AMERICAN INSTITUTE FOR STRATEGIC COOPERATION

# CONTROLLING THE SPREAD OF LAND-ATTACK CRUISE MISSILES

K. Scott McMahon
Dennis M. Gormley

*WITH A FOREWORD BY*
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January 1995

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# FOREWORD

Scott McMahon and Dennis Gormley's able study of the problem of controlling the spread of land-attack cruise missiles to many countries calls attention to the growth of a substantial threat that has so far been relatively neglected by Western leaders. Our leaders were, for many years, mainly preoccupied with the contingency of a massive attack on Western Europe, through the Fulda Gap in Germany, by the Soviet army and its East European allies. That attack, in the standard strategic analysis, would have quickly become nuclear, at the initiative of either the Soviet Union or the United States, and would have resulted in hundreds of millions of dead and wounded in the NATO and Warsaw Pact countries. In so catastrophic a contingency, the likelihood seemed rather remote that the Warsaw Pact commanders might decide to use conventionally armed cruise missiles so precise that they could destroy quite hard military targets without serious harm to civilians and civilian structures. And the use by the United States of unmanned air vehicles for such purposes—or for any of the many other sophisticated military purposes they could serve—appeared less than critical in the standard apocalyptic case.

What is more, preparing for the huge standard contingency, it seemed to our military planners, was relevant for smaller cases too. They designed our general purpose military forces on the assumption that if we were ready for the massive, apocalyptic contingency, we could handle smaller ones also. These smaller contingencies were supposed to be "lesser included cases" of the canonical attack, on the theory, as it was phrased, that the dog that could deal with the cat could easily handle the kitten.

That comforting view was always subject to doubt. Some "lesser" threats aren't really included in the larger ones: a nuclear response may be plainly inappropriate and unbelievable. If democracies are to avoid relying on transparent bluffs they need more discriminating, politically usable technologies for the most important plausible circumstances of attack.

By the mid-1960s, when the United States and its European allies had deployed very substantial non-nuclear forces in the center of Europe and when both sides had eliminated the gross vulnerabilities of their strategic nuclear forces, the prospect of an all-out nuclear exchange following a massive Soviet attack through the thickest Western defenses in the center of Europe appeared to an increasing number of those concerned with national and alliance defense to be extremely unlikely.

By far the most likely contingencies critically affecting the interests of NATO members, according to the unanimous view expressed in 1987 by the seventeen distinguished members[1] of the bipartisan Presidential Commission on Integrated Long-Term Strategy, were illustrated by a potential Iraqi invasion of Kuwait and the possibility that, after seizing Kuwait, Iraq might continue by invading the Saudi oil fields and the United Arab Emirates. NATO, and especially its European members, had tended, as the Commission said, to treat contingencies like that in the Persian Gulf as "out of area," as if they were deep in outer space. Yet it should have been plain that a takeover by a hostile ambitious power of the planet's last large pool of low-cost oil reserves would endanger extremely important interests of Europe, the United States and the rest of the world as well, including the Third World. For such contingencies, however, the sort of far-fetched, apocalyptic nuclear response that may have seemed adequate to discourage an equally far-fetched unrestrained Soviet attack in the center of Europe through the West's thickest defenses was plainly irrelevant.

The idea that the United States needed to prepare for contingencies like that in the Persian Gulf had sparked the Advanced Research Projects Agency's Long-Range R&D project (LRR&D-1) at the beginning of the 1970s. That seminal project was responsible for many of the technologies that benefited the United States in Operation Desert Storm and some that it has yet to exploit adequately. Nonetheless, it was always clear to members of the LRR&D-1 project that the cumulative revolution in microelectronics was likely to make advanced technologies for reconnaissance, communication, navigation and precise guidance for unmanned air vehicles available to many countries besides the United States, both because of the major military uses of these advanced technologies and their potential important civilian utility.

Small countries, like Israel, have used unmanned air vehicles that the United States had developed, and used them in several effective ways. Even Third World countries, like Egypt, bought stealthy unmanned air vehicles developed by the United States. Israel and Egypt were concerned with real world contingencies, quite distinct from the stylized suicidal "exchanges" that had absorbed NATO planners so completely.

Such advanced unmanned air vehicles have relevance for the real world contingencies NATO members face today. The collapse of the Warsaw Pact has made it obvious to everybody that the threats that preoccupied

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[1] These members included a recently retired Chairman of the JCS, a former Supreme Allied Commander Europe, three former National Security Advisors, and a former Secretary and a former Deputy Secretary of State.

NATO excessively in the recent past have no real world relevance today. But it hasn't been obvious to everyone, it seems, that the end of the Warsaw Pact hardly meant the end of all mortal military dangers. The collapse of the Communist dictatorships was of enormous historic importance, but there is no evidence that the brave new world of disorder that is emerging will be much less dangerous. Or that the United Nations (UN), a universal organization that includes potential adversaries, can take care of the dangers emerging.

McMahon and Gormley show that the ongoing revolution in the technologies of information and denial of information will soon offer a variety of potential adversaries in many regions the ability to use precise cruise missiles in ways that would seriously harm our interests. To bring the problem close to home and make it vivid, one might think about the recent Cessna aircraft that, after having been picked up on radar at Washington National Airport, hit the White House just below the President's bedroom. One should not draw comfort from a belief that such penetrations require a deranged pilot on a suicide mission. An unmanned air vehicle doesn't need a pilot, deranged or not; and unmanned air vehicles can be cheaper, smaller, stealthier and harder to detect than a manned vehicle—with, perhaps, radar cross-sections two or three orders of magnitude less than that of a Cessna. And they can be extremely precise and effective.[2] They might be launched from concealed land locations at modest distances from their targets; or brought within range and launched from freighters, diesel or nuclear-propelled submarines or other boats so numerous and so varied that they would be hard to distinguish and track. Such "two-stage" delivery of cruise missiles could present a threat here at home as well as threats to our forces or allied forces or civilians abroad. Moreover, they might be part of a serious but isolated terrorist threat, or they might be one important component of a widespread military attack.

In part because it's uncommon to think much about the threat that McMahon and Gormley describe and analyze, our Secretary of Commerce has permitted the sale to foreign countries of material with little application to civilian commerce and very large utility for cruise missiles—radar-absorbent material, for example, easily used to reduce a missile's radar signature.

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[2] It was anticipated from the start that the global positioning system (GPS) of satellites we had put in place to aid the navigation and guidance of military ships and aircraft would have both a widespread civilian use and the potential for use by adversaries. GPS receivers are now available commercially for $450 apiece, or $250 in large quantities. Moreover, the high civilian value of precise information obtainable from GPS has outmoded the original plans to code the most precise signals for the exclusive use of our own military, and to make generally available only less accurate signals for civilian use—and, therefore, for adversaries. *Differential* GPS, developed in the civilian marketplace, will make widely available better guidance accuracies than were originally anticipated for military purposes—perhaps five meters, or substantially less.

We don't want to make civilian air transports invisible to the radars of air traffic controllers. It should be feasible, then, to restrict severely the sales of radar-absorbent material. The case of GPS, however, is different. Billions of dollars and many lives might be saved by using differential GPS (or something similar) to permit an increased density of civilian air traffic and yet reduce the danger of collisions in mid-air, or during take-offs and landings, in trans-oceanic as well as overland flights. That makes it a waste of time, or worse, counterproductive, to try to negotiate agreements among many countries, including potential adversaries, to restrain the spread of GPS technology.

The spread is quite sure to continue and will call for a serious effort to cope with it. We will need improved air defenses in distant theaters as well as at home, and precise and usably discriminate offense to discourage or respond to attacks from a variety of potential sources. What is more, the precise and discriminate offense we need is likely to include advanced uses of GPS in both manned and unmanned aircraft. Especially for technologies of mixed civilian and military utility, if we rely on international agreements, or on universal organizations that include potential adversaries, like the United Nations, we may restrict ourselves but not some potential adversaries.

The evolution of nuclear energy, and specifically that of separated plutonium, offers some spectacular illustrations of counterproductive international agreements and of the use of a UN agency—the IAEA—that spread the technology of nuclear explosives it purported to restrain. And, in that case, the supposed civilian benefits—nuclear electric power from breeder or thermal reactors using separated plutonium as fuel—were greatly exaggerated, while the feasibility of quickly turning separated plutonium into a nuclear explosive was denied or greatly understated, as it had been from the start of the nuclear age even by some of the great figures in the Manhattan Project.

"Whatever else hospitals do, they should not spread disease," a saying of Florence Nightingale, was the epigraph to the 1975 study[3] that resulted in the US government's abandoning plutonium fuel as the basis for the future of nuclear electric power. The study showed that the International Atomic Energy Agency (IAEA) and various national programs of Atoms for Peace had been spreading fissile material and much of the know-how needed for turning it into nuclear weapons without usable warning.

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[3] *Moving Towards Life in a Nuclear Armed Crowd?* by Albert Wohlstetter, Thomas A. Brown, Gregory Jones, David C. McGarvey, Henry Rowen, Vince Taylor and Roberta Wohlstetter. Report to the US Arms Control & Disarmament Agency, 22 April 1976.

The history of the spread of nuclear explosives suggests the comparable danger in an excessive and wishful focus on agreements with potential adversaries to take care of the cruise missile threat. It also should remind us that advanced cruise missiles may be armed with nuclear—or biological or chemical—warheads as well as the advanced conventional munitions we had in mind in designing the land-attack cruise missile. Long before the nuclear age, it was obvious that the civilian and military uses of chemicals overlapped: chemicals used in agricultural fertilizers and explosives used in construction can quickly and easily be turned to military use. We have to cope with those threats as well.

And cope with the spread of ballistic missiles. Ballistic missiles of short range are already spread very widely. Space launchers will have a genuine civilian utility for quite a few countries and a nominal or arguable utility for others. But space launchers *are* ballistic missiles of very substantial range.[4]

In sum, the neglected threat that McMahon and Gormley ably analyze illustrates a grave, more general problem that we have yet to face: The growing new world disorder has implications for national and alliance defense and offense that cannot be dealt with adequately by agreements with potential adversaries or by decisions of international organizations they can veto. Such implications of the disorder call for much more serious consideration than they have so far received.

*September 1994* *Albert Wohlstetter*[*]

[4] The same preoccupation with the standard implausible apocalyptic contingency that has led to a neglect of the cruise missile threat in any of several much more likely contingencies critical for the interests of the United States and other NATO members, has encouraged a parallel neglect of ballistic missile threats. The American Institute for Strategic Cooperation (AISC) has published a report by Gregory S. Jones on the future of the ballistic missile threat, *The Iraqi Ballistic Missile Program: The Gulf War and the Future of the Missile Threat*, 1992, and expects to publish another report on the topic by Mr. Jones. See also the RAND Report by Brian G. Chow, *National Space Launch Programs: Economics and Safeguards*, R-4179-USDP, 1993. Jones and Chow were both major contributors to the original and follow-on studies that brought about the radical change in US policy on the separation of plutonium to fuel civilian reactors. Fred S. Hoffman, then director of PAN Heuristics, led a Presidential policy panel in 1983 that showed the utility of a theater and US continental defense against the limited ballistic missile attacks likely in real world contingencies of importance to the United States and its allies. Analysts focused exclusively on the all-out apocalyptic nuclear attack had said that there was no point in air defense if the United States did not have a leak-proof defense against a massive and unrestrained ballistic missile attack. The Hoffman panel pointed out that in the plausible attacks of critical importance, the United States would need some air *and* ballistic missile defenses.

[*] *ALBERT WOHLSTETTER proposed ARPA's Long Range R&D study of precise and discriminate technologies in the early 1970s and chaired its panel on strategic choices; he headed the study that led President Ford to abandon the recycling of plutonium in breeder, light water, and natural uranium reactors; and co-chaired the mid-1980s bipartisan Presidential Commission on Integrated Long Term Strategy that stressed the need to prepare discriminate technologies for plausible, important contingencies, like that in the Persian Gulf.*

# EXECUTIVE SUMMARY

## PROSPECTS FOR CRUISE MISSILE PROLIFERATION

Until recently, the problem of cruise missile proliferation centered on antiship—not land-attack—systems. But now there is growing concern that the developing world will acquire land-attack cruise missiles. In view of their precision of delivery, low flight profile, and small radar cross-section, land-attack cruise missiles could threaten effective delivery of not only nuclear, biological, and chemical weapons but conventional payloads as well. Should such strike systems proliferate into the arsenals of rogue states, they could present serious challenges to US force planners in a variety of military contingencies.

Technology push creates strong incentives for Third World nations to acquire land-attack cruise missiles. Technology push is manifested in the growing availability of cheap navigation and guidance technology, mission planning tools, and commercial satellite imagery. These technologies and products stand as the missing elements in partly explaining why land-attack cruise missiles have not already spread more widely into Third World arsenals. Still uncertain is just how aggressively the developing world will exploit the revolution in guidance and navigation that could motivate and enable indigenous development programs, or cause the upgrading of antiship cruise missiles and remotely piloted vehicles to land-attack systems. Technology push is also reflected in growing industrial world incentives to sell land-attack cruise missiles—some of which possess significant low-observable characteristics like the French *Apache* missile—to Third World customers, particularly as the industrial world market shrinks with the end of the Cold War.

Doctrinal drive also creates strong incentives for Third World nations to acquire land-attack cruise missiles. Doctrinal drive is reflected in the increasing need for regional powers to seek self-sufficiency in national security—seen most prominently in the demise of Soviet security guarantees to its former allies. Cruise missiles offer attractive operational and cost advantages to Third World states who may be in the marketplace for aircraft and ballistic missiles.

Although we conclude that the evidence is sufficiently compelling to suggest that cruise missile proliferation will become a significant threat to US security interests, not enough attention has been focused on the factors that will shape the pace and scope of this threat. Among the most important factors is the relative effectiveness of voluntary controls in constraining the spread of both cruise missile systems and relevant enabling technologies—the subject of this monograph. Equally critical are the Third World's view of the specific utility of land-attack cruise missiles in various military contingencies and the degree to which systems integration will challenge Third World manufacturers.

## MTCR EFFECTIVENESS

The Missile Technology Control Regime (MTCR) is frequently criticized for not being more effective in controlling the spread of ballistic missiles worldwide. Overlooked in such criticism is the limited nature of the MTCR (a voluntary rather than binding agreement with limited membership) and the fact that despite its shortcomings, the MTCR represents a constraining mechanism of considerable importance. Although the MTCR's provisions may not entirely stop the spread of controlled systems and technology, they can slow the pace of proliferation enough to permit more deliberate diplomatic or defensive countermeasures to become effective.

Supplier consensus on the danger of cruise missile proliferation is lacking. Indeed, we found that while the consensus against missile proliferation in general has yet to become firmly established, there appears to be a stronger consensus—even among MTCR members—for restricting ballistic rather than cruise missile or unmanned air vehicle (UAV) systems. This conclusion is supported by the export activities of MTCR member governments. Key members have demonstrated a greater willingness to export cruise missiles and other UAVs than ballistic missiles.

The MTCR is most restrictive in its treatment of missiles capable of carrying 500-kg payloads to ranges of 300 km or more. MTCR members should make a "strong presumption to deny" exports of any missiles meeting this range-payload threshold. But the threshold is better suited to impeding ballistic than cruise missile proliferation. From an engineering standpoint, it is relatively easier to "scale-up" the range of an existing cruise missile system than a ballistic missile. And the technology required to produce a 1,000-km range cruise missile is not fundamentally different from that needed for very short range systems. Hence, UAVs and UAV technologies falling clearly below the MTCR's range-payload threshold can be exported and applied to the development of long-range cruise missiles.

The MTCR does not restrict manned aircraft exports. This exemption represents a direct way to work around MTCR restrictions on UAVs. The relationship between manned aircraft and UAVs is strong. In fact, the structures, propulsion, autopilots, and navigation systems used in manned aircraft are essentially interchangeable with those of cruise missiles and other UAV variants; likewise for UAV and manned aircraft production facilities and equipment.

To impede the spread of cruise missile production capabilities, the MTCR would have to restrict the sale of aircraft-related technologies. But such restrictions appear no more realistic today than they did when the MTCR was developed in the mid-1980s. In fact, global competition to export aircraft and UAVs, their related technologies, and production facilities is increasing. Developing countries are increasingly taking advantage of the "buyers market" in aerospace to demand offsets providing indigenous aircraft maintenance, and even production, capabilities. The willingness of former East Bloc aircraft producers to undercut the prices of their Western competitors will likely further accelerate the diffusion of production capabilities related to cruise missiles. Thus, the link between cruise missiles and manned aircraft represents a major challenge to MTCR effectiveness in controlling the spread of cruise missiles.

Russia's aerospace marketing activities are especially worrisome. Russia is marketing a variety of cruise missile systems at arms shows around the globe. Among the more troubling systems is a conventionally armed version of the air-launched AS-15 cruise missile—a *Tomahawk*-class system with an abbreviated range. Some Russians contend that national laws, not the MTCR, will govern their exports of missile technology. Also of concern is the flow of systems and technologies to China. Russian technology transfers could facilitate China's development of more advanced cruise missile weapons, and there is little evidence to suggest that China will be persuaded to forego exporting them, the MTCR notwithstanding.

## COCOM EFFECTIVENESS

The Coordinating Committee for Multilateral Export Controls (CoCom) terminated on March 31, 1994 after operating throughout the Cold War era. Nevertheless, because CoCom members have vowed to create a follow-on regime, it is important to consider the CoCom's treatment of UAVs and their enabling technologies. In this regard, CoCom was similar to the MTCR—CoCom authors wrote in protection for the export of aircraft and aircraft subsystems.

CoCom partners responded to the collapse of the East Bloc by treating certain proscribed countries differentially. Generally, this differential treatment meant that a variety of UAV components could be exported at national discretion to Poland and the Czech and Slovak Republics, and with favorable consideration to Bulgaria, Latvia, Mongolia, and Romania.

The future of the CoCom regime is unclear at present. CoCom members are considering a follow-on agreement aimed primarily at filling the gaps in current nonproliferation accords. CoCom's replacement could possibly aim at stemming the transfer of conventional weapons, especially transfers to areas of conflict or excessive military buildups.

Although it is too soon to predict how UAVs might be treated under a CoCom follow-on, negotiators do not envision any follow-on overlapping with the MTCR. Hence, if UAVs are covered at all, the restricted variants will likely be those falling below the MTCR thresholds.

## THE EFFECTIVENESS OF UN INITIATIVES

Iraq's 1990 attack on Kuwait focused world attention on the dangers of excessive arms buildups. This led to the UN Security Council's "Perm-5 Talks" on export guidelines for conventional weapons. The talks began in 1991 but stalled just two years later over such basic issues as the types of weapons that would be covered. It does not appear that the discussions—if resumed at all—will produce any agreement on arms transfer guidelines that will have any significant impact on cruise missile proliferation. Indeed, to the extent that the talks focused on missiles at all, they did so by emphasizing potential restrictions on exports of "surface-to-surface" missiles, thereby leaving out air-launched cruise missiles, which can be readily adapted to ground-launched configurations. However minor this oversight may appear, it reflects the policy community's fixation on ballistic missiles to the exclusion of potentially dangerous cruise missile transfers.

The UN Register seems not to have fostered arms export moderation as its authors had hoped. All major arms exporting nations have strong incentives to accelerate exports to protect otherwise shrinking defense industries. Nevertheless, the willingness of key Western members to make heretofore confidential transfers a part of the public record could intersect positively with MTCR deliberations to foster restraint on missile transfers not subject to a strong presumption of denial. Such transfers include MTCR Category II missiles. Although the latter can in some cases be "scaled-up" to 300-km range and 500-kg payload, they can nonetheless be exported at the discretion of MTCR member governments.

## RECOMMENDATIONS FOR IMPROVING EXPORT CONTROLS

Although the problem of cruise missile proliferation is just beginning to manifest itself, the findings presented in this monograph suggest that constraining the spread of cruise missiles may be relatively more difficult than constraining the spread of ballistic missiles. Hence, there is need for immediate action while there is still time to constrain rapid advances in the cruise missile threat. In this regard, a critical first step is acknowledgment of the cruise missile proliferation challenge. This should be followed by the establishment of a revamped missile nonproliferation agenda that places cruise and ballistic missile nonproliferation efforts on an equal footing.

We examined the Clinton administration's treatment of cruise missile proliferation in congressional testimony, major foreign policy speeches, and policy proclamations on export controls and counterproliferation initiatives. Not one of these key addresses or documents specifically mentioned cruise missiles as an important element in the overall missile proliferation problem. Each focused instead on ballistic missile and space-launch vehicle proliferation. However minor such an omission may appear, it will become increasingly important to draw specific attention to the cruise missile dimension of the missile proliferation threat—particularly in light of the export control challenges discussed in this monograph.

Any new MTCR initiatives must be firmly grounded in reality. Reality dictates that member states recognize that they no longer monopolize aerospace expertise or industrial capabilities. Some developing countries are already producing relatively unsophisticated cruise missiles, and they might exploit satellite navigation systems to build longer range cruise missiles over time. Moreover, a latent cruise missile production capability exists in many regions because of the globalization of the manned aircraft and UAV industries. Hence, although technology denial efforts aimed at unsophisticated cruise missiles should not be abandoned, neither should they be expected to have a major impact.

We recommend that the MTCR focus its attention on slowing the spread of relatively advanced systems, such as stealthy cruise missiles capable of high speed and/or long range. The critical enabling technologies needed to acquire advanced cruise missiles—including stealth and advanced propulsion systems—are produced almost exclusively by MTCR members or by states that might be persuaded to support tighter controls. Because stealth and advanced propulsion systems are covered under the dual-use section of the MTCR, they can be exported at the discretion of MTCR member governments. But given the special sensitivity of stealth technology transfers, in particular, it would seem advisable for the relevant producing states to discuss common constraints on exports, perhaps even outside the context of MTCR deliberations.

The MTCR member governments should be sensitized to the fact that, with the predicted worldwide expansion of the aircraft upgrade and UAV markets, export control authorities can expect export license applications for advanced subsystems usable in cruise missiles. MTCR members should take such applications as a warning signal. The recipient state's end-use intentions should thereafter be thoroughly investigated, especially when the recipient does not have current, acceptable aerospace systems employing such technologies. Exports of stealth and advanced propulsion systems should be prohibited or proceed only with utmost caution if available evidence suggests that the recipient government is interested in acquiring cruise missiles. If the export is permitted, end-use monitoring would be advisable, even in cases where end uses involving manned aircraft seem certain. Monitoring might deter—although it cannot prevent—diversions of end items and production equipment from acceptable aerospace projects to cruise missile applications.

These measures will require little more than a better balance in the level of bureaucratic scrutiny paid to ballistic and cruise missiles. Yet they will be nonetheless invaluable. Enhancing bureaucratic scrutiny and awareness of the cruise missile threat might yield benefits far beyond other measures to improve MTCR enforcement. Enhanced awareness could influence the conduct of other international arms control and disarmament efforts.

Quiet diplomacy also has an important role to play. Appropriate member states should query the French on their export intentions in regard to the *Apache* cruise missile, which incorporates advanced stealth characteristics and appears readily capable of being upgraded to a 300 km-500 kg system. If the *Apache* does ultimately prove to be exportable according to MTCR Category II provisions, MTCR member governments should encourage France to conclude rigorous end-use monitoring agreements with any recipient states to deter diversions of *Apache* components to longer range cruise missiles. The retransfer of an advanced technology system such as *Apache* to a rogue state could have significant national security consequences for future Western defense planning.

Russia is currently the most critical "weak link" in the export control chain. The United States and other MTCR member states should ensure that cruise missile exports are given treatment equal to that of ballistic missiles in monitoring Russian compliance with MTCR. The United States should investigate the capabilities of, and Russian export intentions for, advanced systems such as the ramjet-powered ASM-MSS and the AS-15 or its derivatives.

Even the most perfectly crafted export control strategy would be limited in what it could achieve, which is to slow the pace of, not stop, cruise missile proliferation. Yet slowing the pace can raise the costs and risks that proliferators must incur to acquire advanced cruise missiles. It also furnishes the United States and other affected states with time to develop effective defenses against emerging threats. Demonstrating that effective cruise missile defenses are being developed apace with the emerging cruise missile threat could have a strong deterrent effect on Third World acquisition plans for such missiles.

## OUTLINE OF *CONTROLLING THE SPREAD OF LAND-ATTACK CRUISE MISSILES*

This monograph examines the effectiveness of export control regimes in constraining the spread of land-attack cruise missiles and their associated enabling technologies.

After a brief introduction and overview in Chapter 1, Chapter 2 assesses the current setting and future prospects for the proliferation of land-attack cruise missiles, focusing especially on those factors likely to condition the pace and scope of Third World acquisition efforts. Chapter 3 examines the MTCR, the former CoCom and its potential replacement, the UN Register of Conventional Arms, and the UN Security Council's initiative on export guidelines for conventional weapons. In Chapter 4 each regime—foremost the MTCR—is evaluated against five measures of effectiveness to determine strengths and weaknesses, to identify loopholes and the prospects for closing them, and to render an overall judgment on each regime's utility in constraining cruise missile proliferation. And, finally, Chapter 5 offers recommendations, including ones affecting both general policy concerns as well as specific measures, designed to bolster regime effectiveness.

## CHAPTER 1

# INTRODUCTION

US and allied missile proliferation initiatives have traditionally focused on controlling the spread of ballistic missiles. More recently, however, analyses including the Department of Defense's "Bottom Up Review" have expressed growing concern that land-attack cruise missiles could emerge to threaten US interests in the mid- to late 1990s and beyond.[1] An explosion in commercially available navigation, guidance, and satellite-based digital mapping technology portends the widespread proliferation of unmanned air vehicles. Due to their precision of delivery, low-flight profile, and potentially low radar cross section, they threaten effective delivery not only of nuclear, biological, and chemical weapons, but conventional payloads as well. Without effective export controls or improved air defenses, a cruise missile-armed adversary could present new challenges to the ability of the United States to project military power globally.

This monograph examines the effectiveness of export control regimes in constraining the spread of land-attack cruise missiles and their associated enabling technologies. To set the stage for our analysis of export controls, in Chapter 2 we first assess the current state of cruise missile proliferation, which has largely been limited to antiship cruise missiles. We then turn to considering what factors might shape the future scope and pace of Third World acquisition of cruise missiles for land-attack missions. Per force, we focus on two critical dimensions affecting cruise missile proliferation: Third World military and financial incentives and the availability of key enabling technologies for land-attack cruise missiles. Chapter 3 presents an overview of current and potential regimes that restrict the transfer of cruise missiles and related technologies (e.g., guidance and control, engines, airframes, stealth materials, etc.). We specifically examine the Missile Technology Control Regime (MTCR), the former Coordinating Committee for Multilateral Export Controls and its potential replacement, the United Nations (UN) Register of Conventional Arms, and the UN Security Council's initiative on export guidelines for conventional weapons.

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[1] Les Aspin, *Report on the Bottom-Up Review* (Washington, DC: Department of Defense, October 1993), 44. For a general examination of cruise missile proliferation trends, see W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, Connecticut: Praeger Publishers, 1992).

In Chapter 4 we establish a framework for analyzing the effectiveness of each regime specifically with regard to controlling cruise missiles and their enabling technologies. The framework, adapted from one developed by the National Academy of Sciences, consists of five prerequisites for successful system or technology denial. We examine each of the export control regimes—with most attention devoted to the MTCR—by employing the analytical framework as our basis for judging the strengths and weaknesses of each regime's provisions. We identify loopholes, assess the prospects for closing them, and render an overall judgment on the utility of each regime in constraining cruise missile proliferation.

Finally, in Chapter 5, we offer recommendations. They include ones affecting both general policy matters as well as specific measures designed to bolster regime effectiveness.

Appendices to the monograph contain official documentation and relevant provisions of various export control regimes.

## CHAPTER 2

# PROSPECTS FOR CRUISE MISSILE PROLIFERATION

## DISTINGUISHING CRUISE FROM BALLISTIC MISSILES

To appreciate fully just how existing export controls affect the prospects for cruise missile proliferation, it is first important to distinguish the differences between ballistic and cruise missile systems—particularly the close relationship between unmanned cruise missiles and manned aircraft. Unlike ballistic missiles, cruise missiles fly through the air in powered flight for the duration of their trip. They fall into the category of aerodynamic missiles. Ballistic missiles, by contrast, shed their rocket motors after propelling the missile outside the atmosphere, after which they pursue an unpowered ballistic course to the target.[2] *Jane's Aerospace Dictionary* defines cruise missiles as aerodynamic vehicles that are "wing supported." A more restricted definition of cruise missiles would relegate them to the category of aerodynamic missiles employing air-breathing propulsion to achieve extended ranges (e.g., the US *Tomahawk* and the Russian AS-15 cruise missiles).

The first aerodynamic missiles were adapted from drones or manned aircraft reduced in size or range to achieve the desired range-payload objective. Designed with two wings and three surface tails (not until the 1960s did four-wing, four-tail cruciform designs come along), they used standard liquid-fueled aircraft engines and autopilots for guidance and control. Increasingly more sophisticated guidance schemes replaced these original designs, including command updates, terminal guidance having passive or active radar and passive infrared (IR) seekers. Television and IR imaging systems came along about the same time as inertial navigation systems replaced autopilots. Liquid fuels eventually were replaced by solid propellants, and air-breathing engines (turbojets and turbofans) finally came along to extend missile range. When higher specific energies were desired for increased speed or range, ramjets were employed.

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[2] Of course, a reentry bus can be configured to undertake terminal maneuvers to avoid active defenses. For more on the differences between ballistic and cruise missiles, see System Planning Corporation, *Ballistic Missile Proliferation: An Emerging Threat 1992* (Arlington, Virginia: System Planning Corporation, 1992), passim.

## CRUISE MISSILE PROLIFERATION TRENDS TO DATE

Aside from the German V-1 cruise missile, most aerodynamic missiles were produced to attack ships—antiship cruise missiles (ASCMs)—and airplanes or to defend coastal areas. Later some were adapted to attack land targets. Aerodynamic missiles can be launched from the ground, aircraft, ships, or submarines. Most, to date, have been relatively short-range systems such as the greatly proliferated ASCMs, which are now in at least 40 Third World military arsenals.

It is important to understand what has motivated the Third World to acquire and to develop ASCMs, as the ASCM case may shed light on what may occur in the 1990s and beyond in the area of land-attack cruise missiles. Perceived military utility appears to have been a compelling factor in explaining the rapid proliferation of ASCMs throughout the Third World. Moreover, despite their great expense (a typical ASCM costs about $800,000), ASCMs promise high payoff for Third World nations not possessing the prestige and operational flexibility of large military establishments. ASCMs offer each acquiring Third World country the ability to defeat a major naval combatant in a superpower's navy. Despite the vast differences in gross national product and military capability between Third World nations and the industrialized powers, one accurately placed ASCM launched from a Third World patrol boat or off-shore launcher is capable of achieving strategic results. Argentina's use of *Exocet* ASCMs in the Falklands War against the British Royal Navy is perhaps the best example of both the effective use of ASCMs and just how close Argentina came to achieving strategic results with just one weapon system.[3]

The United States has become the most prolific exporter of cruise missile systems in the form of the *Harpoon* ASCM. The *Harpoon* is a second-generation system having four clipped-tip triangular wings at midbody and four smaller wings as moving control fins at the rear—a more sophisticated design compared with the first-generation airplane design. It can be launched from ships, submarines, and aircraft. It uses a turbojet engine for propulsion and has an active radar seeker for terminal guidance.[4] The *Harpoon 1C* has a range of 100 to 120 km. Overall, the United States has transferred *Harpoons*

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3. For the best appraisal of the Falklands conflict and the impact of *Exocet* cruise missile attacks on British naval operations, see Max Hastings and Simon Jenkins, *The Battle for the Falklands* (New York: W. W. Norton, 1983), 153-154, 316-320.

4. The sea-skimming version of the *Harpoon* employs a radar altimeter to get the missile to the target area; another version employs a climb-and-dive approach, necessitating an inertial navigation scheme in the high-altitude mode.

to 23 nations, including NATO allies, the Middle East (including Iran), the Far East, and South America. Taiwan has reverse-engineered the *Harpoon* into the *Hsiung Feng-2* or HF-2, which is reportedly for sale.

ASCMs generally, and the *Harpoon* in particular, are relevant to the proliferation of land-attack cruise missiles for at least two reasons: first, they are so widely proliferated within the Third World; and, second, they are potentially adaptable to land-attack missions. In the case of the *Harpoon*, its land-attack version is the US Navy's *SLAM*, which gained prominence in the 1991 Persian Gulf War. Thus, it is safe to assume that countries which have acquired the *Harpoon* at least have an important building block for expansion into the land-attack area, however short-range that might be. The key to extending the range of cruise missiles lies in engine, guidance, and navigation technology.

## PROSPECTS FOR LAND-ATTACK CRUISE MISSILE PROLIFERATION

Because cruise missiles for land-attack—especially longer range missions—require sophisticated guidance and complicated support infrastructures to map terrain, they have been relegated largely to superpower arsenals. However, both technology push and doctrinal drive are creating compelling incentives for Third World nations to acquire land-attack cruise missiles capable of precise delivery of both conventional payloads and nuclear, biological, or chemical (NBC) weapons.

The technology push stems from numerous factors, the most important of which is the widespread availability of commercial satellite navigation and guidance technology, together with a variety of increasingly sophisticated mission planning tools and commercially available satellite imagery. Combined, these latter technologies and products stand as the major missing elements in helping to explain why more Third World nations have not already developed or procured land-attack cruise missiles in militarily significant numbers. Worldwide technology diffusion is also prompted by increased motivation on the part of the developed world to sell sophisticated technology and systems to the Third World as the developed world's needs shrink in the aftermath of the Cold War.[5]

[5] The US Air Force and US Navy—like the French Air Force over the last two decades or more—may not be able to go into large-scale production for a future fighter until sufficient foreign sales are made to bring down per unit costs. And in an effort to preserve national industrial bases, nations may err on the side of transferring technology by reducing the number of production lines (and accompanying overhead and production costs) to perhaps just the front-line model. As a consequence, prospective buyers have a rare opportunity to purchase the best the West is producing. And with offsets included, the Third World recipient is receiving not just aircraft but technological infrastructure as well.

With the demise of the bipolar world, technology push interacts strongly with doctrinal need. Regional powers now have even greater incentive to seek regional self-sufficiency and security from potential adversaries. Perhaps the clearest example of international system change interacting with technology proliferation is reflected in Russia's arms sales. As heir to the former Soviet Union's foreign policy, Russia has chosen not to continue furnishing the far-flung security guarantees her predecessor state so generously distributed around the globe during the height of the Cold War. Nevertheless, while formal security guarantees may have evaporated, the collapse of the Soviet empire has led to a virtual fire sale of high technology, weapon systems, and scientific talent to many of her former allies and virtually anyone else with sufficient capital.

One major consequence of the above trends is that the most sophisticated versions of the industrial world's land-attack cruise missiles may be transferred to Third World recipients. For a glimpse of possible future transfers, one need only consider Russia's offering of a shorter range version of the 3,000-km range AS-15 cruise missile at the February 1993 Abu Dhabi Defense Exhibition, or the French *Apache* stealth cruise missile, which was on display for export at air shows in Paris (June 1993) and Singapore (February 1994).[6] Direct transfers of advanced technology systems such as these could accelerate indigenously-based development efforts as well as directly threaten regional and Western interests—particularly if they fall into the hands of rogue states or states with reckless transfer practices. Thus, the extent to which existing export controls preclude or constrain such transfers is a topic of considerable concern—and one which will be addressed systematically in this monograph.

## Third World Motivations for Acquiring Land-Attack Cruise Missiles

To what extent the Third World will react to the availability of new guidance and control technology and acquire land-attack cruise missiles depends on several factors, not the least important of which are the effectiveness of voluntary controls on the part of the industrial world. Third World nations also must make difficult choices about the level of investment in domestic infrastructure development relative to national defense programs. And within national defense programs, competing priorities inevitably exist for finite resources.

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[6] Information on these displays is derived from interviews with attendees of the Abu Dhabi exhibition and attendance and discussions with company representatives at the Paris and Singapore exhibitions.

Because prestige is frequently an important factor in a Third World nation's acquisition of a weapon system, operational issues are just as often less critical in motivating a country to acquire a particular weapon system. This is especially true with respect to the way many countries view ballistic missiles. However, the *Tomahawk*'s performance in the Persian Gulf War has improved, if not equalized, the prestige value of cruise missiles relative to ballistic missiles.[7]

If, on the other hand, the degree of survivability against a Western power's air force were the principal criterion for judging the relative importance of major weapon systems, cruise missiles might become an alternative to aircraft rather than ballistic missiles. Third World aircraft are especially vulnerable to preemptive attacks, particularly with the advent of stealth aircraft and low-observable cruise missiles. Tied as they are to vulnerable airfields, huge investments in aircraft may not make as much sense as a more balanced approach that includes far more survivable and ground-mobile cruise and/or ballistic missiles.

Another useful way to look at investment in the category of weapon delivery for land-attack missions is to compare the relative cost and operational advantages and disadvantages of cruise and ballistic missiles. In terms of relative cost, cruise missiles are clearly less costly to design, develop, procure, maintain, and operate. Although the relative costs are much closer than they once were, it is insightful to compare the relative costs of the German V-1 cruise missile and V-2 ballistic missile programs. Put simply, the costs of the two programs reflected the difference in complexity between the simple V-1 design and the far more elaborate V-2 design. V-1s were procured under a contract with German industry for the equivalent of $500 per unit in 1943 dollars. By contrast, each V-2 launched was estimated to have cost roughly five hundred times more than a V-1 cruise missile.[8]

In today's combat environment, cruise missiles possess certain notable advantages over ballistic missiles. Perhaps the most important one lies in the area of accuracy. The aerodynamic stability of the cruise missile permits the use of less-sophisticated and, therefore, less costly guidance and control methods than is the case for ballistic missiles, which must undergo the stresses of reentry and high speed. New commercially available guidance and navigation

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7. For example, see Patrick J. Garrity, *Does the Gulf War (Still) Matter? Foreign Perspectives on the War and the Future of International Security* (Los Alamos, New Mexico: Center for National Security Studies, 1993), passim.

8. David Israel, "History Repeats?" an unpublished paper dated February 1992.

technology offers delivery accuracies today of at least 100-m CEP (circular error of probability)[9] and 10-m CEP in the near future for slow-flying aerodynamic vehicles like cruise missiles—all at costs substantially lower than far more complex ballistic missile guidance systems. This is because cruise missiles can receive satellite navigation corrections all the way to the target from the US Global Positioning System (GPS) or Russia's Global Navigation Satellite System (GLONASS).

Most of the ballistic missiles currently deployed in Third World arsenals possess CEPs in the range of 1,000 to 2,000 m.[10] Absent sophisticated and costly maneuvering reentry vehicles or post-boost vehicles, Third World ballistic missiles can potentially receive satellite navigation corrections only until main engine cutoff, which occurs early in their flight sequence. Assuming satellite navigation corrections before main engine cutoff, Third World ballistic missiles will be relegated to CEPs of no better than 200 to 300 m for the foreseeable future. For example, China is developing the M-9 missile with a reported CEP of 300 m. And despite the drawbacks of command guidance, the Indian *Prithvi* missile employs it in combination with an inertial navigation system to achieve a CEP in the neighborhood of 250 m. Theoretically, better accuracies are possible for Third World ballistic missiles with the addition of map-matching guidance schemes integrated into maneuvering reentry or post-boost vehicles for the terminal delivery phase.[11] The latter improvements, however, are both costly and subject to some export controls. In sum, the relative inaccuracy of ballistic missiles when compared with cruise missiles proscribes the effectiveness and utility of the former when they are equipped with conventional payloads. Cruise missiles, by contrast, offer the Third

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9. CEP is a measure of accuracy, defined as the radius of a circle in which 50 percent of the reliable missiles are successfully delivered.

10. The most widely proliferated longer range ballistic missile in the Third World is the Soviet-designed *Scud B*. Declassified US Department of Defense estimates assert that Soviet forces could achieve *Scud B* CEPs of approximately 600 to 900 m. Third World forces have demonstrated significantly less proficiency in their conduct of ballistic missile operations. It seems unlikely that Third World *Scud* operators could even match the upper bound in accuracy achieved by their Soviet counterparts. Iraq, for instance, achieved CEPs of roughly 2 km with its *Scud*-derived, 650-km *Al Hussein* missiles during the 1991 Persian Gulf War. For details and source materials on *Scud B* accuracies, see Dennis M. Gormley, *Double Zero and Soviet Military Strategy: Implications for Western Security* (London: Jane's Publishing Co., 1988), 75-77; for details on *Al Hussein* accuracies see Gregory S. Jones, *The Iraqi Ballistic Missile Program: The Gulf War and the Future of the Missile Threat* (Marina del Rey, California: American Institute for Strategic Cooperation, Summer 1992), 31-32.

11. For a useful treatment of missile accuracy see Jones, *The Iraqi Ballistic Missile Program*, especially 42-43.

World the capacity to attack military targets effectively without resort to NBC weapons.

Cruise missiles also possess other appealing operational features when compared with ballistic missiles. They can be placed in canisters, which makes them particularly easy to maintain and operate in harsh environments. Their relatively compact size offers more flexible launch options, more mobility for ground-launched versions, and a smaller logistics burden, which could reduce their battlefield vulnerability to detection—and thus improve their prelaunch survivability. Moreover, cruise missiles dictate no special launch pad stability requirements and can be launched from commercial ships and airplanes, as well as ground launchers. And finally, the cruise missile's aerodynamic stability, which makes it an inherently easier and cheaper platform from which to achieve precise delivery of conventional payloads, also makes it a better platform for effective dispersal of chemical and biological agents.

Where effective defenses against ballistic missiles were non-existent a decade ago, at least the potential now exists (especially with improved *Patriot* designs) to defend against theater ballistic missile threats. Russia, too, is marketing internationally its S-300 dual-mode (air and missile) defensive system. Although in theory, existing air defenses ought to have some capability against aerodynamic threats like cruise missiles, unless the country under attack possessed a modern air defense system, even crude cruise missile designs (that is, missiles with large radar cross-sections[12] ) could present serious challenges.

Cruise missile exhaust plumes are not generally detected by launch warning systems, and, unlike ballistic missiles, their flight paths are unpredictable. Most important, however, cruise missiles can fly low and thereby pose severe detection challenges even for airborne radars due to ground clutter. And as higher quality terrain elevation data become available through the commercial marketplace, future Third World cruise missiles will stress the most capable of existing air defenses through very low flight profiles. Reductions in radar cross sections, which are generally easier to accomplish in more streamline cruise missile designs than for manned aircraft, will further exacerbate the air defense challenge. But perhaps the most demanding problem for defense against cruise missiles stems from their low cost. The US Army estimates that for a given investment of $50 million, a Third World nation could acquire

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12. Radar cross-section (RCS) is a standard measure defining how visible a target is to a radar and, therefore, at what range a given radar can detect and track the target. For a tutorial on the importance of RCS in aircraft and cruise missile design, see Bill Sweetman, *Stealth Aircraft: Secrets of Future Airpower* (Osceola, Wisconsin: Motorbooks International, 1986), especially chapter 3.

at least 100 cruise missiles. An equal investment for ballistic missiles would purchase only fifteen tactical ballistic missiles and three transporter-erector-launchers.[13] Thus, while the individual penetration survivability of a cruise missile may not compare favorably with a tactical ballistic missile, saturation attacks with low-cost cruise missiles could more than compensate—especially in light of the cruise missile's better accuracy and resulting higher lethality.

## KEY CRUISE MISSILE ENABLING TECHNOLOGIES

The design requirements for the original cruise missile entailed some form of simple midcourse guidance (preprogrammed autopilot or remote/command guidance), a conventional airframe (metal skin structure with conventional aerodynamic flight controls), conventional propulsion (jet propulsion or use of liquid rocket motors), and terminal guidance (either passive radio frequency homing, radar, or passive IR for terminal homing). Such designs possessed severe limitations. Midcourse guidance had limited autonomy and accuracy, while propulsion systems produced limited ranges due to poor fuel efficiency (typically 300 km or less). Terminal guidance systems required a "cooperative target," in that the ability to acquire targets at operating ranges beyond 150 km was severely limited by uncertainties in midcourse guidance.

The two critical enabling technologies that promise to create major incentives for the Third World to acquire cruise missiles include precise navigation and guidance technology (GPS and GLONASS) and higher efficiency, lower volume engine technology.

### Navigation and Guidance Technology and Systems

Satellite navigation and guidance offers a straightforward solution to the midcourse and terminal guidance challenges enumerated above. By using very accurate satellite navigation updates together with even a rudimentary inertial navigation system, a modern cruise missile can achieve autonomous midcourse guidance and very accurately deliver a payload to within a few meters of its intended target.

Originally scheduled for completion in late 1993, the US GPS system known as NAVSTAR will consist of twenty-one satellites in orbit with three spares. Cruising in polar orbits, each satellite has a clock and transmits a signal enabling a ground receiver with a similar clock to determine its exact

[13] Department of the Army, Office of the Deputy Chief of Staff for Operations and Plans, Force Development, Concepts, Doctrine, and Policy Division, "Army Theater Missile Defense," briefing charts, (US Department of the Army, Washington, DC, n.d.).

position on the earth. A ground station maintains the accuracy of the system by introducing minute corrections into the system. Signals from three satellites are needed to achieve a precise two-dimensional position. Four satellites are required for a three-dimensional fix. Receipt of signals from more than four satellites only increases the accuracy of the fix.[14]

Each satellite transmits two signals with slightly different frequencies.[15] Coarse/Acquisition, or C/A-code, signals are available to all users and furnish an accuracy of roughly 30 m. The Precision or P-code signals, which are encrypted, are intended only for military users; they deliver an accuracy of roughly 15 m. Because the Department of Defense (DOD) fears that C/A-code accuracy is sufficient to threaten US security interests, it has introduced a feature—called Selective Availability (SA)—that intentionally degrades the C/A code signal to produce an accuracy of 100 m in latitude and longitude and 140 m in altitude.[16]

SA can be corrected by employing differential techniques—called DGPS—consisting of a receiver and broadcast station on a geodetically referenced site, which applies a correction to the GPS signal and rebroadcasts that correction to portable units within a radius of around a few hundred km.[17] The application of DGPS to cruise missile guidance and navigation is illustrated in Figure 2.1. Inherent range limits for local-area DGPS service are being overcome with the introduction of wide-area DGPS. This is accomplished by collecting local-area differential corrections and transmitting them to a central facility where they are then sent to a satellite for broadcast. Reports indicate

[14] GPS completion has slipped, probably to 1995. Currently, at a minimum, there is 24-hour, two-dimensional access to the NAVSTAR system. In most places around the world, the coverage is most often three or four satellites. When completed, the ideal situation is for a receiver to have access to five signals from five satellites at any one time.

[15] For technical details see Department of Commerce, *Federal Radio Navigation Plan, 1990*, PB-91-190868 (Washington, DC: US Department of Commerce, 1990); and J.J. Spilker, *Signal Structure and Performance Characteristics*, Published in Global Position System, Institute of Navigation, 1980. The most useful layman's guide is Jeff Hurn, *GPS: A Guide to the Next Utility* (Sunnyvale, California: Trimble Navigation, 1989).

[16] Accuracy for GPS is defined differently than missile CEP accuracy. Thus, a 100-m GPS accuracy has a confidence of 2 dRMS, which means that at least 95 percent of the time the position information reported is within 100 m of its true position. By contrast, CEP has a 50 percent confidence level, making CEP four-tenths as large as 2 dRMS. In other words, a 100-m GPS accuracy equates to a 40-m CEP for a missile.

[17] For technical details see P. Munjal and M. Amanda, "Wide Area Differential GPS—Potential for Accurate Global Navigation," 48th Institute of Navigation Meeting, 29 June-1 July 1992.

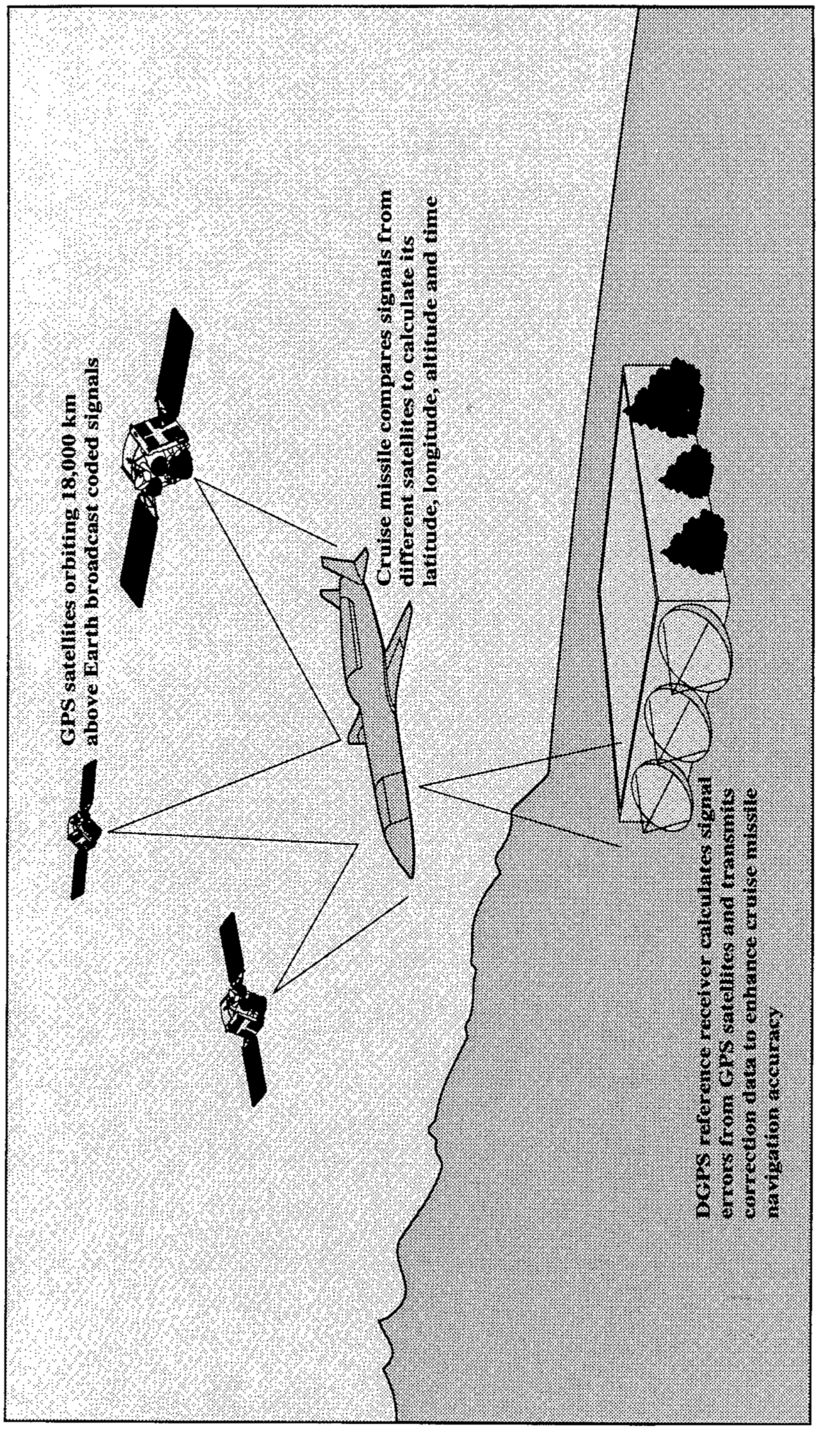


Figure 2.1. Differential GPS concept for cruise missile navigation.

that using DGPS techniques can improve accuracy by a factor-of-ten for the C/A-code signal; for the military P-code, one estimate suggests the attainment of accuracies of between 75 cm and 5 m.[18] Importantly, differential GPS data can be incorporated not only into weapon systems but also into the making of very accurate map products for both mission planning and terrain contour matching purposes. Commercial DGPS systems are readily available on the open market throughout the world with prices dropping in keeping with price reductions occurring in the general electronics marketplace.

Russia's GLONASS is similar in design to GPS, although the pace of implementation has slowed due to Russia's uncertain economic conditions. Because GPS is much closer to full deployment, GLONASS may be marketed less as an independent source of satellite navigation information than as a complement to GPS by virtue of the fact that joint use ensures the reliability of GPS and actually improves its accuracy.

As with the US GPS system, GLONASS will deploy 21 satellites (with three spares).[19] Technically, it is similar in principle to GPS, although its coordinate system and the orbital planes of the satellites are somewhat different. Like GPS, GLONASS has a C/A-code equivalent with roughly the same accuracy of 100 m and a military user P-code equivalent with about the same accuracy as the GPS P-code. GPS and GLONASS integrated receivers have already been developed and tested by Honeywell and Northwest Airlines for airline applications, with accuracies reportedly below 20 m.[20] GLONASS/GPS integrated receivers furnish an attractive option for Third World users who fear any degradation of GPS signal quality and accuracy.

## Integrating GPS and Inertial Navigation Systems

A major constraint in Third World missile performance relates to the relative quality of their inertial navigation systems (INS). By using accelerometers and gyroscopes that detect motion and calculate needed changes in relative position, INS furnish guidance and control for both aerodynamic and ballistic

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18. W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, Connecticut: Praeger Publishers, 1992), 61.

19. In early 1992, eight of the 21 satellites had been launched with completion scheduled for late 1994. The pace has clearly slipped.

20. Steve Wooley, "Proliferation of Precision Navigation Technologies and Security Implications for the U.S.," Presentation to the Proliferation Countermeasures Working Group, Washington, DC, December 9, 1991 (Alexandria, Virginia: Institute for Defense Analyses, 1991), 8.

missile systems. Unfortunately, INS accumulate inaccuracies as a function of time. Given the slow speed of long-range cruise missiles, INS alone do not provide sufficient accuracy for conventional missions. While INS technology in the United States has reached the point where a strategic ballistic missile like the MX can achieve a CEP accuracy of 100 m, these packages are extremely expensive and controlled from acquisition by Third World countries.

The advent of GPS has changed the INS picture in revolutionary terms—and in just a decade. Consider that in the early 1980s Third World countries had marginal navigation systems, such as the attitude heading reference system for the Mig-21, Mig-23, and Mig-25 aircraft, and poor INS for their ballistic missile systems—mostly Soviet furnished *Scuds*. A decade later the developing world is just beginning to gain access to radically improved navigation and guidance by coupling GPS receivers with cheap and relatively inaccurate INS systems, which are readily available for commercial aircraft. Hybrid technology (INS plus embedded GPS) is now widely available. Overall, there has been a quantum jump in capability, which will become increasingly available for military applications in the decade ahead.[21] The developing world can jump ahead roughly 15 years of navigation development simply by purchasing available INS systems linked to GPS or GLONASS—at prices that continue to drop.[22]

There is evidence that several countries are actively engaged in exploiting GPS, possibly for missile guidance purposes. Pakistan, China, Burma, Israel, Iran, Russia, France, and Germany have all shown interest in the integration of GPS into missiles and unmanned air vehicles. A number of countries (Pakistan, China, India, Indonesia, and Thailand) appear headed toward seeking DGPS to improve the quality of their photogrammetric techniques.[23]

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21. For a recent example of applications in integrated INS/GPS systems, see Mark Hewish, "Integrated INS/GPS Takes Off in the U.S.," *International Defense Review* 26 (February 1993): 172-174; Mark Hewish, "GPS Users Proliferate Following Gulf War," *Defense Electronics & Computing*, no. 4 (1992), editorial supplement to *International Defense Review* 25 (September 1992): 115-120; and Wooley, Proliferation of Precision Navigation Technologies," 12.

22. According to Steve Wooley, stand-alone and relatively accurate INS for Western commercial aircraft cost something in the neighborhood of $150,000. Cheaper, less-accurate systems—widely available from France, Germany, China, the United States, and the United Kingdom—cost roughly $50,000, but can be updated with GPS and GLONASS. The integration complexity varies depending on the platform. See Wooley, "Proliferation of Precision Navigation Technologies," 11. As far as GPS technology is concerned, Rockwell offers the NAVCORE V, a five-channel receiver in embedded chip form, 4 by 2.5 inches in size, for $450 apiece, or $250 in bulk.

23. Wooley, "Proliferation of Precision Navigation Technologies," 14.

## Mission Planning for Cruise Missile Applications

The advent of GPS technology also brings within the Third World's reach all the necessary tools for sophisticated mission planning, and possibly even terminal guidance schemes employing terrain matching techniques. While GPS as a guidance technique for cruise missiles obviates the need for detailed digital map making, some countries may, nevertheless, desire to develop accurate digital maps to improve the penetration and survivability of their cruise missiles. Flying cruise missiles at very low altitudes dictates the need for accurate terrain elevation data, which can be preprogrammed into the cruise missile, thereby avoiding the need for an expensive terrain avoidance radar system.

The products for such mission planning are readily available today. Conventional wisdom has it that civilian space programs have little military utility. In fact, SPOT and Landsat commercial products were used extensively in operations Desert Shield and Desert Storm for broad-area search and mission planning. Moreover, the recent US government decision to permit the sale of sophisticated spy satellite technology and products (viz., imagery depicting objects 1 m in diameter) to commercial customers has generated concern that militarily relevant imagery will become available to potentially hostile powers, despite safeguards for controlling its spread.[23] Geographic Information Systems (GIS), comprising personal computer hardware and very sophisticated software (AutoCad, e.g.), now permit users to make very accurate digital maps with GPS data inputs. Such hardware and software capabilities can be used for more than just preprogramming the route of a cruise missile. Better maps and commercially available satellite imagery allow Third World states to develop better targeting by improved photogrammetric techniques. According to Steve Wooley, the Center for Mapping at Ohio State University blended imagery with DGPS data to archive highway and land features data. They used an eight-channel GPS receiver, stereoptic cameras, and standard GIS technology roughly costing $850,000 in order to map several states. Their output product permitted vans traveling at 50 to 60 mph to achieve accuracies

[23] Safeguards on misuse of such high-resolution imagery reportedly include the requirement that companies maintain a record of every job requested. Moreover, the government reserves the right to shut down services during "periods when national security/or foreign policies may be compromised." As tight as these safeguards may appear, they cannot eliminate the prospect that a hostile power might use an apparently legitimate company to purchase imagery useful for supporting the targeting of fixed military installations. That such services might be eliminated in a crisis only deals with constraining a hostile nation's access to time-critical imagery; it would not preclude the acquisition in peacetime of militarily-relevant imagery for targeting fixed installations. See Edmund L. Andrews, "U.S. to Allow Sale of the Technology for Spy Satellites," *The New York Times*, 11 March 1994, 1[A].

of approximately 2.5 m. In other words, the technology is commercially available today to permit proliferating states to digitize satellite imagery generated by SPOT and Landsat, add position information taken from differential GPS, and employ it together with a radar altimeter to create a terrain comparison (TERCOM)-like guidance system for intermediate and terminal homing.[25] The challenge is one of integrating these components into a weapon system, which is a difficult challenge indeed for any Third World country. Yet, in a decade or so, it is safe to say that such targeting systems will probably be available in Third World cruise missiles.[26]

Third World countries are already engaged in exploiting the benefits of this technology. The US government approved the sale of GIS technology to Iraq in March 1987 for the stated purpose of remote sensing and photo interpretation, according to Iraq's Remote Sensing Center in Baghdad. After using the Center's new capabilities to support its war against Iran, Iraq started taking a strong interest in imagery of Kuwait and Saudi Arabia. According to the chairman of SPOT Image Corporation, between 1988 and 1990 his firm delivered twenty images of the area, including overlapping ones, to Iraq. SPOT denied another Iraqi request after its invasion of Kuwait in August 1990.[27]

The simple fact is that the United States and its allies no longer have an exclusive monopoly on space technology. Foreign government spending on space is increasing, and cooperative and cost-sharing agreements have reduced individual country burdens. Moreover, widespread availability of low-cost, dual-use space technologies (such as charged coupled devices) means that the prospects for enhanced imagery support to Third World users will inevitably increase.

## Propulsion Systems

It is unlikely that Third World countries will develop the indigenous capacity to produce efficient turbofan engines for small, long-range cruise missiles

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25. Wooley, "Proliferation of Precision Navigation Technologies," 19.

26. To build such highly accurate maps using DGPS, the developer must have access to en route navigation points, which should not be difficult to achieve. What's more, TERCOM guidance is viewed in the United States as a great challenge because of the extensive and costly mapping that is required to support TERCOM-guided cruise missiles, not the technology components of the guidance system itself. It should be noted, however, that the United States must plan against a variety of worldwide military contingencies, which raises the cost of mission planning considerably. By comparison, a Third World nation's scope of mapping activity will be on a much smaller scale.

27. Michael Krepon, "Bush Ignored Warnings on Saddam," *Defense News* 7 (1-7 June 1992): 19.

by the end of this decade. But that does not mean that turbofan engines cannot be acquired through the international marketplace. Turbofan engine technology like that reflected in the Williams F-107 used for the Air-Launched Cruise Missile and *Tomahawk* long-range cruise missile is available in Russian systems such as the AS-15 and SS-N-21 long-range cruise missiles. As already noted, derivatives of the AS-15 cruise missile outfitted with turbofan engines have been advertised for sale at international air shows. Moreover, US commercial sales to China of turbofan engines for jet trainer aircraft illustrate the challenge associated with controlling cruise missile proliferation at a time when there are far fewer limits on manned aircraft—commercial and military alike.[28]

Turbojet engines are available from a variety of industrial and Third World manufacturers.[29] Several countries, including Russia, China, France, and the United Kingdom, produce turbojet engines suitable for cruise missile applications. Given past practices, Chinese and Russian sales to the Third World are quite likely in the future; French and British sales have already occurred. Moreover, US turbojet engines are widely proliferated with the *Harpoon* ASCM. Also involved in the manufacture and sales of small turbojet engines for supersonic aircraft are India, Israel, South Africa, and Taiwan. Depending on payload weight, such turbojet technology in a small engine configuration ought to be able to support cruise missiles capable of ranges out to 1,000 km.

## SOME FINAL THOUGHTS ON FUTURE CRUISE MISSILE PROLIFERATION

In evaluating the developments discussed briefly in this chapter, it is safe to conclude that to date the problem of cruise missile proliferation has centered on antiship—not land-attack—systems. Still uncertain—though evidence of

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[28] According to an unconfirmed account in *The Washington Post*, AlliedSignal concluded a turbofan deal with the Chinese in 1987. Beijing claimed the engines would be used in jet trainer aircraft. AlliedSignal officials reminded US authorities that similar turbofans were available from other manufacturers and used in business aircraft around the world. The Commerce Department thus approved the sale. But DOD opposed it, citing an intelligence community finding that China could use the turbofans to upgrade its *Silkworm* ASCMs and create cruise missiles capable of carrying 450-kg payloads to ranges of about 600 km. China's proven willingness to sell missiles to the Third World raised the possibility that rogue states would acquire the upgraded *Silkworms* and use them against US forces in the future. Even so, economic considerations ultimately seem to have won the day. The Clinton administration reportedly approved the half-billion-dollar sale in 1994. See Jack Anderson and Michael Binstein, "Worrisome Engine Sales to China," *The Washington Post*, 9 May 1994, 14[C].

[29] See Carus, *Cruise Missile Proliferation*, 76-79, for a useful overview.

strong Third World interest is growing—is just how aggressively regional adversaries of the United States will exploit the revolution in guidance and navigation that now makes land-attack cruise missiles appear so attractive as an alternative or complement to ballistic missiles and attack aircraft.

It is also fair to say that the cruise missile threat has been both exaggerated and understated—though the latter phenomenon dominates the former. Exaggeration is reflected in the general tendency to focus on the individual components of land-attack cruise missile capability—particularly the implications and impact of the availability of GPS for cruise missile guidance—without giving sufficient attention to the challenges facing the Third World in systems integration.[30] What separates the industrial from the developing world is the former's capacity to integrate technology components into complex systems that produce repeatable results according to desired specifications. When cruise missile proliferation is approached purely from the standpoint of individual technology components, it is easy to conclude that the spread of cruise missiles represents a more significant threat than ballistic missile proliferation.

Two critical issues affecting the prospects for cruise missile proliferation are not dealt with in any significant way in the current literature. They are: first, the motives informing the developing world's acquisition of highly accurate cruise missiles for land-attack use in specific military contingencies; and, second, the time it might reasonably take for various nations to match desire with capability in some militarily significant way.[31] Given the varied paths available to the Third World for acquiring land-attack cruise missiles (viz., direct purchase from the industrial world; upgrading ASCMs or UAVs for land-attack missions; or developing an indigenous manufacturing capability), clearly the relative effectiveness of existing export controls will significantly shape the pace and scope of future cruise missile proliferation. This monograph serves the purpose of offering an analytical evaluation on the issue of export control effectiveness.

Overall, we judge Third World incentives to acquire land-attack cruise missiles to be sufficiently compelling to suggest a threat of some considerable magnitude probably emerging by the end of this decade, and becoming significantly more prominent thereafter. An important challenge will be in monitoring the emergence of this threat. The trend toward a substantial loosening of

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30. CBS News produced what is perhaps the most notable illustration. See "No Miss," *CBS News 60 Minutes*, Jeff Fager, producer, 26 December 1993.

31. These issues will be treated in Dennis M. Gormley, *Leveling the Military Playing Field: Cruise Missile Proliferation and the Challenge to U.S Force Projection*, forthcoming.

dual-use export controls increases the chances of technological surprise. To the extent that virtually no attention has been given to this prospect, the cruise missile threat has been understated.[32] In stark contrast, "a virtual blizzard of books, scholarly articles and now official analyses" on ballistic missile proliferation has offered just about everything that can be said about that subject, or so noted Janne Nolan in the journal *Survival*.[33] In part, the relative levels of attention are a function of the recent emergence of the enabling technologies for land-attack cruise missiles. Ballistic missile proliferation came into prominence as an important security issue in the mid-1980s. Yet, there are political reasons as well which inevitably affect analytical attention spans. Political controversy in the United States and Western Europe surrounding ballistic missile defenses has fixated the analytical and policy communities on the issue of ballistic missile proliferation—at the expense of a broader consideration of other and perhaps equally serious proliferation trends.[34] Whatever the reasons for the imbalance, to the extent that this monograph helps correct it by adding a critical analytical dimension to the discussion, it will have served its purpose.

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32. The notable exception being Carus, *Cruise Missile Proliferation.*

33. Janne E. Nolan, review of *Going Ballistic: The Build-Up of Missiles in the Middle East*, by Martin Navias, in *Survival* 36, no. 1 (Spring 1994): 177-179.

34. For an analysis of how politics affected analytical consideration of the threat of Soviet theater ballistic missiles in the 1980s, see Gormley, *Double Zero*, xi-xx and 174-190.

CHAPTER 3

# MEASURES TO REGULATE MISSILE PROLIFERATION: REGIME PURPOSES AND CHARACTERISTICS

## BACKGROUND

Currently, only one export control regime—the Missile Technology Control Regime (MTCR)—actively attempts to control the proliferation of ballistic and cruise missiles and their enabling technologies. The MTCR, therefore, receives the majority of this monograph's attention. By contrast, the former Coordinating Committee for Multilateral Export Controls (CoCom), the United Nations (UN) Permanent-5 arms control initiative, and the UN transparency in armaments initiative are either in transitional states or are far less focused than the MTCR on the problem of missile proliferation to merit equal analytical treatment. Nevertheless, the latter initiatives are presented and evaluated to determine their potential contribution to constraining cruise missile proliferation.

## THE MISSILE TECHNOLOGY CONTROL REGIME

### History and Purpose

The United States Government recognized decades ago that the proliferation of missiles could undermine US and allied security. The United States thus established restrictions on its own exports of complete missile systems and clearly identifiable missile components and production technologies. By the late 1970s, however, it had become apparent that controlling "clearly identifiable" missile components would not suffice. A study by the US Arms Control and Disarmament Agency (ACDA) determined that proliferators could purchase "dual-use" technologies, i.e., those with military and commercial applications, and apply them to missile production. These technologies could be purchased from the United States on a component by component basis using normal civilian export licensing procedures.[35]

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[35] Frederick J. Hollinger, "The Missile Technology Control Regime: A Major New Arms Control Achievement," in US Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers 1987* (Washington, DC: US Government Printing Office, 1988), 25.

The ACDA finding, along with growing evidence that several Third World countries were attempting to develop ballistic missiles capable of delivering nuclear weapons, prompted President Ronald Reagan to issue National Security Decision Directive-70 in November 1982. The Directive ordered an investigation of enhanced controls on missile proliferation.[36] The objective was to design controls on the export of US hardware and technology that would at once encourage cooperation in the space field and reduce the potential contribution of space exports to nuclear capable missile programs.[37]

US officials realized that unilateral American controls would not be enough. The United States thus initiated negotiations aimed at developing a multilateral missile control agreement with six of its closest allies: Canada, West Germany, France, Italy, Japan, and the United Kingdom. These negotiations lasted more than four years. In April 1987, the MTCR was announced by its seven founders as a voluntary accord (i.e., not a legally binding international treaty) aimed at limiting "the risks of nuclear proliferation" by controlling transfers that could contribute to the development of "nuclear weapons delivery systems other than manned aircraft."[38]

In 1993, MTCR member governments agreed to extend the regime's purview to cover missile delivery systems for chemical weapons (CW) and biological weapons (BW) in addition to nuclear weapons.[39] Currently, 25 countries have joined the MTCR as full partners; Argentina and Hungary are the latest members.[40] Two major missile suppliers, Russia and China, have

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36. Ibid.; and Robert Shuey, "Missile Proliferation: A Discussion of U.S. Objectives and Policy Options," *Congressional Research Service Report for Congress* 90-120 F, 21 February 1990, 38.

37. Hollinger, "The Missile Technology Control Regime," 25.

38. The White House, "Missile Technology Control Regime: Fact Sheet to Accompany Public Announcement," (Washington, DC: Office of the Assistant to the President for Press Relations, 16 April 1987).

39. Arms Control and Disarmament Agency, Office of Public Affairs, "Fact Sheet: The Missile Technology Control Regime (MTCR)," (Washington, DC: US Arms Control and Disarmament Agency, Office of Public Affairs, 17 May 1993), 3.

40. The other 23 members are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

agreed to abide by the MTCR guidelines, but have not joined as full partners.[41]

## How the MTCR Works

The MTCR seeks to accomplish its purpose through member adherence to an agreed set of export policy guidelines. These guidelines (see Appendix A) are applied to an extensive list of items, including complete missile systems and missile-related subsystems, components, and technologies. The items are compiled on a consensual basis; they are listed in the MTCR's "Equipment and Technology Annex." The Annex itself is divided into two sections: the first (Category I) contains complete missile systems and highly sensitive missile-related equipment; the second (Category II) lists dual-use items. The MTCR offers both general export guidance applicable to the entire Technical Annex, as well as specific guidance tailored to each of the two Annex Categories.

## General Export Guidelines

The MTCR's principal guidance directs members to assess both the intended end-use of any item in the Technical Annex, as well as an item's potential contribution to the development of missile systems for the delivery of nuclear, biological, or chemical (NBC) weapons. In this regard, member governments are directed to exercise "particular restraint" in the transfer of any Annex item or any missile (regardless of its inclusion in the Technical Annex) that the member believes, on the "basis of all available, and persuasive information," is "intended" for the delivery of NBC weapons. MTCR members should make a "strong presumption to deny such transfers."[42]

In evaluating "available" information on the recipient government's end-use intentions, MTCR member states are directed to undertake, inter alia, a general assessment relating to any concerns about NBC proliferation; an assessment of the capabilities and objectives of the recipient's missile and space programs;

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41. The USSR, in a joint statement released after the June 1990 US-Soviet summit in Washington, DC, pledged its support for the "objectives" of the MTCR. Three years later, Russian Prime Minister Viktor Chernomyrdin provided written assurances that the Kremlin would adhere to the regime's guidelines. Chinese officials pledged Beijing's adherence to the regime during November 1991 talks with US Secretary of State James Baker. China later backed up its verbal pledge with written assurances. "US and Russia Agree to Joint Space Station," *Arms Control Today* 23, no. 8 (October 1993): 22; "Secretary's Talks in China: A Summary of Results," *US Department of State Dispatch* 2, no. 47 (Washington, DC: US Department of State, Bureau of Public Affairs, 25 November 1991), 859; and The Arms Control Association, "Fact Sheet: The Missile Technology Control Regime," (Washington, DC: The Arms Control Association, May 1992).

42. Arms Control and Disarmament Agency, "Fact Sheet: The Missile Technology Control Regime (MTCR)," 3.

an evaluation of the significance of the transfers in terms of their potential to "contribute" to the development of delivery systems (other than manned aircraft) for NBC weapons; and an assessment of the transfer's end-use and assurances that the item will not be used in the development of an NBC delivery system or retransferred without explicit consent.[43]

## Category I Items: Export Guidelines

MTCR member governments have agreed that Category I items could be used as, or applied directly to the development of, missiles for NBC delivery. Hence, Category I items are, for all intents and purposes, automatically considered able to "contribute" to the development of NBC missiles. A complete listing of Category I items is contained in Appendix B; in summary form, Category I includes

- Complete rocket systems (including ballistic missile systems, space launch vehicles, and sounding rockets) and unmanned air vehicle (UAV) systems (including cruise missile systems, target drones, and reconnaissance drones) capable of delivering 500-kg payloads to ranges of 300 km or more.
- Certain major subsystems usable in rockets and UAVs meeting the 300 km-500 kg threshold—rocket stages and engines, reentry vehicles, guidance sets, thrust vector controls, and warhead mechanisms.
- Specially designed production facilities and production equipment for rockets and UAVs meeting the 300 km-500 kg threshold and their major subsystems.

The 300 km-500 kg threshold was arbitrarily established by MTCR members and reflects their definition of, and their original 1987 focus on, "nuclear capable" ballistic missiles. The 1987 range-payload threshold was supplemented with new guidance contained in the introduction to the 1993 Technical Annex. This guidance essentially clarifies the old definition of "nuclear capable" by directing MTCR members to "take account of the ability to trade off range and payload" before exporting any Annex-listed item. In other words, members should consider whether a recipient government might be able to modify finished missiles or missile components to permit development of missiles meeting the 300 km-500 kg threshold.[44]

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[43] Ibid., 4.

[44] [Department of State, Office of Politico-Military Affairs], "Missile Technology Control Regime (MTCR): Equipment and Technology Annex," ([Washington, D.C.]: [US Department of State, Office of Politico-Military Affairs], 1 July 1993), Introduction.

Because Category I items are inherently usable as, or in the development of, missiles for NBC delivery, MTCR members have agreed to make "a strong presumption to deny" Category I transfers, regardless of the recipient's "intended" end use. In the unlikely circumstance that an MTCR member government does decide to export a Category I item, it should do so only after meeting two conditions. It must first obtain from the recipient state "binding government-to-government undertakings embodying" assurances that the Category I items "will be used only for the purpose stated," and will not be modified, replicated, or retransferred without prior consent. Second, the member government must assume "responsibility for taking all steps necessary to ensure that the item is put only to its stated end use." Finally, the guidelines advise MTCR members that any system containing a Category I item will itself be considered Category I unless the item in question "cannot be separated, removed, or duplicated." And the export of Category I production facilities is flatly prohibited.[45]

## Category II Items: Export Guidelines

The dual-use items listed in Category II include a variety of subsystems, components, machinery, and technologies usable in the development of missiles and other military systems, as well as commercial systems. Specifications and other details for these items are presented in Appendix B. The major classes of these dual-use items are

- Propulsion components
- Propellants and constituents
- Propellant production technology and equipment
- Missile structural composites—production technology and equipment
- Pyrolytic deposition/densification technology and equipment
- Structural materials
- Flight instruments, inertial navigation equipment, software, and production equipment
- Flight control systems
- Avionics equipment
- Launch/ground support equipment and facilities
- Missile computers

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45. Arms Control and Disarmament Agency, "Fact Sheet: The Missile Technology Control Regime (MTCR)," 3-4.

- Analog-to-digital converters
- Test facilities and equipment
- Software and related analog or hybrid computers
- Reduced observables technology, materials, and devices
- Nuclear effects protection.[46]

In 1993 MTCR members agreed for the first time to include certain complete missile systems in Category II. Thus, Category II, Item 19, covers complete rocket or UAV systems capable of "a maximum range equal or superior to 300 kilometers."[47] According to an ACDA official, the 300 km threshold in Item 19 counts even if a missile system can carry only a "negligible" payload to that range. Moreover, Item 19 is covered by the Annex language on range-payload tradeoffs. This means that even shorter range systems such as antiship cruise missiles (ASCM) might be covered if they could be modified through payload reductions to achieve a 300-km range. Item 19 thus reflects the MTCR's expanded mandate to cover CW- and BW-capable missiles. MTCR members agreed that even missiles with relatively small payloads deserved export scrutiny as they could still deliver enough chemical or biological weapons to execute destructive attacks.[48]

According to a Department of Defense official with extensive experience in MTCR matters, at its own discretion a member government may export Category II items and associated production facilities, but only after it has made an internal, engineering-based finding that the items are not usable in a missile for NBC delivery, or in one captured by the MTCR Category I, 300 km-500 kg threshold. If, on the other hand, the internal finding is positive for either application, then the MTCR member is obligated to obtain assurances from the recipient state that the items will not be put to these end uses.[49]

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46. [Department of State, Office of Politico-Military Affairs], "Summary of the Equipment and Technology Annex," ([Washington, DC]: [US Department of State, Office of Politico-Military Affairs], n.d.).

47. [Department of State], "Missile Technology Control Regime (MTCR): Equipment and Technology Annex," Category II, Item 19.

48. Barry Schoen, Arms Control and Disarmament Agency, Office of Weapons and Technology Control, telephone interview, 21 September 1993.

49. Dr. Richard Speier, Department of Defense, Office of the Undersecretary of Defense for Policy, personal interview, 19 November 1993.

End-use assurances are, however, not required for a variety of Category II items if they are "exported as part of a manned aircraft or in quantities appropriate for replacement parts for manned aircraft." This language, or similar terminology, is applied to such UAV-relevant items as lightweight turbojet and turbofan engines, instrumentation, navigation and direction finding equipment and systems, flight control systems and technology, avionics equipment and technology (including the US Global Positioning System or similar satellite receivers), and analog and digital computers[50] (see Category II, Items 3, 9-11, and 13 in Appendix B for a full listing).

### MTCR Implementation and Enforcement

The MTCR export guidelines, both general and specific, are implemented according to national legislation. Licensing and enforcement activities therefore vary among member states. The accord does not make provision for penalizing countries that violate its guidelines, but individual members can, and do, impose sanctions on violators unilaterally. MTCR members meet at least yearly to discuss enhancements to the regime as well as intelligence information on missile projects of concern. A primary strength of the regime is member agreement that an export denial by one member state will be upheld by all.[51]

## COORDINATING COMMITTEE FOR MULTILATERAL EXPORT CONTROLS

### CoCom History and Purpose

Created at the beginning of the Cold War in 1949, CoCom was a non-treaty organization made up of NATO members (except Iceland), Japan, and Australia. Its purpose was to restrict the transfer of technologies and equipment that would enhance the military power of the USSR and the nations it dominated, the so-called East Bloc. The disintegration of the USSR and the resulting changes in East-West security relations prompted CoCom members to terminate the regime's operations on March 31, 1994. CoCom members committed themselves to negotiating a follow-on regime and, in the meantime, to maintaining controls on the most sensitive weapons and technologies restricted by

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50. [Department of State], "Missile Technology Control Regime (MTCR): Equipment and Technology Annex," Category II, Items 3, 9, 10, 11, and 13.

51. National Academy of Sciences, *Finding Common Ground: U.S. Export Controls in a Changed Global Environment* (Washington DC: National Academy Press, 1991), 71, 134-135; and Shuey, "Missile Proliferation," 14.

the CoCom. According to US officials, a CoCom replacement will be designed to meet post-Cold War arms proliferation challenges.[52]

## CoCom's Approach

CoCom's essential operating principles remained constant after its founding and all CoCom decisions were made on the basis of member consensus. On this basis, CoCom members established an extensive list of embargoed goods and a list of countries to be targeted for export restrictions. The CoCom referred to its targets as "proscribed destinations." As a Cold War regime, CoCom targets were determined essentially on East-West grounds. During and after the Cold War, the target list changed little.[53] Only Hungary was completely removed from the list of proscribed destinations. The Soviet Union was replaced by its newly-independent republics. CoCom members did decide, however, that some former East Bloc members would be treated differentially, about which more will be said later on.

## General Export Guidelines

CoCom established three lists of restricted items covering everything from machine guns to nuclear reactors. Like the MTCR, the CoCom made a distinction between inherently military and dual-use items. The CoCom lists were sporadically revised and updated during wholesale reviews conducted by CoCom members. Individual CoCom members also proposed the addition or deletion of embargoed items on an ad hoc basis.[54]

There was no established methodology for list development, but in 1978 CoCom members did establish general criteria to describe the type of items that should be included in each list. The lists are identified below along with their associated criteria.

- The International Munitions List included "materials, equipment, and technology specifically designed for and used in national military systems."

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52. "Reforming Export Controls," *US Department of State Dispatch* 5, no. 15 (Washington, DC: US Department of State, Bureau of Public Affairs, 11 April 1994), 204.

53. The list of proscribed countries included Afghanistan, Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Czech Republic, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldavia, Mongolia, North Korea, Poland, Romania, Russian Federation, Slovak Republic, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, and Vietnam.

54. Mr. Joseph Smaldone, Chief, Arms Control and Disarmament Agency Office of Weapons and Technology Control, telephone interview, 7 October 1993.

- The International Industrial List included unique dual-use items that, "if acquired, would be of significant assistance to an adversary's military capability," as well as technologies that proscribed countries were so deficient in that, in the event of war, they could not close the gap with CoCom members in a "reasonable period of time."

- The International Atomic Energy List used the Industrial List criteria.[55]

There were three levels of control for the items in each list. The majority of items in each were controlled at the "general exception" level, i.e., a complete embargo. Export approvals for general exception items were possible, but rare and required unanimous consent by CoCom members. The next level of control was "favorable consideration." Favorable consideration was granted for some items in each list for appropriate destinations and end uses. Destination and end-use conditions were detailed in the list along with technical parameters the items for export had to meet. There was a presumption of approval for favorable consideration items; such cases were presented to the CoCom membership and, if no objections were raised within roughly thirty days, the export could proceed.[56] The final level of control was "national discretion." This level was applied to items, with specified conditions, that CoCom members agreed warranted national controls, but not a collective review prior to export. As with the MTCR, licensing and enforcement activities to implement the CoCom regime were national prerogatives and thus varied among member states.[57]

## Major CoCom Reforms

The CoCom system underwent two principal reforms prior to its 1994 termination: a major decrease in the number of controlled items and adjustments in the level of controls applied to some former East Bloc nations. List revisions were driven, in part, by the global dissemination of technology and industrial capability. Newly industrializing countries produced items that were once manufactured exclusively by CoCom members. Such items were

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55. National Academy of Sciences, *Common Ground*, 65.

56. Smaldone, Arms Control and Disarmament Agency, telephone interview; and Mr. Robert Price, Director, Department of State Office of CoCom Affairs, telephone interview, 8 October 1993.

57. National Academy of Sciences, *Common Ground*, 127; and Harald Mueller, "The Export Controls Debate in the 'New' European Community," *Arms Control Today* 23, no. 2 (March 1993): 12.

decontrolled because newly industrializing countries refused to join the CoCom regime.[58]

The collapse of the Soviet Union and Warsaw Pact also contributed to list revisions. In June 1990, CoCom members responded to the "revolution of 1989" with an initiative aimed at the emerging democracies of Eastern Europe; they began a list review that led to the removal of 50 percent of the dual-use items on the Industrial List.[59] Additional list reductions occurred thereafter.

Beyond outright decontrol of CoCom-proscribed items, regime members responded to the East Bloc disintegration by treating targeted countries differentially. This treatment was implemented via the select application of the control levels outlined above; CoCom members voted to extend favorable consideration, and even national discretion, to a variety of goods bound for proscribed destinations that were "in transition to a democratic system." Beneficiaries meeting this criteria included Bulgaria, the Czech and Slovak Federal Republics, Mongolia, Poland, Romania, Estonia, Latvia, and Lithuania.[60] Differential treatment was not unprecedented. In 1985, the United States succeeded in convincing its CoCom partners to apply the favorable consideration level of control to many items bound for the People's Republic of China (PRC).

## The CoCom and UAVs

The CoCom was similar to the MTCR in its treatment of UAVs and their enabling technologies. In fact, some MTCR language describing restricted equipment was taken directly from CoCom. The CoCom maintained complete UAV systems on its Munitions List in item ML10. Munitions List items were held at the "general exception" level and were thus rarely exported to proscribed destinations. However, as with the MTCR, the CoCom authors wrote in protection for aircraft and aircraft subsystem exports. These caveats appeared in the notes to item ML10 (see the Appendix C for item ML10 and relevant notes). Essentially, the notes indicated that the listed item was not

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58. Price, Department of State, telephone interview.

59. Department of State, Bureau of Public Affairs, "Gist: U.S. Exports: Strategic Technology Controls," *U.S. Department of State Dispatch* 2, no. 30 (Washington, DC: US Department of State, Bureau of Public Affairs, 29 July 1991), 551.

60. United Kingdom Department of Transportation and Industry, *CoCom Lists and Notes, Supplement 2* (London: United Kingdom Department of Transportation and Industry, August 1993), 2.

meant to embargo "aircraft" or "aero-engines" designed or modified for military use which had been certified for civil use by the civilian aviation authorities of a member country.[61]

The Industrial List included a variety of dual-use items applicable to UAV development. Most were restricted at the "general exception" level and were accompanied by extensive technical and performance parameters. The Industrial List also embargoed the following for each item: equipment, assemblies, and components; test, inspection, and production equipment; materials and software; and technical data and assistance. An illustrative, but not exhaustive, list of major categories and key items is presented in Appendix D.

As noted, CoCom member states responded to the collapse of the East Bloc by treating certain proscribed countries differentially. This treatment applied only to items on the Industrial List, not the Munitions List. Generally, this differential treatment meant that a variety of UAV-relevant components (composite materials and laminates, digital computers, optical sensors, accelerometers and gyros, and propulsion systems) could be exported at national discretion to Poland, the Czech Republic, and the Slovak Republic; and with favorable consideration to Bulgaria, Latvia, Mongolia, and Romania.[62]

## The Future of CoCom

CoCom's future is unclear at present. Following the collapse of the East Bloc, there were calls to transform the regime to meet the security challenges of the post-Cold War era. In this regard, transatlantic discussions were initiated. According to US officials familiar with the negotiations, the former CoCom members are considering replacing the regime with a new agreement aimed primarily at filling the gaps in current nonproliferation accords. Hence, while the latter accords are currently focused on stemming the spread of NBC weapons and missiles, a CoCom replacement might attempt to control the transfer of conventional weapons, especially transfers to areas of conflict or excessive military buildups. A CoCom replacement will attempt to extend membership to formerly proscribed countries, so long as the latter implement export control policies and procedures that meet agreed standards.[63]

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61. Ibid., 64-65.

62. Ibid., 18, 20, 21-22, 43, 46, and 48-49.

63. Smaldone, Arms Control and Disarmament Agency, telephone interview.

Although discussions of a follow-on to CoCom continue, it does appear that the operations of any new regime will be less formal than those of the original. For instance, US officials believe that the new regime might operate more like the MTCR. Thus, instead of formal votes to approve the export of covered items, there might be general export guidelines accompanied by information sharing on Third World weapon programs and military buildups of concern. It is likely that some type of agreed list of embargoed items will remain. Although it is too soon to predict how UAVs might be treated under a CoCom follow-on, negotiators do not envision any follow-on overlapping with the MTCR.[64] Hence, if UAVs are covered at all, the restricted variants will likely be those falling below the MTCR thresholds. This at least raises the possibility that shorter range ASCMs might be covered.

## UN INITIATIVES

The 1991 Persian Gulf War precipitated substantial international pressure for restraints on future arms transfers to the Middle East. The fact that war had acted as a catalyst for arms control was nothing new; the major powers had proposed arms export restraints after the Arab-Israeli wars of 1948, 1967, and 1973 as well. These initiatives had failed, but 1991 brought new circumstances and was seen as a chance to start afresh. For example, Israel and several of its traditional Arab rivals had cooperated for the first time to defeat a regional aggressor, Iraq. Iraq's ability to rapidly attack Kuwait and threaten Saudi Arabia had heightened world sensitivities to the dangers of uncontrolled military buildups. And, most importantly, the Cold War was over. Hence the prospect for joint restraint by the world's largest arms exporters—the United States and the USSR—seemed better than ever.

It was in this spirit of post-Cold War cooperation that world leaders launched their latest efforts to stem the spread of conventional weaponry. These efforts centered on two initiatives: a UN proposal for "transparency" in arms exports; and an initiative by the five permanent members of UN Security Council (the United States, United Kingdom, France, the USSR, and the PRC—the so-called Permanent-5), to establish guidelines for their arms exports. The goals and status of each initiative are briefly presented below.

### The UN Transparency in Armaments Initiative

Arms control advocates have long viewed agreements promoting "openness," or "transparency," in military activities as a useful first step toward actual arms control or reduction agreements. Transparency, in this

[64] Ibid.

view, enhances mutual security by permitting military adversaries to examine one another's arsenals and military preparations, thereby allaying suspicions and preventing worst case threat assessments. In fact, proposals aimed at promoting transparency in global conventional arms exports date back to the UN's forerunner, the League of Nations.[65]

The Desert Storm experience helped the supporters of transparency and won them critical backing from the major powers and organizations, including Canada, the United States, and the European Community. As such, the negotiations for a global transparency accord accelerated and came to fruition on December 9, 1991 when the UN General Assembly passed Resolution 46/36L on "Transparency in Armaments." The resolution, initiated by the European Community and Japan, passed by a vote of 150-0; the PRC and Syria did not participate in the vote, while Iraq and Cuba abstained. It was thereafter operationalized with the creation of the "United Nations Register of Conventional Arms."

Resolution 46/36L calls on all members to submit annual data to the Register on the number of weapons imported and exported from their countries in seven categories: tanks, armored combat vehicles, large caliber artillery systems, combat aircraft, attack helicopters, warships, and missiles and missile launchers. The data from each country is compiled by the UN Secretary General and reported to the General Assembly.

The UN Register is not an arms control or arms reduction measure. Instead, the United States expressed hope that the Register would serve as a global confidence-building measure and, further, that it would foster national procedures for reviewing the potential impact of arms transfers on regional and international security.[66]

## The Permanent-5 Conventional Arms Exports Initiative

The UN discussions conducted after the Persian Gulf War were aimed at more than achieving transparency in arms sales. Some countries, most notably Canada, also pushed the Permanent-5 to adopt actual restraints on their arms exports. The Five presented a compelling target for arms control pressure.

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65. Michael T. Klare, "Gaining Control: Building a Comprehensive Arms Restraint System," *Arms Control Today* 21, no. 5 (June 1991): 10.

66. Arms Control and Disarmament Agency, Office of Public Affairs, "Fact Sheet: United States Submits its Contribution to the United Nations Register of Conventional Arms," (Washington, DC: US Arms Control and Disarmament Agency, Office of Public Affairs, 15 June 1993), 2.

Measured in dollar value, their exports of major weapon systems accounted for more than 85 percent of the global total in the 1980s.[67]

It seemed that export restraints might advance beyond the discussion stage and become a reality in May 1991 when President George Bush announced his Middle East arms control initiative. The Bush proposal covered NBC weapons, missiles, and conventional systems. Regarding NBC weapons and missiles, Bush called on all states in the Middle East to: (1) sign the 1968 Nuclear Nonproliferation Treaty and implement a "verifiable ban on the production and acquisition" of nuclear weapon materials; (2) sign the Chemical Weapon Convention (then under negotiation); (3) "adopt biological weapons confidence-building measures;" and (4) freeze their "acquisition, production, and testing" of surface-to-surface missiles, and ultimately eliminate them.[68] He also called on all suppliers to "coordinate export licensing" of missile production equipment.

As for conventional weapon transfers, Bush urged the Permanent-5 to begin immediate talks aimed at establishing guidelines for exports to the Middle East. He suggested that the guidelines commit the Permanent-5 to: (1) observe a general code of responsible arms transfers; (2) avoid "destabilizing" arms transfers; and (3) establish effective national export controls on the end use of exported arms and related equipment. The proposal concluded with suggestions for consultation and information sharing among the Permanent-5. In this regard, the countries would meet regularly to consult on arms exports, notify one another before exporting "certain" arms, consult on an ad hoc basis to discuss breaches of the export guidelines, and provide one another with annual reports on weapon sales.[69]

The Bush initiative was taken under discussion at Permanent-5 meetings in July and October 1991. For his part, French President Francois Mitterrand urged his colleagues to extend the Bush principles beyond the Middle East and apply them on a global basis. The French proposal was greeted favorably, but it was also agreed that the US emphasis on Middle East arms control should

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[67] Michael O'Hanlon, Victoria Farrell, and Steven Glazerman, "Controlling Arms Transfers to the Middle East: The Case for Supplier Limits." *Arms Control Today* 22, no. 9 (November 1992): 19.

[68] Lee Feinstein, "Bush Unveils Long-Awaited Middle Eastern Arms Control Plan," *Arms Control Today* 21, no. 5 (June 1991): 27-28.

[69] "The Bush Conventional Arms Control Plan," *Arms Control Today* 21, no. 5 (June 1991): 27.

remain.[70] This being the case, the Permanent-5 supported the Bush call for the nations of the Middle East to make their region an NBC weapon-free zone. Likewise, the Five called on the Middle Eastern states to adopt an arms control program that would include a "freeze and ultimate elimination of ground to ground missiles in the region."[71]

The Permanent-5 turned their attention more fully to global arms transfers, both conventional and unconventional, at the October meeting. With respect to conventional armaments, they ended their discussions with a pledge to "avoid" transfers of major weapon systems that, *inter alia*, would be likely to

- "Prolong or aggravate an existing armed conflict"
- "Increase tension in a region or contribute to regional instability"
- "Introduce destabilising military capabilities in a region"
- "Contravene embargoes or other relevant internationally agreed restraints to which they are parties"
- "Be used other than for the legitimate defense and security needs of the recipient state"
- "Support or encourage international terrorism"
- "Be used to interfere with the internal affairs of sovereign states."[72]

It is important to note that the Permanent-5 did not agree to any actual reductions in their arms exports, nor did they identify the types of weapons that the guidelines would cover (e.g., what types would be considered "destabilizing"). They simply agreed to "continue discussing the possibilities for lowering tension and arms levels."[73]

As for George Bush's earlier call for consultations and advance notice of conventional weapon sales, the Five agreed in principal to notification for

70. Alan Riding, "5 Powers Will Seek Ban On Major Mideast Arms," *The New York Times*, 10 July 1991, 9[A].

71. Department of State, Bureau of Public Affairs, "Statement Issued After the Meeting of the Five on Arms Transfers and Non-Proliferation," *U.S. Department of State Dispatch* 2, no. 28 (Washington, DC: US Department of State, Bureau of Public Affairs, 15 July 1991), 508.

72. United Kingdom Ministry of Defense, Foreign and Commonwealth Office, "Press Release—Meeting of the Five on Arms Transfers and Non-Proliferation: London 17/18 October 1991," (London: United Kingdom Ministry of Defense, 18 October 1991).

73. Ibid.

exports to the Middle East, but made less progress on sales to the rest of the world. Regarding the latter, they agreed instead to continue discussions on "arrangements to exchange information for the purpose of meaningful consultation" on arms transfers.[74] But once again, "meaningful consultation" was not defined. Nor could they decide whether information on exports, whether global or Middle Eastern sales, would be provided before or after the transfer.[75] On the subject of global NBC weapon and missile technology exports, they "noted the threats to peace and stability posed by" such weapons and affirmed the "importance of maintaining stringent and, in so far as is possible, harmonised guidelines for exports in this area."[76]

Additional discussions on NBC weapon and missile technology exports were to be held at follow-on meetings, but the Permanent-5 talks did not proceed as hoped. The negotiations reached an impasse when the participants attempted to clarify the general export principles released in October 1991. Disagreements, for instance, arose over the types of weapons that would be considered "destabilizing." Nor could the Five agree on which countries to target for export restraints. A final blow came in September 1992 when President Bush overrode a decade-old agreement with the PRC and approved the sale of F-16 fighter aircraft to Taiwan.[77] The PRC thereafter withdrew from the Permanent-5 negotiations, leaving them "moribund," according to Deputy Assistant Secretary of State Robert Einhorn.[78]

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74. Ibid.

75. Lee Feinstein, "'Big Five' Weapons Exporters: More Talks, More Sales," *Arms Control Today* 21, no. 9 (November 1991): 22.

76. United Kingdom Ministry of Defense, "Press Release—Meeting of the Five."

77. Barbara Opall, "Politics Influence International Fighter Decisions," *Defense News* 8 (9-15 August 1993): 8; and Jessica Mathews, "A New Security Agenda," *The Washington Post*, 4 October 1992, 7[C].

78. Quoted in Lee Feinstein, "Clinton Hears Congressional Views on Restraining Global Arms Trade," *Arms Control Today* 23, no. 7 (September 1993): 26.

CHAPTER 4

# ANALYZING THE EFFECTIVENESS OF EXPORT CONTROLS

## METHODOLOGICAL BACKGROUND

Except for the United Nations (UN) Register, the regimes described in Chapter 3 share a common feature—each aims to deny technology by imposing export controls. In each case, the Missile Technology Control Regime (MTCR), the Coordinating Committee for Multilateral Export Controls (CoCom), and the Permanent-5 talks, groups of major arms suppliers determined, by and large, that their individual and mutual security interests would be best served by preventing the spread of advanced weaponry to potential adversaries.

In 1991 the National Academy of Sciences conducted an exhaustive study of US export control policies in which they established a set of general prerequisites for the implementation of successful technology denial efforts.[79] We have adapted the Academy's prerequisites to suit the specific focus and objectives of our investigation of cruise missile proliferation. As such, the adapted prerequisites for effective controls are

- Supplier consensus that cruise missiles are sufficiently dangerous to warrant cooperative controls
- Supplier consensus regarding cruise missile-related technologies that must be controlled
- Full participation by all suppliers and potential suppliers of cruise missiles and their related enabling technologies
- Supplier consensus on a total export ban or at least the countries to be targeted for such a ban
- Supplier consensus on standards for implementation and enforcement.

## THE MISSILE TECHNOLOGY CONTROL REGIME

Chapter 3 noted that the MTCR is currently the only active regime specifically aimed at stemming the diffusion of missile systems to the Third World. The analysis that follows measures the MTCR's effectiveness against each

[79] National Academy of Sciences, *Finding Common Ground: U.S. Export Controls in a Changed Global Environment* (Washington, DC: National Academy Press, 1991), 113.

of the prerequisites outlined above as a means of assessing the regime's strengths and weaknesses, as well as its overall ability to meet the unmanned air vehicle (UAV) proliferation challenge.

## Prerequisite No. 1: Supplier Consensus on the Danger of Cruise Missile Proliferation

Modern arsenals contain any number of weapon systems that are capable of inflicting tremendous damage on military and civilian targets alike. Even so, the world community has singled out only a few for global control. Indeed, nuclear, biological and chemical (NBC) weapons alone have been subject to nonproliferation treaties with widespread adherence.

By contrast, there has been less consensus on the need to control missile delivery systems. This assertion is reflected first in the stated purpose of the MTCR.

> The purpose of these Guidelines is to limit the risks of proliferation of weapons of mass destruction (i.e., nuclear, chemical and biological weapons), by controlling transfers that could make a contribution to delivery systems (other than manned aircraft) for such weapons.[80]

In other words, MTCR members are apparently firmest in their opposition to missile technology transfers in cases were such transfers might be used in conjunction with NBC weapons. Controlling missiles is, therefore, first and foremost a means to NBC nonproliferation.

The relative lack of consensus against missile proliferation is demonstrated further by the MTCR's form versus that of agreements covering, for instance, nuclear or chemical weapons. The MTCR is a voluntary accord. This indicates that member governments sought to maintain a degree of flexibility in their export rights. The 1968 Nuclear Nonproliferation Treaty (NPT) and the 1992 Chemical Weapons Convention (CWC), on the other hand, absolutely forbid the transfer of nuclear or chemical arms.[81] And as full treaties, the NPT and CWC are binding under international law, while the MTCR is not.

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[80] Arms Control and Disarmament Agency, Office of Public Affairs, "Fact Sheet: The Missile Technology Control Regime (MTCR)," (Washington, DC: US Arms Control and Disarmament Agency, Office of Public Affairs, 17 May 1993), 3.

[81] Arms Control and Disarmament Agency, Office of Public Affairs, "Occasional Paper: Chemical Weapons Convention: A Balance Between Obligations and the Needs of States Parties," (Washington, DC: US Arms Control and Disarmament Agency, Office of Public Affairs, 5 January 1993), 2; and Arms Control and Disarmament Agency, *Arms Control and Disarmament Agreements: Texts and Histories of the Negotiations* (Washington, DC: US Arms Control and Disarmament Agency, 1990), 99.

The relative lack of consensus for controlling missiles versus chemical or nuclear arms can also be seen in the level of support for agreements covering each type of weapon. The MTCR claims 25 full adherents. By contrast, more than 130 countries have signed the NPT, and 130 signed the CWC within 48 hours of its opening for signature. Moreover, while the NPT and CWC have found widespread support among the major powers and developing countries alike, Argentina is the first Third World country to join the MTCR as a full member. And the prospects for extensive Third World support for the MTCR are not great. As a 1993 study by the US Congressional Research Service notes:

> Many of the problems of building consensus against the use and spread of nuclear, chemical, and biological weapons are amplified with missiles. Numerous countries are seeking to develop computer, navigation, space and other technologies that could be used for designing and developing missiles. Supplier controls on such dual-use goods are often perceived as discriminatory, and the distinction between military missile-related technology and a wide range of civilian uses can be exceedingly hard to define. . . . *The consensus against the spread of missiles and missile technology is not likely to be widely shared among many developing countries* (emphasis added).[82]

While it is apparent that the consensus against missile proliferation in general has yet to become firmly established, it is more important for our purposes to note that even among MTCR members the consensus for restricting ballistic missiles is stronger than that for restricting cruise missiles or UAVs. This assertion is supported by the export activities of MTCR member governments. Key members have demonstrated a greater willingness to export cruise missiles and other UAVs than ballistic missiles. For instance, the United States has largely restricted its ballistic missile sales to NATO allies. The only transfers to the Third World have been 37-km range *Honest Johns* to Taiwan and South Korea, and 130-km *Lance* ballistic missiles to Israel; no US transfers have been made since the mid-1970s.[83] By contrast, the United States has sold its turbojet-powered, 120-km range *Harpoon* antiship cruise missile (ASCM) to a

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82. Zachary S. Davis, "Nonproliferation Regimes: Policies to Control the Spread of Nuclear, Chemical, and Biological Weapons and Missiles," *Congressional Research Service Report for Congress* 93-237 ENR, 18 February 1993, 60.

83. W. Seth Carus, *Ballistic Missiles in the Third World: Threat and Response* (Westport, Connecticut: Praeger Publishers, 1990), 16-17; and The International Institute for Strategic Studies, *Strategic Survey* 1988-1989 (London: Brassey's, 1989), 15.

dozen Third World customers.[84] Moreover, the United States has sold reconnaissance drones worldwide, including the advanced *Scarab* model to Egypt. The turbojet-powered *Scarab* is depicted in Figure 4.1. It employs an inertial navigation system (INS) and Global Positioning System (GPS) updates for high accuracy, and can carry a payload of about 130 kg to a maximum range of over 2,500 km.[85] It is hard to imagine the United States exporting a ballistic missile system of similar range and payload to the Third World.

France is reported to have sold ballistic missiles to just one Third World customer;[86] Britain and Italy have not transferred any. Yet, France has sold variants of its solid propellant *Exocet* ASCM, with ranges between 40-70 km, as well as its 90-km range *Armat* ASCM, to a combined total of nearly thirty developing countries. Britain has sold its turbojet-powered, 110-km range *Sea Eagle* ASCM to at least three Third World nations. Italy has widely exported its *Mirach* family of remotely piloted vehicles (RPV), some of which provide the foundation for longer range, land-attack cruise missiles. The turbojet-powered *Mirach 100*, which is capable of carrying a 70-kg payload to a range of 900 km, has been exported to countries such as Iraq, Libya, and Argentina. Italy has also transferred two versions of its *Otomat* ASCM, developed jointly with France, to a combined total of eight Third World countries. Five of these *Otomat* customers purchased the *Otomat Mk 2*, a turbojet-powered platform capable of carrying a 210-kg warhead to a range of 180 km.[87]Appendix E contains additional data on the world aerodynamic missile export market.

To be sure, the US and allied ASCM and RPV exports cited above are systems of relatively short range and/or low payload. As such, the transfers

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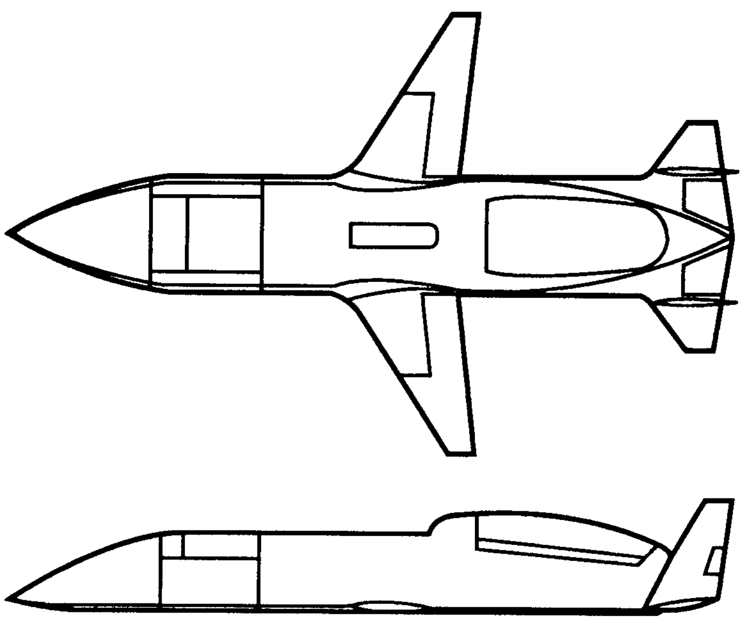
84. System Planning Corporation, *Ballistic Missile Proliferation: An Emerging Threat 1992* (Arlington, Virginia: System Planning Corporation, 1992), 83.

85. Bruce A. Smith, "New Vehicles Mark Teledyne Ryan's Strong Return to RPV Business," *Aviation Week & Space Technology* 127, no. 22 (30 November 1987): 53; "Teledyne Ryan Proposes Model 324 for Navy Midrange RPV Requirement," *Aviation Week & Space Technology* 128, no. 14 (4 April 1988): 19; Ian Harbison, ed., *Unmanned Vehicles Handbook 1993-1994* (Buckinghamshire, England: The Shepard Press Ltd., 1993), 36; and W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, Connecticut: Praeger Publishers, 1992), 92.

86. France reportedly transferred MD-660 ballistic missiles to Israel in 1968. The MD-660s are said to be the basis for Israel's 500-km range *Jericho I* ballistic missiles. Carus, *Ballistic Missiles in the Third World*, 17; and International Institute for Strategic Studies, *Strategic Survey 1988-1989*, 17.

87. System Planning Corporation, *Ballistic Missile Proliferation*, 86-88; Jeffrey M. Lenorovitz, "Italian RPV Wins $16-Million Bid for NATO Missile Range Service," *Aviation Week & Space Technology* 126, no. 8 (23 February 1987): 52; and "French Continue Conservative Pace of Development Programs," *Aviation Week & Space Technology* 124, no. 17 (28 April 1986): 115.

**Figure 4.1. Teledyne Ryan Model 324 "Scarab"RPV**
**Source: Teledyne Ryan Aeronautical, San Diego**



| | |
|---|---|
| Length | 6.14 meters |
| Wingspan | 3.35 meters |
| Height | 61 centimeters |
| Max Gross Weight | 1068 kilograms |
| Speed (Max) | Mach 0.8+ |
| Cruise Range | 2250 kilometers |
| Service Ceiling | 13,000 meters |
| Engine | Teledyne CAE Model 373-8C Turbojet |

were permitted under the MTCR guidelines. However, ASCM and RPV exports are not to be dismissed. Components from ASCMs can be used in longer range platforms. For example, the long-range *Scarab* is powered by a modified *Harpoon* engine.[88] Analysts have warned that Third World states might try to follow the US and Soviet examples and convert some ASCMs into land-attack variants.[89] South Africa, for instance, reportedly in the late 1980s, took an important step in this direction by upgrading an Israeli-designed ASCM with the addition of a gas-turbine engine.[90]

RPV conversions are also possible. According to Indian officials, their country's first cruise missile will be derived from India's new *Lakshya* target drone. At just $639,000 per unit, the *Lakshya* can carry a 200-kg payload to a range of nearly 500 km.[91] Similarly, in the late 1980s, Argentina reportedly converted a *Mirach 100* RPV into a 900-km range, multi-role platform that is believed to be capable of performing land-attack missions. During the same period, Iraq displayed what it claimed was a land-attack cruise missile that experts believed could achieve about a 500-km range. This Iraqi system, the *Ababil*, was apparently based on Italy's design for the *Mirach 600* RPV.[92] Interestingly enough, it appears that under the terms of the UN cease-fire arrangement that ended the 1991 Gulf War, Iraq's *Ababil* program was ambiguously dealt with, whereas its ballistic missile programs were clearly proscribed.[93]

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88. Smith, "New Vehicles," 53.

89. Carus, *Cruise Missile Proliferation*, 37, 39; and Eric H. Arnett, "A Bomb is Not A Dog: Autonomy and Long-Range Conventional Cruise Missiles," (Washington, DC: American Association for the Advancement of Science, n.d.), 20.

90. Carus, *Cruise Missile Proliferation*, 36.

91. "India is Ready to Put its Unmanned Target Aircraft Into Production," *BMD Monitor* 9 (22 April 1994): 146.

92. Carus, *Cruise Missile Proliferation*, 72-73.

93. UN Security Council Resolution 687 ended operation Desert Storm and demanded that Iraq destroy, and never again produce, NBC weapons and/or related technologies, equipment, facilities, etc. However, with respect to missiles, the relevant language, contained in paragraph eight, read as follows:

> Iraq shall unconditionally accept the destruction, removal, or rendering harmless, under international supervision, of: . . . All *ballistic* missiles with a range greater than 150 kilometers and related major parts, and repair and production facilities (emphasis added).

There is also evidence that some MTCR members may be willing to export more sophisticated UAV systems to the Third World in the future. Italy is marketing a new turbojet-powered version of its *Skyshark* land-attack missile. The upgraded 200-km range *Skyshark* will incorporate a faceted shape to lower its radar cross section.[94] The French are believed to be working on a faster, stealthier version of their *Exocet* for the export market and are promoting their *Apache* land-attack cruise missile. The *Apache*, which is scheduled for deployment around 1996, will achieve high accuracy through the use of a millimeter wave radar for terrain following (with a GPS option for satellite navigational updates) and possible terminal target detection. The *Apache*'s survivability potential will be greatly enhanced by virtue of its stealth characteristics and low-level flight capability. French industry executives at the 1993 Paris Air Show claimed that the system, which they said could carry a 400- to 500-kg payload to a range of 150 km, would not be restricted under the MTCR guidelines.[95]

There are reasons for the relative nonproliferation emphasis on ballistic over UAV systems. Nations have condemned missile attacks on cities. But it is the ballistic missile, not the cruise missile, that has become notorious in recent warfare for its use in killing and terrorizing noncombatants. By contrast, UAVs have not seen large-scale use as terror weapons since Germany's use of

[Continued]

It is thus apparent that Resolution 687 does not restrict Iraqi cruise missiles. The UN plan developed to monitor Iraqi compliance with 687 calls for monitoring Iraqi production of a variety of major UAV subsystems, but it appears to restrict the development of such components only if they are applied to the acquisition of ballistic missiles with ranges greater than 150 km, as opposed to UAVs of similar capability. In off-the-record interviews conducted by the authors, US Department of Defense officials differed on whether UN Security Council actions had indeed proscribed Iraq's cruise missile program. United Nations, Security Council, *Resolution 687 (1991)*, S/RES/687 (1991), 8 April 1991, 5; and United Nations, Security Council, *Plan for Future Ongoing Monitoring and Verification of Iraq's Compliance With Relevant Parts of Section C of Security Council Resolution 687 (1991)*, S/22871, 1 August 1991, 11-12, 26-27.

94. "Europeans Target Pacific Rim as Key Market for This Decade," *Aviation Week & Space Technology* 136, no. 8 (24 February 1992): 101.

95. "Cruise Missiles Becoming Top Proliferation Threat," *Aviation Week & Space Technology* 138, no. 5 (1 February 1993): 26; "Cruise Into the Future," *Jane's Defense Weekly* 17 (20 June 1992): 1081; Carus, *Cruise Missile Proliferation*, 114; and Carol Reed, "Matra Plans New Cruise Missile," *Jane's Defense Weekly* 15 (29 June 1991): 1168. The technical press, as cited, reports that the *Apache* will have a payload of 780 kg and a range of 150 km. However, French industry officials at the Paris Air Show indicated that the *Apache* would only carry a payload of between 400 and 500 kg, suggesting that the *Apache* would clearly not be captured by the MTCR's Category I provision. French industry claims concerning *Apache*'s performance characteristics and their implications for the MTCR are based on personal interviews at the 1993 Paris Air Show.

the V-1 cruise missile against England during World War II. Moreover, UAVs perform a variety of military functions. Antiship variants, for instance, can be employed in the defense of a country's territorial waters. Target drones are used to train soldiers and airmen in military forces worldwide. And the use of RPVs for battlefield reconnaissance is increasingly seen as a vital role for these machines.

Desert Storm showed that Third World armed forces might employ ballistic missiles, even relatively unsophisticated models, to disrupt the military operations of a superior attacking force. Iraq's ballistic missile strikes on Israel and Saudi Arabia forced the diversion of UN coalition air power and other assets to the "*Scud* hunt," thereby delaying commencement of the coalition ground offensive.[96] Iraqi ASCMs, on the other hand, had very little impact. Iraq managed to fire a single ASCM at a US battleship, but it was shot down by the British Navy.[97] Thus, ballistic missiles have gained recent notoriety not shared by UAVs. This may account in part for the relatively greater scrutiny that MTCR members have given ballistic missile transfers compared to UAV exports.

But the most important reason accounting for the differential treatment of ballistic and UAV systems likely stems from the pace of the evolving threat posed by each weapon. Any of the numerous surveys of Third World missile programs clearly reveals that the ballistic missile threat has outstripped that osed by cruise missile systems. At least 19 Third World countries have developed, or otherwise acquired, ballistic missiles of relatively long range.[98] Iraq's 600-km range *Al Hussein*, North Korea's 1,000-km *Nodong*, and Israel's 1,500-km *Jericho II* are but a few of the ballistic missile systems that have been deployed or tested in the last decade. No Third World country is reported to have acquired a land-attack cruise missile of comparable range. In fact, Third World aerodynamic missile arsenals remain almost exclusively composed of the relatively short-range ASCM variants.

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96. H. Norman Schwarzkopf with Peter Petre, *It Doesn't Take a Hero* (New York: Bantam Books, 1992), 421; Lawrence Freedman and Efraim Karsh, *The Gulf Conflict 1990-1991: Diplomacy and the New World Order* (Princeton: Princeton University Press, 1993), 309; and Michael Hedges and Rowan Scarborough, "Despite Sorties, Scuds Remain," *The Washington Times*, 22 January 1991.

97. Clifford Beal, "Anti-Ship Missile Technology: Leaving Well Enough Alone?" *International Defense Review* 25 (October 1992): 964.

98. System Planning Corporation, *Ballistic Missile Proliferation*, 12; and International Institute for Strategic Studies, *Strategic Survey 1988-1989*, 14-19.

As we discussed in Chapter 2, what compels concern about cruise missile proliferation is the recent and growing availability of cheap yet highly effective and accurate navigation and guidance technology. Prior to the advent of GPS, Third World countries had little incentive to develop or acquire relatively inaccurate land-attack cruise missiles, particularly given the comparably easy availability of ballistic missiles on the export market. The commercial market has recently begun to offer highly accurate inertial navigation systems, as well as technologies that can enhance INS accuracy, such as GPS receivers and digital mapping technologies. Essentially, this means that while cruise missile builders might have had to settle for systems missing their targets by a kilometer or more over long ranges, today it is possible to adapt and integrate commercial guidance technologies that will navigate a long-range cruise missile to within at least 100 m of its target, and possibly to within a few meters with differential GPS.[99] Beyond lethality enhancements, emerging guidance technologies also lower the Third World cruise missile builder's costs. According to one estimate, satellite navigation systems in particular could lower the price of simple, low-flying cruise missiles with ranges of more than 1,000 km to less than $250,000 a copy.[100]

Third World UAV builders are already exploiting these new technological opportunities. Israel has equipped its *Delilah* UAV with a GPS package and is working on a new GPS-INS package. Israel has agreed to export this system to Chile. South Africa is working on a GPS unit for airborne military systems. Egypt operates a mini-RPV that employs a GPS package supplied by the United States. India is reported to be developing a terrain comparison system for use in ballistic missiles and a GPS-type system for use in the country's first cruise missile.[101] Unconfirmed reports in the US media state further that Iraq, Iran, North Korea, Pakistan, Indonesia, and Taiwan are also interested in developing GPS-guided cruise missiles.[102] Appendix E contains additional data on Third World aerodynamic missile programs.

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99. Carus, *Cruise Missile Proliferation*, 49-69.

100. Steve Fetter, "Ballistic Missiles and Weapons of Mass Destruction: What is the Threat? What Should be Done?" *International Security* 16, no. 1 (Summer 1991): 11.

101. Carus, *Cruise Missile Proliferation*, 55, 65-66; and George Leopold and Vivek Raghuvanshi, "India Steps Up Cruise Missile Efforts," *Defense News* 8 (2-8 August 1993): 28.

102. John J. Fialka, "Poor Man's Cruise: Airliners Can Exploit U.S. Guidance System, But So Can Enemies," *The Wall Street Journal*, 26 August 1993, 1[A].

It remains to be seen whether or not the appearance of longer range cruise missiles in the Third World, especially land-attack variants, will prompt MTCR members to adopt a more balanced approach in their scrutiny of ballistic missile and UAV technology exports.

## Prerequisite No. 2: Supplier Consensus on Cruise Missile Technologies to Control

In the development of any technology denial regime, reaching a consensus on items to be restricted usually constitutes one of the most difficult parts of the process. The MTCR was no exception. Significantly, its authors found that delineating UAV-related items for control was a more challenging exercise than that posed in identifying ballistic missile technologies to restrict.[103] Nonetheless, a consensus was reached; it is most evident in the MTCR members' decision to make a "presumption to deny" the export of certain missile systems and technologies.

This language constitutes the essential export guidance for NBC missiles and Category I systems. Regarding the former, the general guidance applied to all items in the MTCR Technical Annex now states that there will be a "presumption to deny" the transfer of any item an MTCR member believes is "intended" for use as or in an NBC delivery system, range and payload thresholds notwithstanding. This new language should restrict the export of UAVs falling below the Category I, 300 km-500 kg threshold, but only as long as the MTCR member government determines, first, that a recipient state is in the process of acquiring NBC weapons and second, that the exported UAV or component will actually be used for NBC delivery. It may be difficult to find "persuasive" evidence to meet both these conditions,[104] and it thus remains to be seen what impact the new language will have.

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[103] Frederick J. Hollinger, "The Missile Technology Control Regime: A Major New Arms Control Achievement," in US Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers 1987* (Washington, DC: US Government Printing Office, 1988), 26.

[104] Although it may be logical to assume that missile technology exports should be denied to any country believed to be engaged in an NBC weapon program, regardless of end-use intentions vis-a-vis the technology, recent history demonstrates that this assumption is not valid. France, for instance, was willing to transfer advanced rocket technologies to India and Brazil in the late 1980s despite New Delhi's well-known nuclear weapon program and strong suspicions that Brazil was conducting one as well. For its part, the United States has transferred missile technologies to Israel despite the latter's possession of a nuclear arsenal. A number of transfers involved technologies for Israel's *Arrow* anti-tactical ballistic missile. These have included missile propellants, computers, accelerometers, and composite materials. A 1993 investigation by the US General Accounting Office found that despite proliferation concerns arising from the technology transfers, the United States had no effective means in place to monitor Israeli compliance with the end-use guarantees it made to obtain the *Arrow* technologies. David B. Ottaway, "U.S. to Bar India's Buying Missile Device: Sale of French Data to Brazil Opposed," *The Washington Post*, 17 July 1989; Sidney Graybeal and Patricia McFate, "Space Vehicles Pose Ballistic Threat," *Defense News* 7 (18-24 May 1992): 31; and General Accounting Office, *U.S.-Israel Arrow/Aces Program: Cost, Technical, Proliferation, and Management Concerns* GAO/NSIAD-93-254 (Washington, DC: US General Accounting Office, August 1993): 8-9.

Given the potential difficulty in discerning a recipient state's end-use intentions, it seems certain that the MTCR's restrictive presumption of denial guidance will be more readily invoked to control exports of Category I items, i.e., complete missiles capable of carrying 500-kg payloads to ranges of at least 300 km, as well as certain major subsystems for such missiles. The 300 km-500 kg threshold was chosen in the mid-1980s for its ability to control nuclear missiles without restricting the continued export of shorter range, conventionally-armed missiles, ASCMs, reconnaissance drones, and other widely-used military hardware. But the threshold, however justified, creates some difficulties in enforcing the MTCR's coverage of cruise missiles.

To begin with, the Category I threshold can be difficult to apply to UAVs, which can be deceiving when it comes to estimating their true payload capability. For instance, in judging a reconnaissance RPV's payload, an MTCR government licensing authority would have to decide whether to count the system's recovery package or on-board equipment supporting its reconnaissance gear. Off-loading such equipment would enable a recipient government to convert the RPV to a cruise missile with longer range or greater payload. Any licensing authority unaware of such RPV characteristics would risk approving the export of a platform that, upon closer scrutiny, might be seen to meet the Category I threshold.

Vigilance and informed judgment is thus essential for identifying some UAV systems as Category I items. But even with proper identification, there remains a more formidable challenge to the MTCR's ability to restrict air breathers. To wit: the technology necessary to produce a 1,000-km range cruise missile differs little from that needed to produce one with a nominal range of only 150 km.[105] Hence, technologies falling clearly below the Category I range-payload threshold can nonetheless contribute to the development of longer range cruise missiles. Moreover, from an engineering standpoint, it is relatively easier to "scale-up" the range of an existing cruise missile system than a ballistic missile. A proliferator might, for instance, lengthen the airframe of a shorter range cruise missile and add fuel to increase the system's range.[106] For the cruise missile builder, a modification of this type would be a

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105. Carus, *Cruise Missile Proliferation*, 93.

106. According to a brochure from the McDonnell Douglas Missile Systems Company, the *Harpoon's* 120-km range has been doubled via a straightforward modification. McDonnell Douglas extended the missile's sustainer section by 23.2 inches, added fuel and a battery with increased capacity, and moved the wings forward on the airframe to "maintain maneuverability and flying characteristics." The company is marketing "retrofit" kits to convert existing *Harpoon* Block 1C models into the longer range Block 1D variants. Modifications to the *Harpoon's* land-attack derivative, the *SLAM*, also demonstrate how shorter range cruise missiles form the basis for longer range systems. In this regard, McDonnell Douglas replaced the *SLAM's* cruciform wings (which had been optimized for the *Harpoon's* sea-skimming mode) with planar wings. The modification

fairly straightforward undertaking. In contrast, a similar effort would confront a ballistic missile builder with qualitatively new aerodynamic phenomena. To cite one example, a reentry vehicle designed for a shorter range ballistic missile would be subjected to higher temperatures and stresses at longer ranges. Hence, it might simply burn up on reentry. Range increases alone would confront the cruise missile builder with no comparable hurdles.

So despite the apparent MTCR member consensus on the type of missiles and missile technologies that require the most stringent controls, there appears to be a relatively greater risk, as compared with ballistic missiles, that complete UAV systems or technologies usable to develop longer range cruise missiles will be exported. In some cases, UAVs might be mistakenly judged to fall below the Category I threshold. They might thus be exported without the "binding government-to-government" assurances and other safety measures that the guidelines demand in the exceptional cases where Category I exports are permitted at all. Such risks are inherent in, and to a certain extent unique to, UAVs. Proper MTCR enforcement should, however, at least ensure that UAV items falling just below the Category I threshold are scrutinized in accordance with the regime's less strenuous Category II export guidelines.

In Category II, to reiterate, MTCR members have identified a host of dual-use subsystems and enabling technologies, as well as design and test equipment, that could be applied to UAV development. In 1993, the members agreed to add Item 19, which states that any complete UAV system capable of traveling 300 km or more, regardless of payload, will be subject to Category II restrictions. Hence, UAVs meeting this range threshold should only be exported if the MTCR member government determines, or otherwise receives assurances, that they will not be used to support the development of missiles capable of NBC delivery, or missiles capable of delivering 500-kg payloads to ranges of 300 km or more.

The new Item 19 language is significant because it requires MTCR governments to scrutinize certain exports more thoroughly, e.g., shorter range land-attack cruise missiles, as well as ASCMs, and other UAVs that might be converted to land-attack variants. For example, it seems clear that France's new *Apache* cruise missile could be modified to fly at least 300 km. This being the case, prior to exporting the weapon, the French government would

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permitted a near doubling of the *SLAM's* high altitude range to about 185 km. McDonnell Douglas Missile Systems Company, "*Harpoon* Block 1D," Marketing brochure, n.d., McDonnell Douglas, St. Louis, Missouri; and Stanley W. Kandebo, "Upgraded SLAM to Complement TSSAM," *Aviation Week & Space Technology* 140, no. 12 (21 March 1994): 53.

have to make a determination or obtain guarantees from the recipient state that the *Apache* would not be used to support the development of a missile for NBC delivery, or one exceeding the Category I, 300 km-500 kg threshold. These conditions could be violated if the *Apache* itself were modified or its components, e.g., its GPS-INS unit, were put to use in a more capable missile.

Similarly, the United States would have to make the required end-use determinations to permit future exports of its *Scarab* reconnaissance drone. The *Scarab* can clearly carry a "negligible" payload to a range well beyond 300 km.

Finally, the regime contains new language in the introduction to the Technical Annex urging members to "take account" of the ability to trade off range for payload before transferring any Category I or II items. With this addition, the MTCR member governments have been put on notice that complete missile systems are restricted even if they can only meet the MTCR thresholds through modifications. Although this is not an entirely new MTCR axiom, it does strengthen a provision that is highly relevant to UAVs as it is well known that payload and fuel modifications can be undertaken to significantly increase the range of UAV systems.

The new MTCR language contained in the regime's guidelines and Technical Annex should prompt enhanced member scrutiny of a wider range of UAV technology exports. This enhanced scrutiny might be thought of as a "safety net." By forcing an assessment of NBC missile intentions and range-payload tradeoff issues, it will capture some UAV systems and technologies that are not clearly eligible for Category I restrictions. It will force a closer examination of Category II items for the same reasons. However, the safety net applies to missile end uses only. It is weakened by the MTCR's continued exemption of critical subsystems and enabling technologies useful in UAV systems if they are exported to support manned aircraft programs.

The MTCR is not intended to restrict manned aircraft exports. Nevertheless, from the standpoint of UAV proliferation, this exemption clause creates significant loopholes for potential cruise missile proliferators. The relationship between manned aircraft and UAVs is strong. In fact, the structures, propulsion systems, autopilots, and navigation systems used in manned aircraft are essentially interchangeable with those of cruise missiles and other UAV variants.[107] So too, therefore, are the production facilities and equipment for

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[107] Hollinger, "The Missile Technology Control Regime," 26; and Carus, *Cruise Missile Proliferation*, 90-94.

UAVs and manned systems. The MTCR does restrict "specially designed" UAV production facilities, but the term "specially designed" is given a specific definition in the MTCR Technical Annex:

> "Specially Designed" describes equipment, parts, components or software which, as a result of "development," have unique properties that distinguish them for certain predetermined purposes. For example, a piece of equipment that is "specially designed" for use in a missile will only be considered so if it has *no other function or use*. Similarly, a piece of manufacturing equipment that is "specially designed" to produce a certain type of component will only be considered such *if it is not capable of producing other types of components* (emphasis added).[108]

There are in fact few production facilities that can be defined as "specially designed" for cruise missiles. These facilities, like UAV-related technologies and equipment, can be employed, and thus exported, for manned aircraft production.

As a purely voluntary accord, judgments regarding an importer's true end-use intentions,[109] i.e., cruise missiles or manned aircraft, are left to the discretion of the exporting MTCR member government. Some member governments have been more willing than others to accept an importer's word on end-use intentions.[110] But even governments firmly committed to stemming cruise missile proliferation might inadvertently assist a proliferator. This is because cruise missile testing, one of the only sure intelligence indicators that such a project is underway, can be conducted under the auspices of an acceptable manned aircraft or RPV program. Key cruise missile subsystems (e.g., guidance, flight controls, airframes, propulsion systems, etc.) can be tested and proven in this manner without raising international suspicion. The proliferator's true intentions might not become apparent until a cruise missile prototype was fielded and put through its paces in end-to-end tests.

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108. [Department of State, Office of Politico-Military Affairs], "Missile Technology Control Regime (MTCR): Equipment and Technology Annex," ([Washington, DC]: [US Department of State, Office of Politico-Military Affairs], 1 July 1993), Terminology.

109. It is also important to note that a government's stated end-use intentions, even if genuine and legitimate, may not remain so if that government perceives a change in its security environment, or is replaced by new leadership that sees a requirement for cruise missile development. End-use commitments may therefore be transitory. Cruise missile production capabilities, however, remain once the necessary infrastructure is in place.

110. National Academy of Sciences, *Common Ground*, 134; and David Silverberg, "MTCR More Likely to Lure Soviet Union Than China," *Defense News* 4 (4 September 1989): 31, 34.

The aircraft exemption clause is of little value to proliferators attempting to clandestinely produce ballistic missiles. Field testing of major ballistic missile subsystems, e.g., static firing of rocket motors, suborbital test launches, etc., is susceptible to detection. A ballistic missile proliferator might try to develop a new system under the auspices of producing a space launch vehicle (SLV) for research, or launching commercial satellites, etc. The MTCR is not intended to impede national space programs. As consistent US efforts to derail India's SLV program have demonstrated, however, SLV programs, because they are directly applicable to long-range ballistic missile development, can generate a storm of controversy and even sanctions. Military and commercial manned aircraft programs will generate no similar response. In fact, the industrial powers will often compete fiercely to assist manned aircraft efforts.

Clearly, the MTCR would have to clamp down on the export of aircraft-related technologies to significantly impede the spread of cruise missile production capabilities. But such restrictions appear no more realistic now than when the MTCR was developed in the mid-1980s. Aircraft are widely regarded as legitimate conventional weapons. Commercial and military aircraft exports generate billions of dollars in revenues and hundreds of thousands of jobs for their producers.[111]

If anything, it appears that the global competition to export aircraft and UAVs, their related technologies, and production facilities is increasing. The major powers are expected to begin selling off their Cold War arsenals of military aircraft.[112] They are becoming increasingly dependent on manned aircraft exports to preserve their defense-industrial bases as domestic military budgets decline in the post-Cold War era.[113] Industry analysts predict that the European market alone for UAVs will be upwards of $2 billion in the next decade, while the global market for jet trainers, not counting US purchases, could be twice that figure. In addition, air forces worldwide are expected to

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111. In 1989, for example, the US commercial aircraft industry alone employed more than 300,000 people and generated nearly $25 billion in export revenues. National Academy of Sciences, *Common Ground*, 225.

112. Barbara Opall, "Upgrade Work Could Top New Sales," *Defense News* 8 (9-15 August 1993): 16.

113. Barbara Opall, "Politics Influence International Fighter Decisions." *Defense News* 8 (9-15 August 1993): 8; Giovanni de Briganti, "Government Holds Key to Export Push," *Defense News* 8 (27 September-3 October 1993): 16; Konstantin Sorokin, "Russia's 'New Look' Arms Sales Strategy," *Arms Control Today* 23, no. 8 (October 1993): 9; and Congress, Office of Technology Assessment, *Global Arms Trade: Commerce in Advanced Military Technology and Weapons* OTA-ISC-460 (Washington, DC: US Government Printing Office, June 1991), 21, 48.

begin a rash of fighter upgrades; this will lead to a major trade in aircraft engines, advanced electronics, radar and other aerospace subsystems.[114] The Russians are expecting about $10 billion in annual sales of spare parts and maintenance services for Soviet-designed aircraft.[115] The upgrade market in particular presents a special challenge to current nonproliferation regimes. As Columbia University's Stephanie Neuman writes, many states are currently choosing to enhance the capabilities of existing weapon systems instead of buying new ones. As such:

> Today the major trade is in components, spare parts, technical assistance, and production technologies. Many of these items are shipped in crates and containers, making verification problematic, subterfuge possible, and regulation more difficult.[116]

Aircraft production capabilities are also spreading. The industry was globalized by the 1980s,[117] and developing countries have increasingly been taking advantage of the "buyers market" in aerospace to demand offsets with their purchases that will provide them with indigenous aircraft maintenance, and even production, capabilities.[118] The willingness of former East Bloc

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114. Alessandro Politi, "Italian Firm Looks to Widen Niche," *Defense News* 8 (16-22 August 1993): 20; Robert Holzer, "JPATS Rivals Target World Market for Trainers," *Defense News* 8 (9-15 August 1993): 9; and Opall, "Upgrade Work," 16.

115. Sorokin, "Russia's 'New Look,'" 10.

116. Stephanie G. Neuman, "Controlling the Arms Trade: Idealistic Dream or Realpolitik?" *The Washington Quarterly* 16, no. 3 (Summer 1993): 64.

117. According to the National Academy of Sciences, figures on foreign aircraft maintenance capabilities provide a "useful indicator" of the dissemination of aircraft technical expertise. In this regard, figures for non-communist countries alone indicated that 220 aircraft maintenance facilities existed outside the United States by the late 1980s. Moreover, 20 developing countries in the non-communist world were capable of performing "heavy maintenance," i.e., the capability to tear down an aircraft and completely rebuild it. The Academy further demonstrated the dissemination of expertise by examining suppliers of aircraft subsystems, equipment and components. It cited Seattle-based Boeing Aircraft as one example. Boeing buys parts for the commercial planes it builds from 3,800 firms in 33 countries. The Academy concluded that the globalization of the aircraft industry had "negative implications for control by any single nation of the export of production technology." National Academy of Sciences, *Common Ground*, 226-227, 247.

118. This trend is not new and was demonstrated again in 1993 with the US sale of F/A-18 fighters to Malaysia. As part of the deal, the Malaysian government required the fighter's manufacturer, McDonnell Douglas Corp., to sign a long-term technical cooperation agreement that would enable Malaysia to develop an indigenous aerospace industry by 2020. Barbara Opall, "McDonnell Forms Malaysian Pact," *Defense News* 8 (16-22 August 1993): 1, 29; National Academy of Sciences, *Common Ground*, 240; Opall, "Politics Influence," 8; and Office of Technology Assessment, *Global Arms Trade*, 52.

aircraft producers to undercut the prices of their Western competitors, and in some cases to accept goods for their aircraft (and perhaps for advanced cruise missiles as well), will likely further accelerate the diffusion of cruise-missile related production capabilities.[119]

The MTCR member governments' establishment of a list of UAV technologies that should be restricted is a significant accomplishment. Even so, compared to ballistic missiles, it is apparent that technologies applicable to the development of long-range cruise missiles are more likely to be exported. This is primarily because UAV technologies usable in long-range systems might nonetheless fall below the MTCR Category I threshold or be exported to support manned aircraft programs. Hence, in either case, the technologies can escape the MTCR's most restrictive export controls.

## Prerequisite No. 3: Full Participation by All Suppliers and Potential Suppliers

Technology denial regimes usually find this third condition for success the most difficult of all to meet. With respect to cruise missiles, the challenge may be particularly daunting. As the preceding discussion has pointed out, to gain the adherence of all current and potential cruise missile suppliers and suppliers of the relevant enabling technologies would require full participation by a significant segment of the global aircraft industry. The latter proposition does not appear achievable in the foreseeable future. In fact, even convincing key UAV producers to abide by the MTCR has proven difficult.

Russia is not a full MTCR partner, but the Kremlin has committed itself to abide by the MTCR guidelines. Nevertheless, Russia is marketing several cruise missile systems at arms shows around the globe. Among the more worrisome systems is a conventionally armed version of the air-launched AS-15 cruise missile. Russia's Raduga Machine Building Design Bureau displayed the system, dubbed the Kh-65SE, at the 1993 "IDEX" defense exhibition in Abu Dhabi. Raduga officials claimed that the Kh-65SE had a maximum range of just 280 km, conveniently below the MTCR's Category I range threshold.[120] A year earlier, another apparent AS-15 derivative, dubbed "airborne tactical missile," was displayed in paper form at Moscow's 1992 Air

[119] William Branigin, "US, Russia in Race to Sell Arms in Asia," *The Washington Post*, 31 July 1993, 17[A]; and Daniel Sneider, "Russians Eye New Markets After Malaysia," *Defense News* 8 (9-15 August 1993): 16.

[120] Paul Beaver, "Air-to-Air Missile Has 400 km Range," *Jane's Defense Weekly* 19 (27 February 1993): 7; and Robert S. Norris and William M. Arkin, "Nuclear Notebook," *The Bulletin of the Atomic Scientists* 49, no. 1 (January/February 1993): 56.

Show. Its maximum range was advertised as 500 to 600 km, its payload 410 kg (cluster or penetrating conventional warhead), and its guidance accuracy 18 to 26 m, achieved using a combined "terrain corrected and space navigation system."[121]

Russia has also offered the AS-16 and the SS-N-22 for sale, as well as an advanced, experimental cruise missile, the so-called ASM-MSS. The AS-16 is a rocket-powered, land-attack missile (comparable to the US Air Force SRAM) employing a millimeter-wave active radar for terminal guidance. It can carry a 150-kg warhead to a range of about 165 km. The SS-N-22 is a supersonic ASCM carrying a 500-kg warhead to a range of 110 km. It can be ship or submarine launched, and is particularly troubling because of its reported employment of electronic counter-counter measures and a terminal maneuvering capability. Unconfirmed reports assert that Ukraine has already sold some of its SS-N-22s left over from the Soviet weapon stockpile to Iran.[122] The Russians promoted their new ASM-MSS at the 1992 Moscow Air Show. This missile is air launched and ramjet powered giving it speeds up to Mach 3; it will carry a 320-kg warhead to a maximum range of 250 km, the Russians claim.[123]

Marketing advanced cruise missiles is not a violation of the MTCR, and no Russian sales of complete systems to the Third World have been publicly reported. But the Kremlin has disputed the terms of the MTCR with Washington more than once and its commitment to the regime has been questionable. As James Woolsey, Director of Central Intelligence, told the Senate during a February 1993 hearing on NBC and missile proliferation:

> Economic and nationalist pressures are causing some Russian and Ukrainian leaders to question the wisdom of adhering to the Missile Technology Control Regime. . . . Some Russians contend that national laws, not the MTCR, will govern their export of missile technology. Our initial understanding of the Russian regulations indicate they may not be consistent with the MTCR. Russia, for example, has already sold rocket engine technology to India that would be inconsistent with MTCR guidelines. In a recent arms show in Moscow,

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121. Information based on interviews with air show attendees.

122. Norris and Arkin, "Nuclear Notebook"; and John Mintz, "Sweating Out the Sunburn," *The Washington Post*, 13 June 1993, 1[H].

123. "Large Antiship Missile Powered by Rocket/Ramjet has 155-mi. Range," *Aviation Week & Space Technology* 137, no. 8 (24 August 1992): 64.

the Russians advertised a derivative of the old SS-23 for sale as a civilian rocket, raising additional MTCR concerns.[124]

Nor, apparently, is Moscow's word on the MTCR the last word. Unconfirmed reports allege that Russian military and industry officials have proceeded independently with missile technology transfers that violate both the letter and spirit of the MTCR.[125] One such reported transfer has been of cruise missile technologies to the People's Republic of China (PRC).[126] This is particularly troubling—China is reportedly using the Russian technologies to develop land-attack cruise missiles with low observable characteristics.[127] The PRC has widely exported a variety of ASCMs, and there is little evidence to suggest that it will be persuaded to forgo exporting land-attack models. Indeed, China has demonstrated time and time again that, despite its written commitment to follow the MTCR guidelines, it is willing to violate the regime.[128]

China and Russia are not the only missile suppliers that may be questionable adherents to the MTCR. The capacity to produce missiles and NBC weapons is spreading to many countries in the developing world. As the Congressional Research Service determined in its 1993 report:

> An increasing number of developing nations are reaching a stage in their industrial development where they are no longer dependent on

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124. R. James Woolsey, Director of Central Intelligence, Statement prepared for the Senate Committee on Governmental Affairs, 24 February 1993, United States Central Intelligence Agency, Washington, DC, 6.

125. R. Jeffrey Smith, "US, Russia Near Accord On Technology for India," *The Washington Post*, 14 July 1993, 17[A]; "Ukraine Applies Embargo," *The Washington Post*, 14 April 1993, 29[A]; and John P. Hannah, "Russia Still Abets Mideast Terror," *The Wall Street Journal*, 15 September 1993.

126. Sorokin, "Russia's 'New Look,'" 10; and David A. Fulghum, "Cheap Cruise Missiles a Potent New Threat," *Aviation Week & Space Technology* 139, no. 10 (6 September 1993): 54.

127. Fulghum, "Cheap Cruise Missiles," 54.

128. Steven Greenhouse, "$1 Billion in Sales of High-Tech Items to China Blocked," *The New York Times*, 26 August 1993, 1, 15[A]; Douglas Jehl, "China Breaking Missile Pledge, U.S. Aides Say," *The New York Times*, 6 May 1993, 1, 6[A]; Elain Sciolino and Eric Schmitt, "China Said to Sell Parts for Missiles," *The New York Times*, 31 January 1992, 1[A]; Gordon Jacobs and Tim McCarthy, "China's Missile Sales—Few Changes For The Future," *Jane's Intelligence Review* 4 (December 1992): 559-563; and Paul Lewis and David Silverberg, "West Worries China Will Sell Missiles," *Defense News* 7 (16 March 1992): 1, 45.

> foreign suppliers. It may be increasingly difficult for existing supplier control groups to impose constraints on weapons and weapons technology produced indigenously by emerging supplier nations. . . . U.S. and multilateral export controls have been most effective in limiting access to some of the more sophisticated technologies, but less effective in controlling the spread of older and commercially available technologies.[129]

As noted above, Iraq, Iran, North Korea, Pakistan, Indonesia, and Taiwan are reportedly exploiting such "commercially available technologies" to develop longer range cruise missiles. And it is certain that several Third World states already have an ASCM production capability. Moreover, at least 15 also have, or are acquiring, the capability to produce military aircraft or RPVs. These capabilities might be turned to cruise missile production should a perceived need, or revenue-generating export opportunity, arise.[130]

There is little indication that current or potential cruise missile suppliers in the Third World will join the MTCR in the near future. Some of these countries have proven willing to export their missile systems and know-how. This reality, coupled with the questionable export behavior of Russia and China, underscores the fact that the MTCR's failure to gain widespread adherence will likely remain a fundamental weakness well into the future.

## Prerequisite No. 4: A Consensus on Export Control Targets

A successful technology denial regime should establish a complete embargo on the items it controls, or at least establish a list of proscribed destinations. The MTCR is less formal in its approach. A complete embargo is applied solely to production facilities and equipment for Category I items (i.e., complete rocket and UAV systems capable of carrying 500-kg warheads to ranges of 300 km or more and certain major subsystems usable in them).

This embargo is narrow in scope but nonetheless vital. End items are useful to a proliferator, but production facilities and know-how permit the development of an indigenous aerospace infrastructure. However, this embargo is more effective for ballistic than cruise missiles because of the MTCR's exemption of manned aircraft production facilities, which can be utilized for cruise missile development. For all other items covered by the MTCR Technical

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129. Davis, "Nonproliferation Regimes," 62.

130. Carus, *Cruise Missile Proliferation*, 71.

Annex, exports are permitted on a case-by-case basis at the discretion of individual MTCR member governments.

There is no established list of proscribed destinations. Instead, member governments are supposed to share intelligence on missile projects of concern in order to identify which states should be targeted for export restrictions. However, this is a difficult process. It is complicated first by the secrecy that often surrounds Third World missile projects. Cruise missile programs might be particularly hard to identify because they can be conducted under the auspices of a manned aircraft or acceptable UAV program. Much of the development work can be conducted in this manner before a proliferator's true intentions become clear. Intelligence sharing is further complicated because the activity inherently requires MTCR members to risk compromising their national intelligence sources and methods.[131] Few things are more closely guarded by Western governments.

Ultimately, by adopting an informal approach to identifying export control targets, MTCR members are forced to accept an inherent risk regarding cruise missile proliferation: new Third World cruise missile programs may be identified only after they have advanced to full-scale development. So long as a recipient state's end-use intentions remain ambiguous, items usable in clandestine cruise missile programs might be approved for export. Indeed, ambiguity surrounding end-use intentions for SLV technologies has already prompted public disputes among MTCR member governments.[132] It is reasonable to assume that the informal approach will have more success against militaristic, pariah states that have previously demonstrated an interest in ballistic missile development, e.g., Iraq and North Korea. The MTCR is believed to have impeded the progress of such rogue missile builders even though the latter have partially circumvented the pact by pooling their technical and financial resources and employing clandestine technology procurement networks.

## Prerequisite No. 5: Consensus on Standards for Implementation and Enforcement

Agreed standards of implementation and enforcement strengthen technology denial regimes by ensuring that proliferators will not be able to exploit the "weakest link in the chain." That is, if a regime's member states meet a

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[131] National Academy of Sciences, *Common Ground*, 134.

[132] For example, the United States has disputed French decisions to export SLV technologies to Brazil and India because the items might be used to develop strategic ballistic missiles. Ottaway, "U.S. to Bar India's Buying Missile Device."

common standard for licensing, customs policing, export reviews, etc., they form a united front. A Third World missile builder cannot expect to target countries with relatively lax enforcement standards in an attempt to acquire missile technologies.

As a voluntary accord, the MTCR has not developed such agreed standards. Enforcement standards are national prerogatives and vary among members. There are, for instance, no agreed measures for scrutinizing export applications, or for investigating and penalizing individuals, companies, and governments that violate MTCR guidelines. Disagreements have even arisen over the meaning of key terms in the guidelines, such as "particular restraint" or "specially designed," as well as what constitutes an "acceptable" end use for dual-use technologies.[133] The failure to formulate agreed standards for missile exports is further evidence that a consensus against missile proliferation has not yet fully matured and that MTCR members seek to maintain flexibility in their export rights, especially in the area of dual-use technologies.

CoCom members spent years attempting to adopt an agreed standard of enforcement. If this effort is brought to fruition in a CoCom replacement, it could set a precedent that MTCR members might follow, especially since membership in both regimes will probably overlap in many cases. Until such agreed standards are established for the MTCR, if ever, the most vigilant regime members, such as the United States, will be forced to monitor the export activities of less committed members and intervene with quiet diplomacy to ensure that missile technology exports which undermine the MTCR's goals do not go forward.

## Conclusions

The MTCR is frequently criticized for not being more effective in controlling the spread of ballistic missiles worldwide. Overlooked in such criticism is the limited nature of the MTCR (a voluntary rather than binding agreement with limited membership) and the fact that despite its shortcomings, the MTCR represents a constraining mechanism of considerable importance. Although the MTCR's provisions may not entirely stop the spread of controlled systems and technology, they can slow the pace of proliferation enough to permit more deliberate diplomatic or defensive countermeasures to become effective.

Keeping in mind the MTCR's importance in the above regard, the agreement nonetheless does suffer from a number of weaknesses regarding cruise

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[133] Robert Shuey, "Missile Proliferation: A Discussion of U.S. Objectives and Policy Options," *Congressional Research Service Report for Congress* 90-120 F, 21 February 1990, 14, 22n; and National Academy of Sciences, *Common Ground*, 134.

missile proliferation. Most can be traced directly to the fact that the international consensus against missile proliferation—particularly cruise missile proliferation—has yet to solidify. The regime's shortfalls are exacerbated in the case of cruise missiles due to their close relationship to manned aircraft and more acceptable UAV systems. This relationship permits the development of cruise missiles under the cover of more acceptable aerospace activities; it also decreases the likelihood that supplier countries will identify a cruise missile program and impose an embargo before the program reaches an advanced stage of development.

Restrictions on manned and unmanned aircraft would have to be extensively tightened to impede the spread of cruise missile production capabilities, but such restrictions would result in major financial and other losses to their producers and thus appear doubtful. Moreover, indigenous cruise missile production capabilities exist and are spreading in the Third World. MTCR members will have to be especially vigilant to ensure that dual-use technologies applicable to the development of advanced cruise missiles are not exported for manned aircraft or UAV programs and then diverted to cruise missile projects. The inclusion of shorter range UAV systems in Category II of the 1993 Technical Annex strengthens the regime, and the appearance of longer range cruise missiles in the Third World may prompt MTCR members to monitor UAV-related exports more carefully in the future.

## THE COORDINATING COMMITTEE FOR MULTILATERAL EXPORT CONTROLS

It is too soon to tell if the CoCom will evolve to cover cruise missile technologies, or if a CoCom follow-on will emerge at all. However, the CoCom's history demonstrates some of the difficulties inherent in controlling cruise missile-related equipment. These difficulties will be analyzed briefly below for they illustrate the type of challenges that must be met if cruise missile proliferation is to be effectively curtailed.

### CoCom: Its Post-Cold War Future

The United States is leading the effort to develop a CoCom follow-on that will include the former East Bloc states and other currently proscribed destinations.[134] To reiterate, it is hoped that the new regime will fill gaps in existing nonproliferation accords such as the MTCR, the NPT, and the CWC. Since it

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[134] Thomas W. Lippman, "Clinton, Yeltsin to Meet in Moscow in January," *The Washington Post*, 23 October 1993, 18[A].

appears that a CoCom follow-on will be aimed primarily at conventional weapons, it is at least possible that shorter range UAVs such as ASCMs might be covered, as well as manned aircraft and related technologies. These items might, for instance, be denied to regions where there are excessive arms buildups, e.g., the Middle East. However, a CoCom follow-on will have to overcome key hurdles if it is to be aimed at nonproliferation.

The CoCom's Cold War success was rooted in its members' common belief that the USSR represented a clear threat to their security. The regime therefore had a small number of targets—primarily the USSR and its key client states. Moreover, CoCom members, and the United States especially, were the world's sole producers of many critical military technologies.

Any CoCom follow-on will confront a more difficult task. First, it will be aimed at a larger number of countries. Few of these countries are likely to represent the type of clearly identifiable security threat that the USSR did. In addition, members of a CoCom follow-on will be faced in many circumstances with supporting the regime's new nonproliferation agenda or supporting the military capabilities of Third World allies. These new circumstances will undoubtedly lead to disagreements over which countries or regions should be subject to embargoes. Second, as a nonproliferation regime, a CoCom follow-on would logically have to be even more expansive in its coverage of dual-use technologies. For example, although the Soviet aerospace industry might have benefited only marginally from acquiring, say, production technology for lightweight turbojet engines, the same acquisition by a Third World country could represent a critical breakthrough and cut years off the time required to develop a land-attack cruise missile. But expanding the scope of dual-use controls does not appear to be especially realistic for a CoCom follow-on.

Before the regime terminated, the trend among CoCom members had been to remove controls from an increasing number of dual-use items, partly out of recognition that regime members no longer monopolized their production. And the surest way to derail a CoCom follow-on would be to restrict exports of technologies that generate much needed revenues, e.g., manned aircraft and related technologies. Jan Hoekema of the Dutch Ministry of Foreign Affairs writes on the European perspective on this point:

> In open societies such as ours, deregulation and the free market, rather than regulation, are the norm, and our businesses would not happily exchange the old CoCom restrictions on exports to Eastern

> Europe for potentially stricter controls with respect to the Third World.[135]

It may be that any CoCom follow-on will thus have to follow a policy of placing "higher fences around fewer goods," as one US CoCom expert has described the recent trend.[136] Yet, there is reason to question just how high the fences will be. If a CoCom follow-on does move in the direction that US officials have indicated, then it will become a more informal regime, something akin to the MTCR with information sharing but, ultimately, national discretion permitted for most exports. This raises the prospect that a CoCom follow-on will exhibit critical MTCR weaknesses, e.g., the willingness of some members to interpret guidelines loosely or to readily accept a recipient's claims regarding end-use intentions. Another factor influencing the height of the fences will be the retention or abandonment of the original CoCom members' effort to institute a common standard of enforcement. It remains to be seen whether such standards can be universally implemented by former CoCom members that join a follow-on regime and, perhaps more important, by any former East Bloc states that are permitted to become full partners in a CoCom follow-on.

As for "fewer goods," just how few will likely depend primarily on the scope of regime membership. As previously noted, the technical and industrial expertise required to develop cruise missiles is spreading in the Third World. Neither Europe nor the United States is likely to press for strict controls on aerospace items that are easily obtainable from states remaining outside any CoCom follow-on. Therefore, the effectiveness of a future regime will depend on expanding membership to as many aerospace supplier countries as possible.

Membership expansion will present any CoCom follow-on with the same critical challenge the MTCR has faced in recent years, namely gaining acceptance by rogue suppliers and Third World countries with emerging aerospace industrial capabilities. In fact, despite its nearly decade-long effort, the United

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135. Jan Hoekema, "The European Perspective on Proliferation Export Controls," in Kathleen Bailey and Robert Rudney, eds., *Proliferation and Export Controls* (New York: University Press of America, 1993), 84.

136. Richard Kauzlarich, "US-EC Nonproliferation Cooperation: An American View," in Bailey and Rudney, *Proliferation and Export Controls*, 87.

States failed to persuade even a single newly industrializing state to join the original CoCom. It is certainly logical to question why Third World countries that refused to join the anti-communist CoCom would now sign on to a revamped accord aimed at stemming the flow of dual-use and military technologies to the developing world.

Given the challenges inherent in the CoCom transition, it appears that any CoCom follow-on will have a limited impact on cruise missile proliferation in the near term. Looking further ahead, if a revamped CoCom can gain widespread acceptance by the formerly proscribed countries and retain its predecessor's coverage of advanced, aircraft-related equipment, it could help stem the continued dissemination of advanced cruise missile production capabilities in the future. The success or failure of such an effort will depend largely on whether former CoCom members can maintain their own unity, which deteriorated after the collapse of the Warsaw Pact. They will also have to make regime membership attractive enough, e.g., through permitting access to embargoed goods, so that once-proscribed countries will see greater economic and security benefits in joining a CoCom follow-on than remaining outside of it to export arms in an unrestricted fashion. Prior to the CoCom's termination, Hungary and Poland were examples of countries that apparently decided that their balance of interests tipped toward CoCom membership. It may be much more difficult to convince major arms producers whose economies rely heavily on export revenues, such as Russia and China, to reach a similar conclusion regarding a future CoCom follow-on.

## UN ARMS CONTROL INITIATIVES

### The UN Arms Register

The new UN Register seems not to have fostered arms export moderation as its authors had hoped, at least not yet. For its part, the United States led the world in arms exports to developing countries for the third year running in 1992.[137] The US submission for 1992 to the UN Register indicated that it exported combat aircraft to 12 countries and missiles and launchers to 11 countries.[138]

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137. Barbara Starr, "USA Tops Arms Exports League For 3rd Year," *Jane's Defense Weekly* 20 (31 July 1993): 10.

138. Arms Control and Disarmament Agency, Office of Public Affairs, "Fact Sheet: United States Submits its Contribution to the United Nations Register of Conventional Arms," (Washington, DC: US Arms Control and Disarmament Agency, Office of Public Affairs, 15 June 1993).

Following Iraq's attack on Kuwait, Soviet Foreign Minister Eduard Shevardnadze called on the world to join the USSR in reducing arms exports. But Shevardnadze's appeal was quickly overrun by the reality of the Communist empire's continuing economic disintegration which compelled even greater arms exports. After Saddam's forces were ejected from Kuwait, Soviet Military Industrial Commission Chairman Igor Belousev declared: "We will be selling as much military hardware as we can."[139] The post-Soviet government of Boris Yeltsin is adhering to Belousev's philosophy. Russia intends to export heavily, with a focus on combat aircraft sales. The Russians hope the Middle East will be a major market for their military wares.[140]

France and the United Kingdom ranked second and third, respectively, for 1992 arms exports to the Third World and each country increased its sales substantially over the previous year's figure.[141] The French are expected to accelerate arms exports even further to protect their defense industry, and the United Kingdom will surely do the same.[142] The Chinese dropped out of the Permanent-5 negotiations and, in a September 1993 speech to the UN General Assembly, the Chinese Foreign Minister condemned US efforts to promote arms export restraints, calling the United States a "hegemonic . . . 'world cop'" and a hypocrite.[143]

Harsh rhetoric and recent export trends aside, the UN Register could still foster restraints on missile transfers in the future. This is because, through their data submissions to the UN Register, key Western states have proven

[Continued]

Countries receiving US aircraft included Chile, Ecuador, Egypt, Greece, Israel, Kuwait, Netherlands, Philippines, Saudi Arabia, South Korea, and Turkey. Missiles and launchers were exported to Bahrain, Canada, Egypt, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, and Turkey.

139. Quoted in Charles Lane, et al., "Arms for Sale," *Newsweek*, 8 April 1991, 23.

140. Sorokin, "Russia's 'New Look,'" 7, 9-10.

141. Starr, "USA Tops Arms Exports," 10.

142. de Briganti, "Export Push," 8, 16.

143. R. Jeffrey Smith, "China Denounces U.S. Policy on Arms Transfers," *The Washington Post*, 30 September 1993, 15[A].

willing to make previously confidential arms transfers public.[144] Although limited to a certain extent by national security considerations,[145] publicizing missile sales might nonetheless combine with pressure brought to bear in MTCR deliberations to compel restraint in certain cases. Such cases could include transfers of MTCR Category II missiles, which can be exported at member discretion even though some types can be "scaled-up" to meet the MTCR's 300 km-500 kg threshold.

## UN Permanent-5 Arms Control Initiative

The spirit of post-Cold War cooperation and the realization that regional arms buildups threatened world peace and stability were prominent factors in the 1991 Permanent-5 initiative to regulate arms exports. As Dante Fascell, Chairman of the US House Foreign Affairs Committee, declared a few weeks after the Desert Storm cease fire: "The end of the war with Iraq cannot signal a return to business as usual, especially arms business as usual."[146] By 1993, however, it appeared that "business as usual" had in fact returned to the arms trade.

It certainly seemed that the Permanent-5 talks went astray because they failed to meet the critical prerequisites outlined above for successful technology denial efforts. In this regard, the Five were unable to agree on which weapons warranted special control efforts. Consider, for instance, the comments of Konstantin Sorokin, chief of arms control studies at the Moscow-based Institute of Europe:

> On the face of it this [the Permanent-5 export guidelines] is reassuring, but in practice it will have little effect on the future flow of arms from Russia. It is very difficult, for instance, to define "destabilizing" arms exports. A Soviet Ministry of Defense statement issued August 11, 1990, for example, claimed that Moscow supplied Iraq with only defensive arms, but the Soviet Union was among the chief suppliers of Baghdad's markedly offensive potential.[147]

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144. Based on off-the-record discussions with a former participant in the creation of the UN Register.

145. For example, states are sensibly reluctant to furnish details on national inventories of missiles, which would alert potential adversaries to just how long and at what intensity they could prosecute combat.

146. Quoted in Lane, "Arms for Sale," 27.

147. Sorokin, "Russia's 'New Look,'" 10.

With respect to missiles in particular, both the original Bush initiative and the July 1991 Permanent-5 communique emphasized restrictions on exports of surface-to-surface missiles. Air-launched cruise missiles, which could be readily adapted to ground-launched versions, were apparently not covered. In addition, the prospects for full participation by all Permanent-5 suppliers of cruise missile-related technologies were dimmed by, among other things, US aircraft and missile exports; Russia's stated intention to increase aircraft exports and apparent willingness to export advanced cruise missile systems; and China's outright withdrawal from the talks. The targets for any agreed export guidelines also remained a matter of dispute. The United States continued to arm its established allies around the globe; Russia as well considered arms exports to be an important foreign policy instrument. China withdrew from the talks to protest US arms exports to one potential target—Taiwan.

It is too early to predict the ultimate outcome of the Permanent-5 effort, but it should come as no surprise that the talks stalled over such basic issues as the types of weapons to restrict. The United States and the USSR spent years, even decades, discussing such matters in their strategic arms negotiations. And there were only two parties at the superpower negotiating table.

Perhaps 1991 can be considered the first year of what may be a protracted Permanent-5 negotiating process. The fact that the talks were conducted at all by states with divergent foreign policy goals and interests is significant. Nevertheless, it does not appear that future rounds in the Permanent-5 talks—if conducted at all—will produce any agreement, guidelines, etc., that will have a notable impact on cruise missile proliferation in the near term.[148]

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[148] The Arab-Israeli conflict has made the Middle East a lucrative market for arms. Although the 1993 Israeli-PLO peace accord should reduce tensions, experts do not expect any significant decline in the region's arms imports. These analysts contend that Israel may even want to modernize segments of its armed forces to compensate for the loss of warning time it must accept in trading land for peace. Moreover, the regional arms race is driven as much by fear of Iranian aggression as the Arab-Israeli conflict. Philip Finnegan, "Middle East Arms Sales Won't Drop," *Defense News* 8 (20-26 September 1993): 3.

## CHAPTER 5

# RECOMMENDATIONS FOR IMPROVING EXPORT CONTROLS

## GENERAL POLICY CONSIDERATIONS: RAISING US AWARENESS

The cruise missile proliferation problem is just beginning to manifest itself and, as this study has argued, the problem has the potential to become a significant arms control challenge. This underscores the need for a timely response. Indeed, the importance of taking timely action against the spread of cruise missiles is illustrated by ballistic missile nonproliferation efforts.

The United States recognized the ballistic missile proliferation threat in the early 1980s. The Missile Technology Control Regime (MTCR) was founded in 1987 as a result. But by that time several developing states already possessed long-range ballistic missiles or had them in advanced stages of development.[149] This prompted many experts to conclude that the MTCR was "too little, and too late" to have a significant impact on ballistic missile proliferation.[150] Long-range, land-attack cruise missiles have not been exported to the developing world, nor has the Third World developed an indigenous infrastructure for their manufacture—though several Third World countries have a latent capability reflected in their capability for aircraft maintenance and assembly. At the same time, newly available guidance technologies could bring long-range cruise missile systems within reach of Third World proliferators in the next decade.

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[149] For example, Israel deployed its 500-km range *Jericho I* in 1973 and began testing its 1,500-km *Jericho II* in 1986. Iraq began testing its 650-km *Al Hussein* in 1987 and its 2,000-km *Tamouz* in 1989. India began testing its 250-km *Prithvi* in 1988 and its 2,500-km *Agni* the following year. Duncan S. Lennox and Roger Loasby, eds., *Jane's Strategic Weapon Systems*, (Surrey, United Kingdom: Jane's Information Group, Ltd., 1989).

[150] Janne E. Nolan and Albert D. Wheelon, "Third World Ballistic Missiles," *Scientific American*, 263, no. 2 (August 1990): 34; Steve Fetter, "Ballistic Missiles and Weapons of Mass Destruction: What is the Threat? What Should be Done?" *International Security* 16, no. 1 (Summer 1991): 35; and The International Institute for Strategic Studies, *Strategic Survey 1988-1989* (London: Brassey's, 1989), 21-23.

What makes the prospects of cruise missile proliferation of such great concern is the potential impact on regional stability and US intervention options of highly accurate attack means in the hands of rogue states. Cruise missiles offer future regional adversaries of the United States not only accurate nuclear, biological and chemical (NBC) means of attack, but operationally useful conventional strike means, which could level the military playing field in the highly vulnerable intervention phase of a major regional contingency. Moreover, planned US force reductions and the elimination of the so-called Cold War "overhang" only makes matters worse; without the slack and redundancy of an extensive overseas system of bases and lines of communication that proved so useful in the 1991 Gulf War, US military forces will be less capable of absorbing the shock of any successful adversary strikes with highly accurate cruise missiles.[151] Cruise missile proliferation must therefore be placed on the global arms and export control agenda along side ballistic missiles as a priority issue while there is still time to constrain rapid advances in the threat.

We examined a variety of official policy sources to determine the Clinton administration's treatment of cruise missile proliferation within the context of the MTCR and other export control measures. President Clinton and high-level Executive Branch officials, including Director of Central Intelligence R. James Woolsey, Undersecretary of State for International Security Affairs Lynn E. Davis, Assistant to the President for National Security Affairs Anthony Lake, and others, have addressed the administration's missile nonproliferation priorities during congressional testimony, major foreign policy speeches, and policy proclamations. But not one of these key addresses or documents specifically mentioned cruise missiles as an important element in the overall missile proliferation problem. Each focused instead on ballistic missile and space launch vehicle proliferation.[152]

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[151] Here the critical analytical constituents are the precision of attack in the context of specific intervention vulnerabilities. For a detailed analysis of the impact of cruise missile proliferation on US regional contingency options see Dennis M. Gormley, *Leveling the Military Playing Field: Cruise Missile Proliferation and the Challenge to U.S. Force Projection*, forthcoming.

[152] President William J. Clinton, "Address by the President to the 48th Session of the United Nations General Assembly," 27 September 1993, Office of the White House Press Secretary, New York, New York; "White House Fact Sheet on Non-Proliferation and Export Control Policy," 27 September 1993, Office of the Press Secretary, The White House, Washington, DC; R. James Woolsey, Director of Central Intelligence, Statement prepared for the House Foreign Affairs Committee, Subcommittee on International Security, International Organizations, and Human Rights, 28 July 1993, United States Central Intelligence Agency, Washington, DC; Lynn E.

One or more reasons may account for the failure to include cruise with ballistic missiles in treating the missile proliferation problem. Because ballistic missiles represent a more mature threat than cruise missiles, the nature of the cruise missile threat and the unique challenges associated with it remains an under-appreciated phenomenon. On the other hand, inattention to the cruise missile problem may be explained by the comparative difficulty of restricting technologies appropriate to cruise versus ballistic missile development and by the potential effect unmanned air vehicle (UAV) controls could have on other US aerospace exports.

The Clinton administration is engaged in an effort to "streamline" US export control policies and promote US high-technology exports, including combat aircraft and aircraft upgrade packages.[153] During testimony before Congress, Commerce Secretary Ronald H. Brown explained that the streamlining effort was designed to reform an export control system that he described as "so unwieldy and bureaucratic that it is a major impediment to doing business." Brown went on to underscore a pilot program being implemented that "provides 'fast track' export licensing support to California's defense companies."[154] For his part, Secretary of State Warren Christopher has advised all US embassies to promote US strike aircraft technology sales, and the President has even intervened personally to seal major aircraft export deals.[155]

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Davis, Undersecretary of State for International Security Affairs, Statement prepared for the House Foreign Affairs Committee, 10 November 1993, US Department of State, Bureau of Public Affairs, Washington, DC; and Anthony Lake, Assistant to the President for National Security Affairs, "From Containment to Enlargement," Speech before the Johns Hopkins University School of Advanced International Studies, Washington, DC, 21 September 1993, The White House Office of the Press Secretary, Washington, DC.

153. Keith Bradsher, "Administration Plans New Export Initiative," *The New York Times*, 28 September 1993, 1; and Barbara Opall, "U.S. Firms: Export Laws Hurt Business," *Defense News* 8 (9-15 August 1993): 16.

154. Ronald H. Brown, Secretary of Commerce, Statement prepared for the House Foreign Affairs Committee, Subcommittee on Economic Policy, Trade, and Environment, 5 August 1993, US House of Representatives, Washington, DC, 3.

155. Opall, "Export Laws Hurt," 16; and Peter Behr, "White House Readies High-Powered Campaign to Promote Exports," *The Washington Post*, 21 August 1993, 1[B].

Hence, enhanced controls on UAV technology transfers would likely undermine the Clinton administration's economic and trade goals.[156]

The US Department of Defense has been less remiss in drawing attention to both ballistic and cruise missile proliferation. Former Secretary of Defense Dick Cheney, in his last Report to Congress, asserted that:

> During the Iran-Iraq War, the war in Afghanistan, and the Persian Gulf War, we witnessed the outcome of 10 years of ballistic missile proliferation, including the use of those missiles against cities and innocent civilians. The danger posed by the proliferation of ballistic missile technology continues. *In addition, we must also address the growing proliferation threat posed by cruise missiles.* They can strike an area no larger than an individual city block. The size and flight profiles of cruise missiles can stress the capabilities of air defenses. These features make cruise missiles highly effective weapons even when armed with only conventional explosives. When armed with chemical, biological, or nuclear warheads, cruise missiles would represent an even greater threat (emphasis added).[157]

Similarly, Cheney's successor, Les Aspin, highlighted the cruise missile problem in his so-called Bottom-Up Review of US defense policies and force structures:

> A different threat of particular concern in the post-Cold War period is the proliferation of shorter-range ballistic and cruise missiles armed with nuclear, biological, or chemical warheads. Ballistic and cruise missile deployments are expected to increase worldwide, despite stepped-up efforts to inhibit their proliferation.[158]

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[156] As noted above, the Clinton administration's priorities were demonstrated by its 1994 decision to export turbofan engines to China. According to an unconfirmed account in *The Washington Post*, the administration approved the half-billion-dollar sale despite Department of Defense warnings that Beijing could use the turbofans to develop 600-km range cruise missiles for export to the Third World. See Jack Anderson and Michael Binstein, "Worrisome Engine Sales to China," *The Washington Post*, 9 May 1994, 14[C].

[157] Dick Cheney, *Report of the Secretary of Defense to the President and the Congress* (Washington, DC: US Government Printing Office, January 1993), 17.

[158] Les Aspin, *Report on the Bottom-Up Review* (Washington, DC: Department of Defense, October 1993), 44.

Of course, Department of Defense (DOD) officials also recognize the trade-offs and difficulties posed by export controls. American jobs and the US aerospace industrial base could on occasion be jeopardized by curbing exports of cruise missile-usable subsystems. In 1993 testimony before Congress, Under Secretary of Defense for Policy Frank Wisner noted the dilemma:

> Foreign military sales have become . . . a significant portion of our defense industry's overall business; . . . sales cannot be considered in isolation of their industrial-base implications; . . . we must bear in mind . . . that other nations may be willing to provide capabilities equivalent to those a US sale would provide, but without the restriction we might impose and at the cost of US jobs.[159]

And during his February 25, 1993 confirmation hearing, then-Deputy Secretary of Defense William J. Perry told the Senate Armed Services Committee that controlling dual-use technologies was a "hopeless task."[160]

Given DOD's unique responsibility in the area of countering the consequences of proliferation, the Clinton administration created the Defense Counterproliferation Initiative. According to then-Secretary of Defense Les Aspin, who announced the initiative on December 7, 1993 in a speech delivered to the National Academy of Sciences, the DOD's new initiative was not meant to suggest a lessening of attention to the prevention side of nonproliferation policy, but only to recognize the DOD's special responsibility to deal with an increased threat of proliferation. As far as missile proliferation was concerned, ballistic missiles were called out with no mention of cruise missile proliferation. And in the category of defensive measures to protect US military forces, ballistic missile threats and theater missile defense—not cruise missiles and improved air defense—were called out prominently.[161] One could simply conclude that cruise missiles and improved defenses against them were not given explicit mention because of the brevity of the speech. However minor such an omission may appear, it will become increasingly important to

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159. Quoted in Pamela Pohling-Brown, "New Administration Signals Sales Onslaught," *International Defense Review* 26 (July 1993): 558.

160. Congress, Senate, Committee on Armed Services, *Nominations Before the Senate Armed Services Committee, First Session, 103D Congress*, 103rd Cong., 1st sess., 1994, 337.

161. Les Aspin, Secretary of Defense, Speech before the National Academy of Sciences Committee on International Security and Arms Control, 7 December 1993, US Department of Defense, Office of the Assistant Secretary of Defense for Public Affairs, Washington, DC.

draw specific attention to the cruise missile dimension of the missile proliferation threat—particularly in light of the export control challenges discussed in this monograph.

## SPECIFIC MEASURES TO ENHANCE THE MTCR AND RAISE INTERNATIONAL AWARENESS

Any new MTCR initiatives must be firmly grounded in reality. Reality dictates that member states recognize that they no longer monopolize aerospace expertise or industrial capabilities. Some developing countries are already producing relatively unsophisticated cruise missiles, and they might exploit satellite navigation systems to build longer range cruise missiles over time. Moreover, a latent cruise missile production capability exists in many regions due to the globalization of the manned aircraft and UAV industries. Hence, although technology denial efforts aimed at unsophisticated cruise missiles should not be abandoned, neither should they be expected to have a major impact.

It does, however, seem reasonable to expect that technology denial regimes can be more effective in slowing the spread of relatively advanced systems, i.e., stealthy cruise missiles capable of high speed and/or long range. Focusing nonproliferation efforts on such advanced cruise missiles makes sense for three reasons. First, in the future, advanced cruise missiles will present a relatively greater threat to US and allied power projection forces and to United Nations expeditionary forces. Second, unlike low-technology cruise missiles which have already proliferated, the advanced technologies needed to develop sophisticated models are still largely subject to some control. And finally, enhanced controls can be developed rapidly because the MTCR regime is already in place to focus attention on the problem.

The critical enabling technologies needed to acquire advanced cruise missiles—including stealth technology and advanced propulsion systems—are produced almost exclusively by MTCR members or by states that might be persuaded to support tighter controls. Several Third World countries are known to be working with composite materials to build airframes for missiles and manned aircraft with reduced radar cross sections, but the major industrial powers alone possess advanced stealth technologies and engineering capabilities.[162] Even so, because several European countries have now mastered stealth technology, it is subject to leakage into the developing world.

162. As of 1990 at least, the Director of US Naval Intelligence indicated that "only a few industrialized countries can incorporate the more sophisticated aspects of stealth technology into their weapon systems," quoted in W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, Connecticut: Praeger Publishers, 1992), 75.

Regarding advanced propulsion systems, the acquisition of turbofan engines is a significant step. Turbofan engines are more efficient than their turbojet cousins and thus enable aircraft to fly longer distances on the same amount of fuel. Only the major powers are known to be producing compact, lightweight turbofans suitable for advanced, long-range cruise missiles. Indeed, it appears that no Third World country has yet managed to indigenously produce short-range turbofans for antiship cruise missiles.[162]

Ramjet and scramjet engines can be used in supersonic, air-breathing missiles. Proliferators might find supersonic missiles attractive; they would be very useful in attacking mobile or time-critical targets. Ramjet or scramjet production capability is in fact spreading in the Third World: India claims to have developed a ramjet for missile applications and is conducting a research program that has tested an air-breathing engine capable of speeds over Mach 20; Taiwan has developed a ramjet-powered air defense missile; China produces a first-generation ramjet for antiship missile applications; South Korea has developed ramjet components and test facilities; and Israel is reported to be conducting ramjet and scramjet research and development. But to date, only the major industrial powers have demonstrated or deployed state-of-the-art ramjet- or scramjet-powered missiles.[163]

Stealth and advanced propulsion systems are covered under the dual-use, Category II section of the MTCR Technical Annex. As such, the technologies can be exported at the discretion of MTCR member governments. Regime members should of course make a determination, or receive commitments from a recipient government, that the technologies will not be used in the development of a missile for NBC delivery or one that meets the MTCR's Category I threshold, i.e., any system capable of carrying at least a 500-kg payload to a range of at least 300 km. Nevertheless, because the items can be exported for manned aircraft or for shorter range cruise missiles not intended for NBC delivery, there is an inherent risk in all such transfers that the technologies involved will be exported and then diverted to the development of advanced cruise missiles.

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162. Carus, *Cruise Missile Proliferation*, 79; Clifford Beal, "Anti-Ship Missile Technology: Leaving Well Enough Alone?" *International Defense Review* 25 (October 1992): 964; and Duncan Lennox, "Cruise: a Missile for the '90s," *Jane's Defense Weekly* 21 (7 May 1994): 19-20.

163. Orion Enterprises, Inc., "Nuclear Capable Missile Proliferation Volume II: Technology Base Considerations," 24 April 1991, 20, Paper prepared for Sandia National Laboratories under contract 21-1539, Orion Enterprises Inc., Fredericksburg, Virginia; Carus, *Cruise Missile Proliferation*, 38, 78; Vivek Raghuvanshi, "Indians Test Air-Breathing Engine," *Space News* 4 (22-28 February 1993): 7; and T.D. Myers and Gordon Jensen, "Ramjets Experience Renewed Interest Worldwide," *Aerospace America* (July 1990): 28-30.

Given the criticality of stealth and advanced propulsion technologies to long-range, land-attack cruise missiles, it might seem advisable to move these technologies to the MTCR's Category I section. There would thus be a presumption to deny exports of the technologies themselves and transferring their associated production equipment and facilities would be flatly prohibited. However, this is unlikely to gain a consensus of the MTCR membership, at least in the near term. As it is currently constructed, MTCR Category I items are the most sensitive; they are almost exclusively military in their end-use applications. Exporting Category I items is therefore certain to antagonize the United States and result in US trade or other sanctions. Stealth and advanced propulsion systems, on the other hand, fall appropriately into the Category II section. They are all dual-use in nature and can be applied, for instance, to the development of commercial satellites, commercial aircraft, and more acceptable military projects such as battlefield reconnaissance drones and strike aircraft. However critical they may be to advanced cruise missile development, adding dual-use items to Category I would weaken the overall regime by removing the special status of the Category I list.

A more realistic, near-term approach would begin with a general initiative to raise MTCR member awareness of the cruise missile threat. The United States should initiate this effort by launching quiet discussions with individual MTCR member governments. These discussions should aim at heightening MTCR member awareness of all cruise missile-related technologies contained in the MTCR Technical Annex and especially the significance of stealth and advanced propulsion systems in exacerbating the emerging cruise missile threat.

The MTCR member governments should be advised that, with the predicted worldwide expansion of the aircraft upgrade and UAV markets, export control authorities can expect export license applications for advanced subsystems usable in cruise missiles. MTCR members should take such applications as a warning signal. The recipient state's end-use intentions should thereafter be thoroughly investigated, especially when the recipient does not have current, acceptable aerospace systems employing such technologies.

If available evidence suggests that the recipient government is interested in acquiring cruise missiles or does in fact have such a project underway, exports of stealth and advanced propulsion systems of the type described above, and especially their associated production facilities and equipment, should be prohibited or permitted with only the utmost caution. If the export is permitted, end-use monitoring would be advisable, even in cases where manned aircraft end uses seem certain. Monitoring might deter (although it could not prevent) diversions of the end items and production equipment from acceptable aerospace projects to cruise missile applications.

These measures will require little more than a better balance in the level of bureaucratic scrutiny paid to ballistic and cruise missiles, but they will be nonetheless invaluable. Indeed, enhanced awareness of the cruise missile threat might be the single most important step toward improving the enforcement of MTCR restrictions on UAV exports. Moreover, enhanced awareness might influence the conduct of other international arms control and disarmament efforts. For instance, enhanced awareness in the future might prevent repetition of past oversights, such as that committed by the United Nations in its failure to clearly proscribe Iraq's cruise missile program or that committed by the Permanent-5 in their failure to include air-launched cruise missiles in their talks on arms export restrictions. And with the foundation laid through these modest initiatives, the United States might thereafter raise the profile of the cruise missile issue by making it a priority for discussion at the full MTCR membership's ad hoc meetings. Indeed, given the special sensitivity of stealth technology transfers in particular, it would seem advisable for the relevant producing states to discuss common constraints on exports, perhaps even outside the context of MTCR deliberations.

Beyond this general effort, the United States should query the French on their export intentions for the *Apache* cruise missile. If the system is indeed capable of delivering a 400-500 kg payload to a range of only 150 km, the French would be on firm ground to argue that the *Apache* is not captured by the MTCR's Category I, range-payload threshold. But what makes this argument suspect is Matra's proposed *Apache-C* (or *Super Apache*), which is designed to carry virtually the same payload weight (400 to 450 kg) as *Apache* to a maximum range of 600 km—four times the *Apache's* declared range.[165] The *Apache-C's* redesign clearly demonstrates the extent to which cruise missiles can be readily "scaled-up" in performance. At the very least, the *Apache* is definitely Category II—it could clearly, in accordance with Item 19, carry a "negligible" payload to a range of at least 300 km.

If the *Apache* does ultimately prove to be exportable in accordance with MTCR Category II provisions, MTCR member governments could still attempt to lessen any negative consequences that *Apache* exports would have on cruise missile proliferation. France could be urged to conclude rigorous end-use monitoring agreements with any recipient states in the Third World to deter diversions of *Apache* components to longer range cruise missiles. The

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[165] The *Apache-C* is in competition with Aerospatiale's ASMP-C to meet a stated French Air Force requirement for a long-range "intervention" weapon with extremely high accuracy and a conventional payload. For technical details, see Pierre Langereux, "Matra's Super Apache Will Strike at 600 Km with a Precision of 1 Meter," *Air & Cosmos Magazine* (7-13 June 1993): 30-31.

French should also be urged to resist any Third World contracts that require offsets that would enable the recipient to produce *Apaches* or similar cruise missiles in the future.

Russia is currently a potential "weak link" in the export control chain. Russia has enhanced its commitment to the MTCR by submitting written assurances to the United States on its pledge to adhere to the regime's export guidelines. Although, for reasons stated, it is by no means clear that Moscow can or will make good on its commitments, the United States should nonetheless ensure that cruise missile exports are given treatment equal to that of ballistic missiles in monitoring Russian MTCR compliance. The United States and other MTCR member states should query Russian export intentions for advanced systems such as the ramjet-powered ASM-MSS and the AS-15 or its derivatives. These systems appear to be captured by the MTCR's provisions, but their status relative to the regime's guidelines must be clearly determined. Finally, the United States should also urge Russia to forgo future (or additional) exports of advanced cruise missile subsystems and production know-how to China.

Given China's missile export record, Beijing's development of advanced cruise missiles seems certain to accelerate their proliferation elsewhere in the developing world. This could ultimately lead to the acquisition of advanced cruise missiles by Iran, other irresponsible governments, or the strife-plagued states along Russia's periphery. Such developments would be as contrary to Russian security interests as to US and European security interests.

## CONCLUDING OBSERVATIONS

There is clearly much to be done with respect to raising US and international sensitivity to the emerging cruise missile proliferation threat. But even if the US defense and foreign policy establishment can be mobilized and allied governments convinced that their interests will be served by enhanced cruise missile control efforts, there are limits to what such efforts can achieve.

Some developing countries have already demonstrated at least a limited capability to produce the critical technologies and subsystems usable in sophisticated cruise missiles. Other proliferators have proven their ability to circumvent technology denial regimes through the use of clandestine, international procurement networks. The major powers should therefore not expect to halt the proliferation of advanced cruise missiles. But they can slow it; enhanced controls will raise the costs and risks that proliferators incur to acquire advanced cruise missiles. Indeed, no responsible arms control expert has ever claimed that technology denial regimes should be expected to achieve anything more. And slowing cruise missile proliferation is important.

Slowing the proliferation of advanced cruise missiles will provide the United States and other major powers with the "breathing space" they require to develop effective cruise missile defenses. The deployment of effective defenses might in and of itself convince some proliferators that advanced cruise missiles are not worth the investment after all. Breathing space will enable diplomacy to more effectively employ a selective strategy of targeting specific advanced technologies, suppliers, and recipients, as proposed in this monograph.

Enhancing cruise missile nonproliferation efforts is certain to be a major challenge. Although the approach and recommendations offered in this monograph are incremental in nature, they are rooted in the fundamental realities of the post-Cold War international security environment. They might therefore be carried out in time to actually have an impact on cruise missile proliferation.

# APPENDIX A

## THE MISSILE TECHNOLOGY CONTROL REGIME

In April 1987, the United States and its six major trading partners (Canada, the former West Germany, France, Italy, Japan, and the United Kingdom) created the Missile Technology Control Regime (MTCR) to restrict the proliferation of missiles and related technology.

The MTCR, the only multilateral missile nonproliferation regime, is neither an international agreement nor a treaty. It is a voluntary arrangement among countries which share a common interest in arresting missile proliferation. The regime consists of common export policy guidelines applied to a common list of controlled items which each MTCR member implements in accordance with its national legislation. The purpose of the regime is to limit the spread of missiles and unmanned air vehicles/delivery systems capable of carrying a 500 kilogram payload at least 300 kilometers. In January 1993, MTCR Partners announced that the Guidelines had been extended to cover delivery systems intended to carry all types of weapons of mass destruction (chemical and biological as well as nuclear).

The MTCR Annex of controlled items is divided into two sections (Category I and Category II) and includes military and dual-use equipment and technology relevant to missile development, production, and operation.

### Category I

According to the MTCR Guidelines, exports of Category I items are subject to a strong presumption of denial and are rarely licensed for export. Category I items include complete missile systems (ballistic missiles, space launch vehicles and sounding rockets); unmanned air-vehicle systems such as cruise missiles, target and reconnaissance drones; specially designed production facilities for these systems; and certain complete subsystems such as rocket engines or stages, reentry vehicles, guidance sets, thrust vector controls and warhead safing, arming, fuzing, and firing mechanisms. Transfers of production facilities for Category I items are flatly prohibited.

### Category II

The MTCR Guidelines permit licensing of Category II (dual-use) items as long as they are not destined for end-use in the development of a missile of MTCR range/payload capability. Category II items cover a wide range of parts, components and subsystems such as propellants, structure materials, test equipment and facilities, and flight instruments. These items may be exported at the discretion of the MTCR Partner Government, on a case by case basis, for acceptable end uses. They may also exported under government-to-government assurances which provide that they not be used on a missile system capable of delivering a 500 kilogram payload to a range of at least 300 kilometers.

The present MTCR Partners are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States.

As of March 1993, Argentina and Hungary had been admitted to the MTCR, contingent on completing certain technical procedures. The Guidelines remain open to all nations to implement, whether or not they become formal members of the MTCR, and all governments are encouraged to do so.

The MTCR Partners recognize that the technology used in ballistic missiles is virtually identical to that used in space launch vehicles and that there are several countries whose missile or space launch vehicle projects would enable them to export missile technology. MTCR Guidelines have been designed not to impede national space programs or international cooperation in such programs as long as such programs could not contribute to delivery systems for weapons of mass destruction. Bilateral discussions concerning the MTCR have been held with many of these countries and they may seek to join the MTCR once they have established a commitment to the principles of nonproliferation and a record of effective export controls.

## REVISIONS TO MTCR GUIDELINES

### Missile Technology Control Regime

The United States Government has, after careful consideration and subject to its international treaty obligations, decided that, when considering the transfer of equipment and technology related to missiles, it will act in accordance with the attached Guidelines beginning on January 7, 1993. These Guidelines replace those adopted on April 16, 1987.

### Guidelines for Sensitive Missile-Relevant Transfers

1. The purpose of these Guidelines is to limit the risks of proliferation of weapons of mass destruction (i.e., nuclear, chemical and biological weapons), by controlling transfers that could make a contribution to delivery systems (other than manned aircraft) for such weapons. The guidelines are not designed to impede national space programs or international cooperation in such

programs as long as such programs could not contribute to delivery systems for weapons of mass destruction. These Guidelines including the attached Annex, form the basis for controlling transfers to any destination beyond the Government's jurisdiction or control of all delivery systems (other than manned aircraft) capable of delivering weapons of mass destruction, and of equipment and technology relevant to missiles whose performance in terms of payload and range exceeds stated parameters. Restraint will be exercised in the consideration of all transfers of items contained within the Annex and all such transfers will be considered on a case-by-case basis. The Government will implement the Guidelines in accordance with national legislation.

2. The Annex consists of two categories of items, which term includes equipment and technology. Category I items, all of which are in Annex Items 1 and 2, are those items of greatest sensitivity. If a Category I item is included in a system, that system will also be considered as Category I, except when the incorporated item cannot be separated, removed or duplicated. Particular restraint will be exercised in the consideration of Category I transfers regardless of their purpose, and there will be a strong presumption to deny such transfers. Particular restraint will also be exercised in the consideration of transfers of any items in the Annex, or of any missiles (whether or not in the Annex), if the Government judges, on the basis of all available, persuasive information, evaluated according to factors including those in paragraph 3, that they are intended to be used for the delivery of weapons of mass destruction, and there will be a strong presumption to deny such transfers. Until further notice, the transfer of Category I production facilities will not be authorized.

The transfer of other Category I items will be authorized only on rare occasions and where the Government (A) obtains binding government-to-government undertakings embodying the assurances from the recipient government called for in paragraph 5 of these Guidelines and (B) assumes responsibility for taking all steps necessary to ensure that the item is put only to its stated end-use. It is understood that the decision to transfer remains the sole and sovereign judgment of the United States Government.

3. In the evaluation of transfer applications for Annex items, the following factors will be taken into account:

a. Concerns about the proliferation of weapons of mass destruction;

b. The capabilities and objectives of the missile and space programs of the recipient state;

c. The significance of the transfer in terms of the potential development of delivery systems (other than manned aircraft) for weapons of mass destruction;

d. The assessment of the end-use of the transfers, including the relevant assurances of the recipient states referred to in sub-paragraphs 5.a and 5.b below;

e. The applicability of relevant multilateral agreements.

4. The transfer of design and production technology directly associated with any items in the Annex will be subject to as great a degree of scrutiny and control as will the equipment itself, to the extent permitted by national legislation.

5. Where the transfer could contribute to a delivery system for weapons of mass destruction, the Government will authorize transfers of items in the Annex only on receipt of appropriate assurances from the government of the recipient state that:

a. The items will be used only for the purpose stated and that such use will not be modified nor the items modified or replicated without the prior consent of the United States Government;

b. Neither the items nor replicas nor derivatives thereof will be retransferred without the consent of the United States Government.

6. In furtherance of the effective operation of the Guidelines, the United States Government will, as necessary and appropriate, exchange relevant information with other governments applying the same Guidelines.

7. The adherence of all States to these Guidelines in the interest of international peace and security would be welcome.

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Reproduced from: Arms Control and Disarmament Agency, Office of Public Affairs, "Fact Sheet: The Missile Technology Control Regime (MTCR)," (Washington, DC: US Arms Control and Disarmament Agency, Office of Public Affairs, 17 May 1993).

## APPENDIX B

# MISSILE TECHNOLOGY CONTROL REGIME (MTCR) EQUIPMENT AND TECHNOLOGY ANNEX

**July 1, 1993**

## SUMMARY OF THE EQUIPMENT AND TECHNOLOGY ANNEX

### Category I

Complete rocket systems (including ballistic missile systems, space launch vehicles, and sounding rockets) and unmanned air vehicle systems (including cruise missile systems, target drones, and reconnaissance drones) capable of delivering at least a 500 kg payload to a range of at least 300 km as well as the specially designed production facilities for these systems.

Complete subsystems usable in the systems in Item 1, as follows, as well as the specially designed production facilities and production equipment therefor:

> 1) Individual rocket stages; 2) reentry vehicles; 3) Solid or liquid fuel rocket engines; 4) Guidance sets; 5) Thrust vector controls; and 6) Warhead safing, arming, fuzing, and firing mechanisms.

### Category II

> 1) Propulsion components; 2) Propellants and constituents; 3) Propellant production technology and equipment; 4) Missile structural composites: production technology and equipment; 5) Pyrolytic deposition/densification technology and equipment; 6) Structural materials; 7) Flight instruments, inertial navigation equipment, software, and production equipment; 8) Flight control systems; 9) Avionics equipment; 10) Launch/ground support equipment and facilities; 11) Missile computers; 12) Analog-to-digital converters; 13) Test facilities and equipment; 14) Software and related analog or hybrid computers; 15) Reduced observables technology, materials, and devices; and 16) Nuclear effects protection.

# FULL TEXT OF THE EQUIPMENT AND TECHNOLOGY ANNEX

## 1. Introduction

(a) This Annex consists of two categories of items, which term includes equipment and "technology." Category I items, all of which are in Annex items 1 and 2, are those items of greatest sensitivity. If a Category I item is included in a system, that system will also be considered as Category I, except when the incorporated item cannot be separated, removed or duplicated. Category II items are those items in the Annex not designated Category I.

(b) The transfer of "technology" directly associated with any items in the Annex will be subject to as great a degree of scrutiny and control as will the equipment itself, to the extent permitted by national legislation. The approval of any Annex item for export also authorizes the export to the same end user of the minimum technology required for the installation, operation, maintenance, and repair of the item.

(c) In reviewing the proposed application for transfers of complete rocket and unmanned air vehicle systems described in Items 1 and 19, and of equipment or technology which is listed in the Technical Annex, for potential use in such systems, the Government will take account of the ability to trade off range and payload.

## 2. Definitions

For the purpose of this Annex, the following definitions apply:

(a) "Development" is related to all phases prior to "production" such as: design; design research; design analysis; design concepts; assembly and testing of prototypes; pilot production schemes; design data; process of transforming design data into a product; configuration design; integration design; and, layouts

(b) A "microcircuit" is defined as a device in which a number of passive and/or active elements are considered as indivisibly associated on or within a continuous structure to perform the function of a circuit.

(c) "Production" means all production phases such as: production engineering; manufacture; integration; assembly (mounting); inspection; and testing quality assurance

(d) "Production equipment" means tooling, templates, jigs, mandrels, moulds, dies, fixtures, alignment mechanisms, test equipment, other machinery and components therefore, limited to those specially designed or modified for "development" or for one or more phases of "production."

(e) "Production facilities" means equipment and specially designed software therefor integrated into installations for "development" or for one or more phases of "production."

(f) "Radiation Hardened" means that the component or equipment is designed or rated to withstand radiation levels which meet or exceed a total irradiation dose of $5 \times 10^5$ rads (Si).

(g) "Technology" means specific information which is required for the "development," "production" or "use" of a product. The information may take the form of "technical data" or "technical assistance."

(1) "Technical assistance" may take forms such as: instruction; skills; training; working knowledge; and/or, consulting services

(2) "Technical data" may take forms such as: blueprints; plans; diagrams; models; formulae; engineering designs and specifications; and/or manuals and instructions written or recorded on other media or devices (such as disk, tape, read-only memories).

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NOTE: This definition of technology does not include technology "in the public domain" nor "basic scientific research."

(i) "In the public domain" as it applies to this annex means technology which has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove technology from being "in the public domain.")

(ii) "Basic scientific research" means experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena and observable facts, not primarily directed towards a specific practical aim or objective.

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(h) "Use" means: operation; installation (including on-site installation); maintenance; repair; overhaul; and/or refurbishing.

## 3. Terminology

Where the following terms appear in the text, they are to be understood according to the explanations below:

(a) "Specially Designed" describes equipment, parts, components or software which, as a result of "development," have unique properties that distinguish them for certain predetermined purposes. For example, a piece of equipment that is "specially designed" for use in a missile will only be considered so if it has no other function or use. Similarly, a piece of manufacturing equipment that is "specially designed" to produce a certain type of component will only be considered such if it is not capable of producing other types of components.

(b) "Designed or Modified" describes equipment, parts, components or software which, as a result of "development," or modification, have specified properties that make them fit for a particular application. "Designed or Modified" equipment, parts, components or software can be used for other applications. For example, a titanium coated pump designed for a missile may be used with corrosive fluids other than propellants.

(c) "Usable In" or "Capable Of" describes equipment, parts, components or software which are suitable for a particular purpose. There is no need for the equipment, parts, components or software to have been configured, modified or specified for the particular purpose. For example, any military specification memory circuit would be "capable of" operation in a guidance system.

## ITEM 1 - CATEGORY I

Complete rocket systems (including ballistic missile systems, space launch vehicles, and sounding rockets) and unmanned air vehicle systems (including cruise missile systems, target drones and reconnaissance drones) capable of delivering at least a 500 kg payload to a range of at least 300 km as well as the specially designed "production facilities" for these systems.

## ITEM 2 - CATEGORY I

Complete subsystems usable in the systems in Item 1, as follows, as well as the specially designed "production facilities," and "production equipment" therefor:

(a) Individual rocket stages

(b) Reentry vehicles, and equipment designed or modified therefor, as follows, except as provided in Note 1 below for those designed for non-weapon payloads:

- (1) heat shields and components thereof fabricated of ceramic or ablative materials;
- (2) Heat sinks and components thereof fabricated of light-weight, high heat capacity materials;
- (3) Electronic equipment specially designed for reentry vehicles;

(c) Solid or liquid propellant rocket engines, having a total impulse capacity of $1.1 \times 10^6$ N-sec ($2.5 \times 10^5$ lb-sec) or greater;

(d) "Guidance sets" capable of achieving system accuracy of 3.33 percent or less of the range (e.g., a CEP of 10 km or less at a range of 300 km), except as provided in Note 1 below for those designed for missiles with a range under 300 km or manned aircraft;

(e) Thrust vector control sub-systems, except as provided in Note 1 below for those designed for rocket systems that do not exceed the range/payload capability of Item 1;

(f) Warhead safing, arming, fuzing, and firing mechanisms, except as provided in Note 1 below for those designed for systems other than those in Item 1.

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NOTES TO ITEM 2:

1. The exceptions in (b), (d), (e) and (f) above may be treated as Category II if the subsystem is exported subject to end use statements and quantity limits appropriate for the excepted end use stated above.

2. CEP (circle of equal probability) is a measure of accuracy; defined as the radius of the circle centered at the target, at a specific range, in which 50 percent of the payloads impact.

3. A "guidance set" integrates the process of measuring and computing a vehicle's position and velocity (i.e., navigation) with that of computing and sending commands to the vehicle's flight control systems to correct the trajectory.

4. Examples of methods of achieving thrust vector control which are covered by (e) [above] include: flexible nozzle; fluid or secondary gas injection; movable engine or nozzle; deflection of exhaust gas stream (jet vanes or probes); or, use of thrust tabs.

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## ITEM 3 - CATEGORY II

Propulsion components and equipment usable in the systems in Item 1, as follows, as well as the specially designed "production facilities" and "production equipment" therefor:

(a) Lightweight turbojet and turbofan engines (including turbocompound engines) that are small and fuel efficient;

(b) Ramjet/Scramjet/pulse jet/combined cycle engines, including devices to regulate combustion, and specially designed components therefor;

(c) Rocket motor cases, "interior lining," "insulation" and nozzles therefor;

(d) Staging mechanisms, separation mechanisms, and interstages therefor;

(e) Liquid and slurry propellant (including oxidizers) control systems, and specially designed components therefor, designed or modified to operate in vibration environments of more than 10 g RMS between 20 Hz and 2,000 Hz.

(f) Hybrid rocket motors and specially designed components therefor.

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NOTES TO ITEM 3:

1. "Production equipment" in the heading to this item includes the following:

Flow-forming machines, and specially designed components and specially designed software therefor, which:

   a. according to the manufacturer's technical specification, can be equipped with numerical control units or a computer control, even when not equipped with such units at delivery, and
   b. with more than two axes which can be coordinated simultaneously for contouring control.

   TECHNICAL NOTE: Machines combining the function of spin-forming and flow-forming are for the purpose of this item regarded as flow-forming machines.

2. Item 3(a) engines may be exported as part of a manned aircraft or in quantities appropriate for replacement parts for manned aircraft.

3. In Item 3(c), "interior lining" suited for the bond interface between the solid propellant and the case or insulating liner is usually a liquid polymer based dispersion of refractory or insulating materials, e.g., carbon filled HTPB or other polymer with added curing agents to be sprayed or screeded over a case interior.

4. In Item 3(c), "insulation" intended to be applied to the components of a rocket motor, i.e., the case, nozzle inlets, case closures, include cured or semi-cured compounded rubber sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps.

5. The only servo valves and pumps covered in (e) above, are the following:
   a. Servo valves designed for flow rates of 24 liters per minute or greater, at an absolute pressure of 7,000 kPa (1,000 psi) or greater, that have an actuator response time of less than 100 msec;
   b. Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 RPM or with discharge pressures equal to or greater than 7,000 kPa (1,000 psi).

6. Item 3(e) systems and components may be exported as part of a satellite.

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## ITEM 4 - CATEGORY II

Propellants and constituent chemicals for propellants as follows:

(a) Propulsive substances:

(1) Hydrazine with a concentration of more than 70 percent and its derivatives including monomethylhydrazine (MMH);

(2) Unsymmetric dimethylhydrazine (UDMH);

(3) Ammonium perchlorate;

(4) Spherical aluminum powder with articles of uniform diameter of less than 500 x $10^6$ m (500 micrometer) and an aluminum content of 97 percent or greater;

(5) Metal fuels in particle sizes less than 500 x $10^6$ m (500 microns), whether spherical, atomized, spheroidal, flaked or ground, consisting of 97 percent or more of any of the following: zirconium, beryllium, boron, magnesium, zinc, and alloys of these; Misch metal;

(6) Nitro-amines (cyclotetramethylene-tetranitramine (HMX), cyclo-trimethy-lenetrinitramine (RDX));

(7) Perchlorates, chlorates or chromates mixed with powdered metals or other high energy fuel components;

(8) Carboranes, decaboranes, pentaboranes and derivatives thereof;

(9) Liquid oxidizers, as follows: (i) Dinitrogen trioxide; (ii) Nitrogen dioxide/dinitrogen tetroxide; (iii) Dinitrogen pentoxide; (iv) Inhibited Red Fuming Nitric Acid (IRFNA); (v) Compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen.

(b) Polymeric substances:

(1) Carboxy-terminated polybutadiene (CTPB);
(2) Hydroxy-terminated polybutadiene (HTPB);
(3) Glycidyl azide polymer (GAP);
(4) Polybutadiene-acrylic acid (PBAA);
(5) Polybutadiene-acrylic acid-acrylonitrile (PBAN).

(c) Composite propellants including moulded glue propellants and propellants with nitrated bonding.

(d) Other high energy density propellants such as Boron Slurry, having an energy density of 40 x $10^6$ joules/kg or greater.

(e) Other propellant additives and agents:

(1) Bonding agents as follows:
(i) tris(1-(2-methyl)aziridinyl)phosphine oxide (MAPO);
(ii) trimesoyl-l(2-ethyl)aziridine (HX-868, BITA)
(iii) "Tepanol" (HX-878), Reaction product of tetraethlylenepentamine, acrylonitrile and glycidol
(iv) "Tepan" (HX-879), Reaction product of tetlenepentamine and acrylonitrile
(v) Polyfunctional aziridene amides with isophthalic, trimesic, isocyanuric, or trimethyladipic backbone also having a 2-methyl or 2-ethyl aziridine group (HX-752, HX-874 and HX-877).

(2) Curing agents and catalysts as follows:
(i) Triphenyl bismuth (TPB)
(ii) Isophorone diisocyanate (IPDI)

(3) Burning rate modifiers as follows:
(i) Catocene
(ii) N-butyl-ferrocene
(iii) Butacene
(iv) Other ferrocene derivatives

(4) Nitrate esters and nitrato plasticizers as follows:
   (i) Triethylene glycol dinitrate (TEGDN)
   (ii) Trimethylolethane trinitrate (TMETN)
   (iii) 1, 2, 4-butanetriol trinitrate (BTTN)
   (iv) Diethylene glycol dinitrate (DEGDN)

(5) Stabilizers as follows:
   (i) 2-nitrodiphenylamine
   (ii) N-methyl-p-nitroaniline

## ITEM 5 - CATEGORY II

Production technology, or "production equipment" (including its specially designed components) for:

(a) Production, handling or acceptance testing of liquid propellants or propellant constituents described in Item 4.

(b) Production, handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents described in Item 4.

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NOTES TO ITEM 5:

1. Batch mixers or continuous mixers covered by (b) above, both with provision for mixing under vacuum in the range of zero to 13.326 kPa and with temperature control capability of the mixing chamber, are the following:

   Batch mixers having:

   a. A total volumetric capacity of 110 liters (30 gallons) or more; and
   b. At least one mixing/kneading shaft mounted off center.

   Continuous mixers having:

   a. Two or more mixing/kneading shafts; and
   b. Capability to open the mixing chamber.

2. The following equipment is included in (b) above:

   a. Equipment for the production of atomized or spherical metallic powder in a controlled environment;
   b. Fluid energy mills for grinding or milling ammonium perchlorate, RDX or HMX.

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## ITEM 6 - CATEGORY II

Equipment, "technical data" and procedures for the production of structural composites usable in the systems in Item 1 as follows and specially designed components, and accessories and specially designed software therefor:

(a) Filament winding machines of which the motions for positioning, wrapping and winding fibers are coordinated and programmed in three or more axes, designed to fabricate composite structures or laminates from fibrous and filamentary materials, and coordinating and programming controls;

(b) Tape-laying machines of which the motions for positioning and laying tape and sheets are coordinated and programmed in two or more axes, designed for the manufacture of composite airframes and missile structures;

(c) Interlacing machines, including adapters and modification kits for weaving, interlacing or braiding fibers designed to fabricate composite structures, except textile machinery which has not been modified for the above end uses;

(d) Equipment designed or modified for the production of fibrous and filamentary materials as follows:

(1) Equipment for converting polymeric fibers (such as polyacrylonitrile, rayon or polycarbosilane) including special provision to strain the fibre during heating;

(2) Equipment for the vapor deposition of elements or compounds on heated filament substrates; and

(3) Equipment for the wet-spinning of refractory ceramics (such as aluminum oxide);

(e) Equipment designed or modified for special fibre surface treatment or for producing prepregs and preforms.

(f) "Technical data" (including processing conditions) and procedures for the regulation of temperature, pressures or atmosphere in autoclaves or hydroclaves when used for the production of composites or partially processed composites.

NOTES TO ITEM 6:

1. Examples of components and accessories for the machines covered by this entry are: moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.
2. Equipment covered by subitem (e) includes but is not limited to rollers, tension stretchers, coating equipment, cutting equipment and clicker dies.

## ITEM 7 - CATEGORY II

Pyrolytic deposition and densification equipment and "technology" as follows:

(a) "Technology" for producing pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,300 degrees C to 2,900 degrees C temperature range at pressures of 130 Pa (1 mm Hg) to 20 kPa (150 mm Hg) including technology for the composition of precursor gases, flow-rates, and process control schedules and parameters;

(b) Specially designed nozzles for the above processes;

(c) Equipment and process controls, and specially designed software therefor, designed or modified for densification and pyrolysis of structural composite rocket nozzles and reentry vehicle nose tips.

NOTES TO ITEM 7:

1. Equipment included under (c) above are isostatic presses having all of the following characteristics:

   a. Maximum working pressure of 69 MPa (10,000 psi) or greater;
   b. Designed to achieve and maintain a controlled thermal environment of 600 degrees C or greater; and
   c. Possessing a chamber cavity with an inside diameter of 254 mm (10 inches) or greater.

2. Equipment included under (c) above are chemical vapor deposition furnaces designed or modified for the densification of carbon-carbon composites.

## ITEM 8 - CATEGORY II

Structural materials usable in the systems in Item 1, as follows:

(a) Composite structures, laminates, and manufactures thereof, including resin impregnated fibre prepregs and metal coated fibre preforms therefor, specially designed for use in the systems in Item 1 and the subsystems in Item 2 made either with organic matrix or metal matrix utilizing fibrous or filamentary reinforcements having a specific tensile strength greater than $7.62 \times 10^4$ m ($3 \times 10^6$ inches) and a specific modulus greater than $3.18 \times 10^6$ m ($1.25 \times 10^8$ inches);

(b) Resaturated pyrolized (i.e., carbon-carbon) materials designed for rocket systems;

(c) Fine grain recrystallized bulk graphites (with a bulk density of at least 1.72 g/cc measured at 15 degrees C), pyrolytic, or fibrous reinforced graphites useable for rocket nozzles and reentry vehicle nose tips;

(d) Ceramic composite materials (dielectric constant less than 6 at frequencies from 100 Hz to 10,000 MHz) for use in missile radomes, and bulk machinable silicon-carbide reinforced unfired ceramic useable for nose tips;

(e) Tungsten, molybdenum and alloys of these metals in the form of uniform spherical or atomized particles of 500 micrometer diameter or less with a purity of 97 percent or higher for fabrication of rocket motor components; i.e., heat shields, nozzle substrates, nozzle throats, and thrust vector control surfaces;

(f) Maraging steels (steels generally characterized by high nickel, very low carbon content and the use of substitutional elements to produce age-hardening) having an Ultimate Tensile Strength of $1.5 \times 10^9$ Pa or greater, measured at 20 C.

NOTE TO ITEM 8:

Maraging steels are only covered by 8(f) above for the purpose of this Annex in the form of sheet, plate or tubing with a wall or plate thickness equal to or less than 5.0 mm (0.2 inch).

## ITEM 9 - CATEGORY II

Instrumentation, navigation and direction finding equipment and systems, and associated production and test equipment as follows; and specially designed components and software therefor:

(a) Integrated flight instrument systems, which include gyrostabilizers or automatic pilots and integration software therefor, designed or modified for use in the systems in Item 1;

(b) Gyro-astro compasses and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites;

(c) Accelerometers with a threshold of 0.05 g or less, or a linearity error within 0.25 percent of full scale output, or both, which are designed for use in inertial navigation systems or in guidance systems of all types;

(d) All types of gyros usable in the systems in Item 1, with a rated drift rate stability of less than 0.5 degree (1 sigma or rms) per hour in a 1 g environment;

(e) Continuous output accelerometers or gyros of any type, specified to function at acceleration levels greater than 100 g;

(f) Inertial or other equipment using accelerometers described by subitems (c) and (e) above or gyros described by subitems (d) or (e) above, and systems incorporating such equipment, and specially designed integration software therefor;

(g) Specially designed test, calibration, and alignment equipment, and "production equipment" for the above, including the following:

(1) For laser gyro equipment, the following equipment used to characterize mirrors, having the threshold accuracy shown or better: (i) Scatterometer (10 ppm); (ii) Reflectometer (50 ppm); (iii) Profilometer (5 Angstroms)

(2) For other inertial equipment: (i) Inertial Measurement Unit (IMU Module); (ii) IMU Platform Tester; (iii) IMU Stable Element Handling Fixture; (iv) IMU Platform Balance Fixture; (v) Gyro Tuning Test Station; (vi) Gyro Dynamic Balance Station; (vii) Gyro Run-in/Motor Test Station; (viii) Gyro Evacuation and Filling Station; (ix) Centrifuge Fixture for Gyro Bearings; (x) Accelerometer Axis Align Station; (xi) Accelerometer Test Station.

NOTES TO ITEM 9:

1. Items (a) through (f) may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.
2. In subitem (d):
   a. Drift rate is defined as the time rate of output deviation from the desired output. It consists of random and systematic components and is expressed as an equivalent angular displacement per unit time with respect to inertial space.
   b. Stability is defined as standard deviation (1 sigma) of the variation of a particular parameter from its calibrated value measured under stable temperature conditions. This can be expressed as a function of time.

## ITEM 10 - CATEGORY II

Flight control systems and "technology" as follows; designed or modified for the systems in Item 1 as well as the specially designed test, calibration, and alignment equipment therefor:

(a) Hydraulic, mechanical, electro-optical, or electro-mechanical flight control systems (including fly-by-wire systems);

(b) Attitude control equipment;

(c) Design technology for integration of air vehicle fuselage, propulsion system and lifting control surfaces to optimize aerodynamic performance throughout the flight regime of an unmanned air vehicle;

(d) Design technology for integration of the flight control, guidance, and propulsion data into a flight management system for optimization of rocket system trajectory.

NOTE TO ITEM 10:

Items (a) and (b) may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

## ITEM 11 - CATEGORY II

Avionics equipment, "technology" and components as follows; designed or modified for use in the systems in Item 1, and specially designed software therefor:

(a) Radar and laser radar systems, including altimeters;

(b) Passive sensors for determining bearings to specific electromagnetic sources (direction finding equipment) or terrain characteristics;

(c) Global Positioning System (GPS) or similar satellite receivers;

(1) Capable of providing navigation information under the following operational conditions:

(i) At speeds in excess of 515 m/sec (1,000 nautical miles/ hour); and

(ii) At altitudes in excess of 18 km (60,000 feet); or

(2) Designed or modified for use with unmanned air vehicles covered by Item 1.

(d) Electronic assembles and components specially designed for military use and operation at temperatures in excess of 125 degrees C.

(e) Design technology for protection of avionics and electrical subsystems against electromagnetic pulse (EMP) and electromagnetic interference (EMI) hazards from external sources, as follows:

(1) Design technology for shielding systems;

(2) Design technology for the configuration of hardened electrical circuits and subsystems;

(3) Determination of hardening criteria for the above.

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NOTES TO ITEM 11:

1. Item 11 equipment may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

2. Examples of equipment included in this Item: terrain contour mapping equipment; scene mapping and correlation (both digital and analog) equipment; doppler navigation radar equipment; passive interferometer equipment; and imaging sensor equipment (both active and passive);

3. In subitem (a), laser radar systems embody specialized transmission, scanning, receiving and signal processing techniques for utilization of lasers for echo ranging, direction finding and discrimination of targets by location, radial speed and body reflection characteristics.

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## ITEM 12 - CATEGORY II

Launch support equipment, facilities and software for the systems in Item 1, as follows:

(a) Apparatus and devices designed or modified for the handling, control, activation and launching of the systems in Item 1;

(b) Vehicles designed or modified for the transport, handling, control, activation and launching of the systems in Item 1;

(c) Gravity meters (gravimeters), gravity gradiometers, and specially designed components therefor, designed or modified for air borne or marine use, and having a static or operational accuracy of $7 \times 10^6$ m/sec$^2$ (0.7 milligal) or better, with a time to steady-state registration of two minutes or less;

(d) Telemetering and telecontrol equipment usable for unmanned air vehicles or rocket systems;

(e) Precision tracking systems:

(1) Tracking systems which use a translator installed on the rocket system or unmanned air vehicle in conjunction with either surface or airborne references or navigation satellite systems to provide real-time measurements of in-flight position and velocity;

(2) Range instrumentation radars including associated optical/infrared trackers and the specially designed software therefor with all of the following capabilities:

(i) angular resolution better than 3 milli-radians (0.5 mils);

(ii) range of 30 km or greater with a range resolution better than 10 meters RMS;

(iii) velocity resolution better than 3 meters per second.

(3) Software which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path.

## ITEM 13 - CATEGORY II

Analog computers, digital computers, or digital differential analyzers designed or modified for use in the systems in Item 1, having either of the following characteristics:

(a) Rated for continuous operation at temperatures from below minus 45 degrees C to above plus 55 degrees C; or

(b) Designed as ruggedized or "radiation hardened."

NOTE TO ITEM 13:

Item 13 equipment may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

## ITEM 14 - CATEGORY II

Analog-to-digital converters, usable in the systems in Item 1, having either of the following characteristics:

(a) Designed to meet military specifications for ruggedized equipment; or,

(b) Designed or modified for military use; and being one of the following types:

(1) Analog-to-digital converter "microcircuits," which are "radiation hardened" or have all of the following characteristics:

(i) Having a resolution of 8 bits or more;

(ii) Rated for operation in the temperature range from below minus 54 degrees C to above plus 125 degrees C; and

(iii) Hermetically sealed.

(2) Electrical input type analog-to-digital converter printed circuit boards or modules, with all of the following characteristics:

(i) Having a resolution of 8 bits or more;
(ii) Rated for operation in the temperature range from below minus 45 degrees C to above plus 55 degrees C; and
(iii) Incorporating "microcircuits" listed in (1), above.

## ITEM 15 - CATEGORY II

Test facilities and test equipment usable for the systems in Item 1 and Item 2 as follows; and specially designed software therefor:

(a) Vibration test equipment using digital control techniques, and feedback or closed loop test equipment therefor, capable of vibrating a system at 10 g RMS or more between 20 Hz and 2,000 Hz and imparting forces of 50 kN (11,250 lbs) or greater;

(b) Wind-tunnels for speeds of Mach 0.9 or more;

(c) Test benches/stands which have the capacity to handle solid or liquid propellant rockets or rocket motors of more than 90 KN (20,000 lbs) of thrust, or which are capable of simultaneously measuring the three axial thrust components;

(d) Environmental chambers and anechoic chambers capable of simulating the following flight conditions:

(1) Altitude of 15,000 meters or greater; or
(2) Temperature of at least minus 50 degrees C to plus 125 degrees C; and either
(3) Vibration environments of 10 g RMS or greater between 20 Hz and 2,000 Hz imparting forces of 5 kN or greater, for environmental chambers; or
(4) Acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to 2 x $10^5$ N per square meter) or with a rated power output of 4 kiloWatts or greater, for anechoic chambers.

(e) Radiographic equipment capable of delivering electromagnetic radiation produced by "bremsstrahlung" from accelerated electrons of 2 MeV or greater or by using radioactive sources of 1 MeV or greater, except those specially designed for medical purposes.

NOTE TO ITEM 15 (a):
The term "digital control" refers to equipment, the functions of which are, partly or entirely, automatically controlled by stored and digitally coded electrical signals.

## ITEM 16 - CATEGORY II

Specially designed software, or specially designed software with related specially designed hybrid (combined analog/digital) computers, for modeling, simulation, or design integration of the systems in Item 1 and Item 2.

NOTE TO ITEM 16:
The modeling includes in particular the aerodynamic and thermodynamic analysis of the systems.

## ITEM 17 - CATEGORY II

Material, devices, and specially designed software for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e., stealth technology), for applications usable for the systems in Item 1 or Item 2, for example:

(a) Structural materials and coatings specially designed for reduced radar reflectivity;

(b) Coatings, including paints, specially designed for reduced or tailored reflectivity or emissivity in the microwave, infrared or ultraviolet spectra, except when specially used for thermal control of satellites.

(c) Specially designed software or databases for analysis of signature reduction.

(d) Specially designed radar cross section measurement systems.

## ITEM 18 - CATEGORY II

Devices for use in protecting rocket systems and unmanned air vehicles against nuclear effects (e.g., Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems in Item 1, as follows:

(a) "Radiation Hardened" "microcircuits" and detectors.

(b) Radomes designed to withstand a combined thermal shock greater than 100 cal/sq cm accompanied by a peak over pressure of greater than 50 kPa (7 pounds per square inch).

NOTE TO ITEM 18(a):
A detector is defined as a mechanical, electrical, optical or chemical device that automatically identifies and records, or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal or radiation from a radioactive material.

## ITEM 19 - CATEGORY II

Complete rocket systems (including ballistic missile systems, space launch vehicles, and sounding rockets) and unmanned air vehicles (including cruise missile systems, target drones and reconnaissance drones), not covered in Item 1, capable of a maximum range equal or superior to 300 km.

## ITEM 20 - CATEGORY II

Complete subsystems, as follows, usable in the systems in Item 19 but not in the systems in Item 1, as well as specially designed "production facilities" and "production equipment" therefor:

(a) Individual Rocket Stages.

(b) Solid or liquid propellant rocket engines, having a total impulse capacity of $8.41 \times 10^5$ N-sec ($1.91 \times 10^5$ lb-sec) or greater, but less than $1.1 \times 10^6$ N-sec ($2.5 \times 10^5$ lb-sec).

Reproduced from: [Department of State, Office of Politico-Military Affairs], "Summary of the Equipment and Technology Annex," ([Washington, DC]: [US Department of State, Office of Politico-Military Affairs], n.d.); and [Department of State, Office of Politico-Military Affairs], "Missile Technology Control Regime (MTCR): Equipment and Technology Annex," ([Washington, DC]: [US Department of State, Office of Politico-Military Affairs], 1 July 1993).

# APPENDIX C

# THE COCOM INTERNATIONAL MUNITIONS LIST: UAV-RELATED ITEMS OF INTEREST

## MUNITIONS LIST ITEM 10—A PARTIAL LISTING

ML10 "Aircraft" (note that the definition for "aircraft" includes helicopters.), unmanned airborne vehicles, aero-engines and "aircraft" equipment, related equipment and components, specially designed or modified for military use, as follows:

a. Combat "aircraft" and specially designed components therefor;

b. Other "aircraft" specially designed or modified for military use, including military reconnaissance, assault, military training, transporting and airdropping troops or military equipment, logistics support, and specially designed components therefore;

c. Aero-engines specially designed or modified for military use, and specially designed components therefor:

d. Unmanned airborne vehicles, including remotely piloted air vehicles (RPVs), and autonomous, programmable vehicles specially designed or modified for military use and their launchers, ground support and related equipment for command and control. . . .

NOTES:

1. Sub-item b. does not embargo "aircraft" designed or modified for military use which have been certified for civil use by the civil aviation authorities of a member country and which are equipped to international civilian standards, or specially designed components therefor;

2. Sub-item c. does not embargo:

   a. Aero-engines designed or modified for military use which have been certified by civil aviation authorities in a member country for use in "civil aircraft", or specially designed components therefore; . . .

3. The embargo in sub-items b. and c. on specially designed components and related equipment for non-military "aircraft" or aero-engines modified for military use applies only to those military components and to military related equipment required for the modification to military use.

## SUMMARY OF ADDITIONAL MUNITIONS LIST ITEMS OF INTEREST

| | |
|---|---|
| ML4 | Rockets and missiles and associated decoying and jamming equipment. |
| ML5 | Fire control systems including target acquisition, designation, range-finding, surveillance or tracking systems as well as detection, recognition, or identification equipment, and sensor integration equipment. |
| ML8 | Military explosives, fuels (solid or liquid), and liquid oxidizers, including aircraft fuels specially formulated for military purposes. |
| ML11 | Electronic countermeasure and electronic counter-countermeasure equipment. |
| ML14 | Missile launch trainers, target equipment, drone aircraft, and pilot-less aircraft trainers. |
| ML15 | Imaging equipment specially designed for military use including infrared or thermal imaging equipment and imaging radar sensor equipment. |
| ML 16 | Forgings, castings and semi-finished products specially designed for the products embargoed by items ML4 and ML10. |
| ML17 | Miscellaneous equipment materials and libraries, and specially designed components for the fittings, coatings, and treatments for signature suppression that are specially designed for military use. |

Source: United Kingdom Department of Transportation and Industry, *CoCom Lists and Notes, Supplement 2* (London: United Kingdom Department of Transportation and Industry, August 1993), 54, 58, 64-68.

## APPENDIX D

# THE COCOM INTERNATIONAL INDUSTRIAL LIST: CONDENSED LISTING OF AEROSPACE EQUIPMENT AND TECHNOLOGIES

## CATEGORY 1: ADVANCED MATERIALS

- Electromagnetic wave absorbers, related software and technologies.
- Nickel or titanium alloys, related software and technologies.
- Ceramic base materials and composites, related software and technologies.
- Fluorinated compounds, related software and technologies.
- Fibrous and filamentary materials, related software and technologies.

## CATEGORIES 3 & 4: ELECTRONICS AND COMPUTERS

- Electronic computers and related equipment, including assemblies and specially designed components, as follows: rated for operation at temperatures below -45 degrees Celsius or above 85 degrees Celsius; radiation hardened.
- Digital computers primarily designed for strategic applications and having a composite theoretical performance exceeding 20 million theoretical operations per second.
- Hybrid computers containing embargoed digital computers or embargoed analog-to-digital or digital-to-analog converters.
- Analog-to-digital and digital-to-analog converters.
- Radiation-hardened integrated circuits.

## CATEGORY 6: SENSORS AND LASERS

- Optical detectors as follows: (1) space-qualified, single-element or focal plane array (linear or two dimensional), (2) non-space-qualified linear or two dimensional focal plane arrays, and (3) image intensifier tubes.
- Radar systems, equipment and assemblies, having characteristics including inter alia: designed specially for airborne operation and having Doppler signal processing for the detection of moving targets; capable of heightfinding non-cooperative targets; having data processing subsystems with processing for automatic pattern recognition and comparison with target characteristic data bases, or subsystems for correlation or fusion of target data to discriminate targets.

- Laser radar or LIDAR equipment employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less than 20 microradians.

## CATEGORY 7: NAVIGATION AND AVIONICS

- Accelerometers designed for use in inertial navigation or guidance systems and having any of the following characteristics, and specially designed components therefor: (1) a bias stability of less than 130 micro g with respect to a fixed calibration value over a period of one year; (2) a scale factor stability of less than 130 ppm with respect to a fixed calibration value over a period of one year; or, (3) specified to function at linear acceleration levels exceeding 100 g.
- Gyros having any of the following characteristics, and specially designed components therefor: (1) a drift rate stability, when measured in a 1 g environment over a period of three months and with respect to a fixed calibration value, of (a) less than 0.1 degrees per hour when specified to function continuously below 10 g, or (b) less than 0.5 degrees per hour when specified to function from 10 to 100 g inclusive or, (2) specified to function at linear acceleration levels above 100 g.
- Aircraft inertial navigation systems (gimballed and strapdown) and inertial equipment for attitude, guidance or control having any of the following characteristics, and specially designed components therefor: (1) navigation error (free inertial) of 0.8 nautical mile per hour (50% Circular Error Probable (CEP)) or less subsequent to normal alignment, (2) not certified for use on civil aircraft by civil aviation authorities of a member country, or (3) specified to function at linear acceleration levels exceeding 10 g.
- Gyro-astro compasses, and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, with an azimuth accuracy of equal to or less than 5 seconds of arc.
- GPS receiving equipment having either of the following characteristics, and specially designed components therefor: (1) employing encryption/decryption, or (2) a null-steerable antenna.
- Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz GHz inclusive, having either of the following characteristics: (1) power management, or (2) using phase shift key modulation.
- Technology for the development or production of airborne automatic direction finding equipment operating at frequencies exceeding 5 MHz.
- Development technology for active flight control systems (including fly-by-wire or fly-by-light).

## CATEGORY 9: PROPULSION

- Aero gas turbine engines that are either (1) not certified for civil use by the aviation authorities in a member country, or (2) designed to cruise at speeds exceeding Mach 1.2 for more than 30 minutes and contain embargoed items, including, inter alia: directionally solidified or single crystal turbine blades, vanes, or tip shrouds; combustors incorporating thermally decoupled liners, non-metallic liners or shells; components manufactured from organic or metal matrix composite materials; airfoil-to-disk combinations using solid state joining; components using diffusion bonding technology; and adjustable flow path geometry.
- Liquid rocket propulsion systems containing embargoed technologies, including, inter alia: cryogenic systems, e.g., refrigerators, heat pipes, con tainers, and closed-cycle systems; slush hydrogen storage or transfer sys tems; high-pressure turbo pumps and components; high-pressure thrust chambers and nozzles therefor; propellant storage systems with flexible bladders.
- Solid rocket propulsion systems with, inter alia: a total impulse capacity exceeding 1.1 MNs or specific impulse of 2.4 kNs/kg or more when the nozzle flow is expanded to ambient sea level conditions for an adjusted chamber pressure of 7 MPa; and those employing embargoed technologies. The latter include, inter alia, filament-wound composite motor cases; movable nozzle and secondary fluid injection thrust vector control systems; nozzles with thrust levels exceeding 45 kN.
- Hybrid rocket propulsion systems with, (1) a total impulse capacity exceeding 1.1 MNs, or (2) thrust levels exceeding 220 kN in vacuum exit conditions.
- Ramjet, scramjet, or combined cycle engines and specially designed components therefor.

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Sources: United Kingdom Department of Transportation and Industry, *CoCom Lists and Notes, Supplement 2* (London: United Kingdom Department of Transportation and Industry, August 1993), 12, 18, 47-48; and United Kingdom Department of Transportation and Industry, *Security Export Control* (London: United Kingdom Department of Transportation and Industry, September 1991), 5, 19, 24, 26, 39, 43-44, 47-49, 52-54.

## APPENDIX E

# SELECTED AERODYNAMIC MISSILE PROGRAMS AND EXPORTS

TABLE E-1: World Aerodynamic Missile Export Market

TABLE E-2: Selected Third World Aerodynamic Missile Programs

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Sources: W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, Connecticut: Praeger Publishers, 1992), 124-140; System Planning Corporation, *Ballistic Missile Proliferation: An Emerging Threat 1992* (Arlington, Virginia: System Planning Corporation, 1992), 77-91; Duncan S. Lennox and Arthur Rees, eds., *Jane's Air-Launched Weapons*, (Surrey, United Kingdom: Jane's Information Group, 1990); "International Missiles," *Aviation Week & Space Technology* 136, no. 11 (16 March 1992): 80-82; and "International Gas Turbine Engines," *Aviation Week & Space Technology* 136, no. 11 (16 March 1992): 88-90.

# TABLE E-1
# WORLD AERODYNAMIC MISSILE EXPORT MARKET

| COUNTRY/ *MISSILE* | RANGE [km]/ PAYLOAD [kg] | RECIPIENTS |
|---|---|---|
| UNITED STATES | | |
| *Harpoon* | 120/220 | Australia, Brunei, Canada, Denmark, Egypt, Germany, Greece, Indonesia, Iran, Israel, Japan, South Korea, Kuwait, Netherlands, Pakistan, Portugal, Saudi Arabia, Singapore, Spain, Thailand, Turkey, United Kingdom, Venezuela |
| Former USSR | | |
| *SS-N-2 (Styx)* | 38-80/ 400-500 | Algeria, Angola, Bulgaria, China, Cuba, East Germany, Egypt, Ethiopia, Finland, India, Iraq, Libya, North Korea, Poland, Romania, Somalia, Syria, Tunisia, Vietnam, Yemen, Yugoslavia |
| *SS-N-3b (Sepal)* | 450/1,000 | Syria |
| *SS-N-7 (Starbright)* | 100/500 | India |
| *SS-N-22 (Sunburn)* | 110/500 | Iran |
| *AS-5 (Kelt)* | 180/1,000 | Egypt |
| *AS-9 (Kyle)* | 90/200 | Bulgaria, Czechoslovakia, East Germany, Hungary, Iraq, Libya, Poland, Romania |
| CHINA | | |
| *HY-1* | 40/400 | Bangladesh, Egypt, North Korea, Pakistan |
| *HY-2 Silkworm* | 80/500 | Iran, Iraq, North Korea |
| *HY-4* | 150/500 | Iran |
| *FL-1* | 40/500 | Bangladesh, Pakistan, Thailand, Egypt |
| *YJ-1* | 40/165 | Thailand |
| *C-601* | 95/500 | Iran |
| FRANCE | | |
| *Exocet MM 38* | 40/165 | Argentina, Belgium, Brazil, Brunei, Chile, Ecuador, West Germany, Greece, Indonesia, Iraq, South Korea, Malaysia, Morocco, Nigeria, Peru, Thailand, United Kingdom |
| *Exocet MM 40* | 70/165 | Argentina, Bahrain, Brazil, Brunei, Cameroon, Colombia, Ecuador, Kuwait, Morocco, Oman, Qatar, Singapore, Tunisia, United Arab Emirates |
| *Exocet AM 39* | 50-70/165 | Argentina, Egypt, Iraq, India, Kuwait, Libya, Oman, Pakistan, Peru, Qatar, Singapore, South Africa |
| *Armat* | 90/150 | Egypt, Iraq, Kuwait |
| UNITED KINGDOM | | |
| *Sea Eagle* | 110/230 | India, Oman, Saudi Arabia |
| *Sea Eagle SL* | 110/230 | South Korea (unconfirmed or pending) |
| *ALARM* | 45/? | Saudi Arabia (unconfirmed or pending) |
| ITALY | | |
| *Otomat Mk 1* | 60/210 | Egypt, Iraq, Kenya |
| *Otomat Mk 2* | 180/210 | Libya, Nigeria, Peru, Saudi Arabia, Venezuela |
| ISRAEL | | |
| *Gabriel Mk 1* | 20/100 | Singapore, Thailand |
| *Gabriel Mk 2* | 40/180 | Chile, Ecuador, Kenya, Taiwan, South Africa |
| *Gabriel Mk 3* | 35-60/150 | Chile |

# TABLE E-2
# SELECTED THIRD WORLD
# AERODYNAMIC MISSILE PROGRAMS

| COUNTRY | MISSILE | RANGE [km]/ PAYLOAD [kg] | LAUNCH MODE | PROPULSION | STATUS |
|---|---|---|---|---|---|
| Argentina | *MQ-2 Bigua* | 900/40-70 | A,S | Turbojet | ? |
| Brazil | *SM-70 Barracuda* | 70/? | S | Rocket | ? |
| India | *Lakshya* | 500/200 | S | Turbojet | IOC 1994 |
| | *Sagaricka* | 300/? | S | Turbojet? | IOC 2000? |
| Iraq | *FAW-70* | 80/500 | S | Rocket | IOC 1991 |
| | *FAW-150* | 150/500 | S | Rocket | IOC 1991 |
| | *FAW-200* | 200/500 | S | Rocket | IOC 1991 |
| | *Ababil* | 500?/200? | A | Turbojet | IOC 1988? |
| Israel | *Gabriel MK 1* | 20/100 | S | Rocket | IOC 1969 |
| | *Gabriel MK 2* | 40/180 | S | Rocket | IOC 1976 |
| | *Gabriel MK 3* | 35-60/150 | A,S | Rocket | IOC 1980 |
| | *Gabriel Mk 4* | 200/150-200 | A,S | Turbojet | IOC 1993 |
| | *Popeye* | 100/360 | A | Rocket | IOC 1990 |
| N. Korea | *HY-2 Silkworm* | 80/500 | S | Rocket | ? |
| S. Africa | *Skorpioen* | 40/180? | S | Rocket | ? |
| | *Skorpioen-2* | ?/? | ? | Turbojet? | ? |
| | *Skua* | 800/100 | S | Turbojet | ? |
| Taiwan | *Hsiung Feng-1* | 40/180? | S | Rocket | IOC 1980 |
| | *Hsiung Feng-2* | 80/75 | A,S | Turbojet | IOC 1993 |

A = Air
S = Surface
IOC = Initial operating capability