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Mr. Chairman, members of the committee, it is a pleasure to appear before you once again, this time to offer my suggestions on ways to deal with the emerging threat of cruise missiles and unmanned aerial vehicles (UAVs) as they could affect U.S. interests abroad as well as the American homeland. This issue has only just begun to attract the kind of scrutiny is so desperately deserves. In part, this is because the terrible events of September 11 have reminded us of the dangers of focusing obsessively on a narrow range of familiar threats at the expense of perhaps more likely ones. Your committee, too, should be commended for drawing much-needed attention to the critical role that multilateral arms control can play as a complement to the deployment of effective defenses against both ballistic- and cruise-missile threats.

It is vitally important to note at the outset that land-attack cruise missiles and UAVs have yet to spread widely. This fact only underscores the pressing need to bolster existing non-proliferation mechanisms now to abate the long-term effects of the next great missile-proliferation threat. That said, it is also important to note that CIA Director George Tenet, in February 6, 2002 testimony before the Senate Select Committee on Intelligence, said that while the US would likely encounter intercontinental-range ballistic missile threats from North Korea and Iran, and possibly Iraq, by 2015, by 2010 land-attack cruise missile could pose a serious threat not only to our deployed forces but possibly to the US homeland as well.

What accounts for the growing concern that cruise missiles and UAVs may fall into the hands of nations of concern or terrorist groups? As I argued in my testimony before this committee on February 12, cruise-missile proliferation is fueled by two primary realities: first, the quantum leap in unregulated dual-use technologies supporting cruise-missile development; 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. This means that states have a multitude of possible paths to acquire cruise missiles and UAVs, including direct purchase from industrial suppliers; conversion of anti-ship cruise missiles into land-attack systems; conversion of unarmed UAVs and drones into weapons-carrying cruise missiles; conversion of small manned airplanes (including so-called kit planes) into autonomous cruise missiles; and by far the most arduous and US-preferred path, indigenous cruise-missile production.

Today a variety of motivations make cruise missiles and UAVs attractive means of delivering weapons of mass destruction (WMD) and conventional payloads for both state and non-state actors. The fact that cruise missiles and UAVs have become the dominant weapon of choice by the American military has probably enhanced the prestige value of such systems within the Third World. But perhaps the strongest motivating factor for nations of concern is the decided advantage of land-attack cruise missiles over ballistic missiles and even manned aircraft in achieving military objectives. Indeed, their capacity for precise delivery—due in part to the accuracy of GPS-aided guidance and the stable aerodynamic flight of the platform—makes cruise missiles the preferred delivery means not only for biological and chemical attacks, but also for conventional ones.

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 that lacked the prestige and operational utility of large military establishments came to see such missiles as yielding a high military payoff. One accurately placed anti-ship cruise missile potentially could 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.

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—all without achieving air superiority. In this connection, military effectiveness interacts closely with the growing vulnerability of American-style force projection, especially its dependence on short-legged aircraft, ground forces, and related logistical support operating out of a few forward bases. Besides being more effective than ballistic missiles (conservatively) by at least a factor of ten in delivering biological payloads, cruise missiles have several other operational advantages compared with ballistic missiles. Cruise missiles can be placed in canisters, which make them especially easy to operate for extended periods in harsh environments. In contrast to large cumbersome ballistic missiles, more modern and compact cruise missiles offer more flexible launch options (air, sea, and ground), greater mobility for ground-launched versions, and a smaller logistics tail, which improve their pre-launch survivability. Moreover, cruise missiles need no special preparations to ensure launch-pad stability, which means that their operators can practice shoot-and-scoot tactics.

But these strong motivations must be tempered by several possible constraints. However much the prestige value of cruise missiles may have risen since the Persian Gulf War, and no matter how much more effective cruise missiles may be compared to ballistic missiles, acquisition of ballistic missiles starts a proliferating state down the path toward possessing an intercontinental-range missile. Possession of an ICBM carries with it enormous coercive value. Although a regional adversary of the US probably could, without detection, use cruise missiles earmarked for regional warfighting to attack US territory from an offshore vessel, the deterrent coercive 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 to convert manned aircraft into UAVs are a recent phenomenon. Simply put, it takes time for such technologies to be fully absorbed and incorporated into third-world development programs. But perhaps the most important reason why cruise missiles have yet to spread widely is the absence of effective layered defences, including counterforce capabilities, against ballistic missiles. Not until after 2007 will such defences begin to be effectively deployed by US forces.

Yet, to the extent that America successfully pursues effective theater and national missile defenses against ballistic missiles, nations and terrorist group will be even more strongly motivated than otherwise might be the case to pursue land-attack cruise missiles and weapons-carrying UAVs. For example, 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 it own, the emergence of the cruise-missile threat confronts American military forces with enormous challenges. The effectiveness of both airborne and ground-based surveillance radars is being undermined by missile designs that are increasingly sleek and aerodynamic, and have lower radar cross-sections. Reduced radar observability means that the defense has less time to react. Also, many missiles have very low flight profiles and employ terrain features to avoid detection. Low flight impedes airborne surveillance, owing to radar “clutter” from ground objects other than the target, which makes a land-attack cruise missile difficult to detect.

Some existing air defenses—consisting of fighter-based air-to-air missiles, airborne surveillance aircraft, surface-to-air missiles and battle-management command, control and communications—have substantial capability against large land-attack cruise missiles flying relatively high flight profiles. But once cruise missiles fly low or, worse, add stealth features or employ endgame countermeasures (decoys or jammers), severe difficulties arise. Indeed, even defending against easily observable cruise missiles flying relative high is problematic. Radars could mistake friendly aircraft returning to their bases for these targets and inadvertently shoot them down.

The emergence of large numbers of weapons-carrying unmanned aerial vehicles (UAVs) or converted kit airplanes 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. 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.

Several features of cruise missiles, not least their compact size and ease of maintenance, have suggested to some analysts that they may become an attractive alternative for states or terrorist groups lacking the resources or technical skills to build and deploy intercontinental-range ballistic missiles. Various National Intelligence Estimates (NIEs) have drawn attention to the covert conversion of a commercial container ship as a launching platform for a cruise missile. There are thousands of commercial container ships in the international fleet, and US ports alone handle over 13m containers annually. Even a large, bulky cruise missile like the Chinese *Silkworm* could readily fit inside a standard 12-meter shipping container equipped with a small internal erector for launching. Such a ship-launched cruise missile could be positioned just outside territorial waters to strike virtually any important capital or large industrial area anywhere on the globe. And, because a cruise missile is an ideal means for efficiently delivering small but highly lethal quantities of biological agent, a state or terrorist group could forgo acquiring or building a nuclear weapon without sacrificing the ability to cause catastrophic damage.

Indeed, the latest NIE—no doubt influenced by the events of September 11—argues that this among several other attack options is more likely to occur compared to 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, the conversion of small manned airplanes into weapons-carrying, fully autonomous cruise missiles concerns me the most. Terrorist use of large commercial airliners on 11 September came as a complete shock to American planners. To be sure, 11 September engendered a whole rash of reforms to cope with a repeat of just such an attack. But these reforms deal largely with commercial aircraft security rather than 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 civilian and industrial targets. Such platforms, too, stand as effective means of delivering biological weapons.

My purpose is not to suggest that transforming a kit or small private aircraft into a weapons-carrying autonomous attack system is technically simple. Certainly, states of concern are fully capable of such transformations. Iraq has demonstrated that with the conversion of a number of Czech L-29 manned trainer aircraft into UAVs capable of delivering a payload of nearly 500 pounds to a range of over 600km. The most challenging feature of such a transformation is developing and integrating a fully autonomous flight management system into the aircraft. However, a handful of small aerospace companies have recently gone into business selling fully autonomous flight management systems, along with all necessary support services to help with system integration, to enable the transformation of manned aircraft into entirely autonomous UAVs. Existing loopholes in the MTCR's technical annex mean no restrictions (for example, even case-by-case review of transfers) exist to manage foreign acquisition. Of course, even if tighter controls were implemented, they would not apply to domestic acquisition of such systems. Such an autonomous delivery system in the hands of a domestic terrorist means that launches could take place from hidden locations in close proximity to their intended targets. Kit-built airplanes, for example, do not need a hardstand to take off, only a grassy field of much less than a football field's length.

How might the kinds of cruise missile threats I've outlined change or evolve over the next 5 to 10 years? Conventional wisdom would suggest that the cruise-missile threat will evolve over time, from relatively few highly observable missiles in the near-term (1-5 years), via higher numbers of lower observable, terrain-hugging missiles in the mid- term (5-15 years), to larger numbers of stealthy missiles with end-game countermeasures in the long-term (>15 years). But major features of the long-term threat could materialize much sooner if the MTCR's handling of cruise-missile transfers does not improve, or if US-Russian and US-Chinese relations worsen. In either case, it is conceivable that modest numbers of stealthy cruise missiles with countermeasures, accompanied by large numbers of cheap, slow-flying UAVs or converted kit planes, could emerge in 5-10 years. Progress in US cruise-missile defenses seems unlikely to keep pace with even the slowly evolving threat, much less the accelerated version.

How prepared are the military services to cope with the cruise-missile threat's emergence? The Pentagon seems to recognize that the cruise-missile threat could emerge suddenly, as its own planning guidance in the late 1990s specified that capabilities are needed to defend against difficult-to-detect cruise missiles by 2010. Moreover, that guidance also directed the services to be positioned to respond to an even earlier emergence of the threat. However, not enough progress has occurred in rectifying current and prospective shortcomings in either theater or national cruise-missile defences. Such defenses inherently depend on joint solutions, but each service continues to pursue its own vision of cruise-missile defense. Effective defenses will not be possible until all the services possess better elevated sensors capable of providing longer-range surveillance and fire-control-quality information to air-to-air missiles and ground- and ship-based surface-to-air missiles. The latter, too, require improved sensors to cope with stealthy cruise missiles and possible countermeasures. Piecemeal efforts will not add up to an effective wide-area defense against the threat.

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 studying 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 to react to perceived threats. Alternatively, perhaps on the order of 100 aerostats flying at an altitude of 10-15,000 feet could act as a system of surveillance and fire control system for quick-reacting interceptors. Still, numerous challenges exist, not least the problem of furnishing warning information on potentially hostile ships embarking from ports of concern (to make the Coast Guard's monitoring function feasible), as well as developing very high quality combat identification information needed to justify shooting down an air vehicle. It is safe to say that even a limited defense of the entire US homeland against off-shore cruise missiles would cost at least $30-40bn—an unspoken fact when the cost of national missile defense is discussed publicly. Moreover, any effort to construct a homeland defense against cruise missiles hinges on progress in service programs. But such programs lack the necessary funding and have enormous service interoperability, doctrinal, and organizational issues standing 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.

What should one make of the complementary effect of nonproliferation policy in stopping or slowing the evolution of the cruise missile threat? The appropriate mechanism is the MTCR. However, as I testified on February 12 before you, the MTCR is more effective in controlling ballistic than cruise missiles and UAVs for several reasons. 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, loopholes in systematic exemptions for all civilian and military aircraft can be used to circumvent 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, though by no means impossible. In particular, variations in cruise-missile flight profiles—especially those taking advantage of more fuel-efficient flight at higher altitudes—can lead to substantially longer ranges than manufacturers and exporting countries advertise. Finally, and perhaps more important, 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 extraordinarily rapid expansion in commercially available technology facilitated by today's globalized economy. The matter of small aerospace companies being formed specifically to provide fully integrated flight management systems to enable the transformation of manned aircraft into entirely autonomous UAVs is only the most egregious illustration.

Yet, however imperfect its critics argue it has been, the MTCR 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 can be effectively controlled. This tendency to view the MTCR glass as half empty has fostered a reluctance to adapt the regime to cope with several major shortcomings in addressing 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. I outlined five specific reforms in my prepared statement for my February 12 appearance before you, including improved language for determining 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. None of these reforms is conceivable without a determined US effort to work closely with the founding G-7 partners of the MTCR. This core group must convince the broad partnership 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, I have seen no apparent 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 firmest evidence of a continuing failure by the MTCR membership, including the United States, to address the cruise-missile threat lies in 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 in the later regard have inevitably failed, not least because those states who 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 annually 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 needed 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 and UAVs, this 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. Assuming membership willingness to adapt existing provisions to achieve better controls on cruise missiles and

UAVs, the MTCR remains the best option for reinvigorating missile nonproliferation policy to make it a true complement to missile defense.

During the Cold War, arms control and military deployments played complementary roles in maintaining nuclear stability. Today the two policy domains also have useful and mutually reinforcing roles to play. Absent a mending of the MTCR, cruise-missile threats are certain to spread and inevitably make missile defenses more expensive and problematic. But if the MTCR can become as effective in limiting the spread of cruise missiles as it has with ballistic missiles, missile defenses can conceivably keep pace with evolutionary improvements in both missile categories. This will not happen with the committed leadership of both the Congress and Executive branches, and within the latter, increases in resources and personnel within the State Department, Pentagon, and intelligence agencies charged with responsibility for missile non-proliferation policy. No more effective allocation of resources could be made to complement the huge but nonetheless essential missile-defense investments you make to protect the nation's future security.