Conceptually, the key objective of theatre air defenses has always been to create as large a surveillance and engagement zone as possible. The potential payoff of such a strategy is significant. The concept of layered defense in depth allows for multiple shots, including counterforce attacks against aircraft or missile launchers prior to takeoff or launch. Instead of dealing with just one aircraft or missile, counterforce operations potentially reduce the enemy's launch or salvo rate through effective attacks on airbases and missile launchers and supply depots. Long-range detection of threats is also valuable because the resultant warning permits passive defense measures (such as scrambling to protective shelters or donning chemical suits) to be employed more effectively.

The Quest to Improve Air Defense Connectivity

In thinking about the challenges that cruise missiles present, four notable shortcomings characterize today's air defense systems. The first is lack of connectivity. No longer will the Gulf War's highly restricted rules of engagement, which essentially shut down missile defenses for everything but ballistic missiles, prevail in future contingencies. This reality demands improved air defense connectivity. Friendly fire or air fratricide problems are by no means insignificant. Perhaps the most prominent recent example was the inadvertent shooting down by friendly aircraft of two US Army *Blackhawk* helicopters over northern Iraq in April 1994. Yet that rather uncomplicated air environment pales in comparison to the kinds of simulated air campaigns (absent restricted rules of engagement) that are typically examined in joint US military exercises. In such simulations, the level of friendly fire air casualties is reported to be routinely far above acceptable levels of aircraft attrition. As cruise missile threats grow stealthier, fratricide problems will increase. Lower radar cross section values for cruise missiles mean less time for air defenses to react to ambiguous friend or foe challenges.

Providing a common air picture with greatly improved capacity to discern friendly aircraft from enemy cruise missiles requires the merging of various service and Missile Defense Agency (MDA) BMC^3 software programs to achieve interconnectivity among a disparate array of service sensors and shooters. The objective is a longstanding quest, begun formally in 1969 with programs that aimed to improve tactical air control. However, the advent of fast, low-flying, and especially low-observable cruise missiles magnifies the need to create true service interoperability. To put it simply, SIAP (Single Integrated Air Picture) would allow for the integration of various sensor data sent via disparate service data links to form and display a single view of the air picture, available to all relevant units in a given theatre. Having one fully coordinated view of the air picture would accelerate decision-making on identifying friend from foe, prioritizing weapon selection, and executing air defense engagements.

Improving Radar Performance

The second major shortcoming derives from what a low-flying cruise missile with a relatively small radar cross section (RCS) can do to reduce the performance of air defense radars. One example powerfully illustrates the impact of lower RCS. An AWACS surveillance aircraft can detect an enemy aircraft with a 7 m^2 RCS travelling at 800 km per hour at a distance of 370 km. This equates to roughly 28 minutes of time to react and engage the target. But against a smaller cruise missile with an RCS of one-tenth (0.1) of a square meter travelling at the same speed, detection would occur at a range of roughly 130 km, leaving only 10 minutes of reaction time. It is conceivable in the near-term future to find cruise missiles with an RCS of one ten thousandth (0.0001) of a square meter. Assuming the missile is flying at the same speed as above, AWACS detection would occur (if at all) at less than 25 km, leaving less than 2 minutes to react to the threat.

The low-level flight paths of land-attack cruise missiles also severely stress both airborne and ground-based radars. This is because terrain-hugging cruise missiles can literally hide in the competing background clutter of the earth's surface. What's more, many ground-based radars supporting today's air defense missiles will reduce the amount of ground clutter by tilting back the search beam about 3 degrees, effectively lifting it above the ground. This increases the chances that a low-flying cruise missile will go undetected. In addition, whereas airborne radar systems can see as far as several hundreds of kilometers, the earth's curvature means that *Patriot* and *Aegis* ground-based radars trying to detect a cruise missile flying at 50 m altitude might begin to see the missile only when it has closed to within roughly 35 km or less. Finally, as RCS values of adversary cruise missiles plummet, the addition of endgame countermeasures such as towed decoys or terrain bounce jammers to stealthy cruise missiles will tax existing missile sensors even more. Such countermeasures are highly synergistic with low-RCS missiles, as their effectiveness is enhanced when the signature they disguise is already insignificant.

A related weakness is that airborne surveillance platforms are not operationally linked with ground- or sea-based SAMs. For example, the combat picture that a *Patriot* fire battery sees is not one of hundreds of kilometers, but one constrained by the line-of-sight range to the horizon of *Patriot's* associated radar—25km or less. Fighters, too, are also constrained because airborne platforms currently cannot cue or furnish fire-control information to fighter-launched AAMs. This means that SAMs and AAMs can only engage cruise missiles at relatively short ranges, prohibiting in-depth layered defense. These limitations create enormous opportunity costs: any wide-area defense against cruise missiles would require unacceptably large numbers of SAMs, AAMs, and fighters needed for other crucial missions.

To correct these deficiencies, the performance of airborne surveillance radars and missile seekers must be improved. Most importantly, new surveillance and fire-control sensors must eventually be deployed on airborne platforms and linked to SAMs and air-to-air missiles (AAMs) to furnish wide-area defense. Called air-directed surface-to-air missile (ADSAM), the concept would radically alter the current decentralized approach to fire control whereby each SAM is guided to its target by its own ground-based, horizon-limited radar. Instead, ADSAM entails placing a new surveillance and fire-control radar in an elevated platform capable of tracking stealthy cruise missiles out to hundreds of kilometers. This centralized fire-control platform could then direct a ground-based SAM by providing mid-course or terminal guidance updates, or the SAM could guide itself in the terminal phase with its own on-board seeker. The key point is that ADSAM, because it is airborne, enables ground-based SAMs to intercept targets to their full potential range (100-150km), not just the 25-35km associated with their horizon-limited ground-based radars. Beside fire control for air-directed SAMs, such an elevated platform could also furnish precision cues to fighter weapons to increase the effectiveness of their AAMs to their full potential range (around 60km).

The benefits gained from ADSAM are numerous. Most valuable would be the significant increase in the depth of fire for all weapon systems, which creates multiple shot opportunities and greatly reduced leakage against large onslaughts of cruise missiles. The possibility of fratricide would also be greatly reduced owing to the availability of high-quality fire-control information on targets identified and tracked over great distances. Moreover, under the ADSAM concept a single SAM battery could, depending on the particular system, provide defense for 10,000-70,000 km^2 of territory. This would alleviate the need to bunch SAM batteries around point targets to provide 360 degrees of protection against cruise missiles.

Making Air Defense Affordable

The previously mentioned cost-per-kill arithmetic of cruise-missile defense clearly means that defense planners must work toward finding more affordable solutions against large raids of cheap cruise missiles and modified UAVs. This is the third major shortcoming in addressing cruise missile defense.

Simple, cheap solutions permitting defense against conventionally armed and slow-flying UAVs or kit airplanes are conceivable against important point targets. Small machine-gun teams or radar-guided guns could be employed around an airfield's perimeter. Night-vision goggles could be used to detect, track and engage slow-flying targets that had managed to evade airborne air defenses. But these devices would not allow target acquisition beyond about 500 meters. If the UAVs or kit airplanes (or, for that matter, GPS-guided cruise-missiles) carry biological or chemical agents, and the intended targets are not just airbases but cities or other large area targets, broad area coverage and as much battlespace as possible would be needed to allow multiple shots. Engaging slow-fliers further out would require modification of existing systems such as AWACS, JSTARS, and *Patriot* to permit them to track targets in the 60-90-knot range. But unless the cost of defensive interceptors can be driven down dramatically, the offence still could threaten to exhaust defensive missile inventories.

Defense system affordability lies primarily in finding ways to drive down the high cost of missile seekers. The Pentagon's Defense Advanced

Research Projects Agency (DARPA) has invested modestly in approaches that exploit the latest technologies permitting significant savings in seeker costs, using commercial parts to the maximum extent practical and trading some performance for cost. But provided the ADSAM concept is implemented, some trade-off is permissible. Precision fire-control information furnished to a low-cost interceptor could guide it into a narrow basket, whereupon its on-board seeker would engage the incoming missile. A variety of different air-, sea-, or ground-based platforms could be modified to launch such low-cost interceptors.

Defending the Homeland, Too?

The fourth and final shortcoming—at least in terms of considering potential costs and feasibility--lies in the area of homeland defense against cruise missiles. Decisions could be taken to erect some level of modest defenses against off-shore cruise missile launches. The North American Aerospace Defense Command is currently toying with the idea of an unmanned airship operating at 70,000 feet altitude and carrying sensors to monitor low-flying cruise missiles and aircraft. Several airships would be needed together with quick-reacting interceptors, probably also unmanned, to react to perceived threats. While the technical feasibility of such approaches merits close attention, it is safe to say that even a limited defense of the entire US homeland against cruise missiles and small unarmed UAVs would cost at least $30-40bn—a fact left unspoken in the ever-ongoing discussion about the cost of national missile defense. Moreover, any effort to construct a homeland defense against cruise missiles hinges on progress in the three areas discussed just above. However, not only are service cruise missile defense programs lacking the necessary funding, but enormous service interoperability, doctrinal, and organizational issues stand in the way of truly joint cruise missile defenses. In sum, missile defense options alone are likely to be financially taxing, operationally challenging, and too late in coming, to cope with the emerging threat.

B. The Complementary Role of Diplomatic Responses

What should one make of the complementary effect of nonproliferation policy in stopping or slowing down the evolution of the cruise missile threat? The appropriate mechanism is the MTCR. However imperfect its critics argue it has been, the regime has achieved notable success in controlling the spread of ballistic missiles. It has blocked the export of hundreds of components, technologies, and production capabilities, and succeeded in dismantling the *Condor* missile program sought by Argentina, Iraq, and Egypt—a missile that reportedly included sophisticated *Pershing* II-level technology. The major consequence of this success is that the ballistic missile technology that has spread thus far is largely derived from 50-year-old *Scud* technology, a derivative itself of the World War II German V-2 missile program. Missile defenses can exploit many of the weaknesses of this technology. Yet, perhaps because they fear weakening their advocacy, few strong supporters of ballistic missile defense are willing to admit that missile proliferation, especially qualitative missile advances, can be controlled. This tendency to view the MTCR glass as half empty has fostered a reluctance to adapt the regime so that it can address its several major shortcomings in dealing with cruise missile proliferation.

Of course, adapting the 33-nation MTCR to grapple more effectively with cruise missile proliferation would require serious US commitment to a decidedly multilateral mechanism, which has not been high on the list of Bush Administration priorities. Reforms include improved language to determine the true range and payload of cruise missiles and UAVs, controls on stealthy cruise missiles, and more exacting coverage of flight control systems, countermeasures equipment, and jet engines. But none of these improvements are conceivable without a determined US effort to work closely with the founding G-7 partners of the MTCR. This core group must convince the other partners of the benefits of enhanced controls, not just to hinder the widespread proliferation of increasingly sophisticated cruise missiles, but to complicate the currently easy transformation of manned kit airplanes into unmanned terror weapons. Thus far, there is no evidence of the Bush Administration's appreciation of the long-term implications of a failure to address these critical reforms. This would suggest either a failure to appreciate the implications of the spread of cruise missiles and UAVs or possibly an unwillingness to adversely affect the industrial benefits that flow from the explosive growth expected for both unarmed and armed UAVs over the next two decades. Such growth potential will inevitably lead to ever-increasing pressure from the UAV industry to create ever more flexible MTCR rules governing the export of these systems.

The continuing failure by the MTCR membership to address the cruise missile threat is made evident when one sees, in contrast, the time and effort spent on developing an international code of conduct against ballistic missile proliferation. The code is the latest manifestation of the longstanding quest by various states to establish a universal, legally binding treaty covering missile proliferation. Attempts at the latter have inevitably failed, not least because those states which have come to depend upon longer-range ballistic and cruise missiles are unwilling to forgo their benefits in exchange for whatever marginal gains might flow from improved norms. Nonetheless, beginning in 1999, the MTCR membership took up the writing of a politically binding code that calls upon signatories to declare their ballistic missile programs once a year and alert all signatories before the conduct of all ballistic missile tests. After the MTCR membership approved a draft text in September 2001, more than 80 nations, including the 33 MTCR member states, met in Paris in early February 2002 to review and approve a draft document outlining the code's provisions. Putting aside concerns about the nature of the technology carrots necessary to lure states like Iran and North Korea into code membership, the most egregious shortcoming in the code's formulation is the absence of any mention of cruise missiles or UAVs, in spite of the fact that the MTCR covers both classes of missiles.

However useful in theory legally binding norms may be, it is virtually impossible to conceive of a formal treaty regime that could adequately address the problem of missile proliferation. This caveat applies especially to cruise missiles and UAVs. The very features of these systems (small size, conversion potential, multiple uses, etc.) that make them difficult to manage under the MTCR preclude satisfactory treaty negotiation, let alone verification. However, provided the members are willing to adapt existing provisions to achieve better controls on cruise missiles and UAVs, the MTCR remains nonetheless the best option to reinvigorate missile nonproliferation policy and make it a true complement to missile defense.

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