Controlling Unmanned Air Vehicles: New Challenges

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Even though ballistic missiles dominated missile nonproliferation deliberations during the last decade of the twentieth century, land-attack cruise missiles (LACMs)—most notably the U.S. Tomahawk—figured into no less than seven different military contingencies in that time. The Tomahawk's most impressive role was its widespread use against Iraq during Operation Desert Storm, when during the first hours of the air campaign, Tomahawk strikes greatly leveraged the subsequent effectiveness of manned aircraft by destroying critical Iraqi air defense and command and control targets. Tomahawks also figured into a variety of much smaller-scale contingencies, the most controversial of which were the attacks on the al-Shifa pharmaceutical plant in Khartoum, Sudan, and al-Qaeda camps in Afghanistan in retaliation for the al-Qaeda–sponsored embassy bombings in Africa in August 1998.

Although the al-Shifa pharmaceutical plant attack dominated press scrutiny, the ineffectiveness of cruise missile attacks on Osama bin Laden's Afghan camps generated significant interest in new roles for unarmed and, subsequently, armed unmanned air vehicles (UAVs)—even before the terrorist attacks of September 11, 2001. Unarmed UAVs, with their extended loiter capability, could provide surveillance and communications connectivity superior to that of manned aircraft. But armed UAVs could do more. In the aftermath of the terrorist attacks on New York City and the Pentagon, the United States for the first time effectively unleashed Predators armed with two Hellfire missiles for use in Afghanistan, and most prominently, in a pinpoint attack against a top al-Qaeda operative and five companions in Yemen. The notion of combining real-time eyes, by way of several organic surveillance packages, with a weapon allowing for the virtually instantaneous engagement of so-called time-critical targets, was powerfully appealing. Assuming that the authorization to fire could be prearranged or achieved quickly, such a combined sensor and weapons-carrying UAV would more than compensate for the limitations of using LACMs launched from great distances hours after acquiring targeting intelligence. Arguably, the armed UAV has become the most prominently featured military instrument in America's first war of the 21st century.

THE THREAT

The employment of UAVs promises to make military operations more discriminating in their effects. But, as this trend establishes itself, more ominous possibilities are emerging. UAVs—both armed and unarmed—are growing larger. They are breaching the threshold of the most restrictive international nonproliferation restraints. And civilian applications for UAVs are developing. These trends, combined with the inherent capability of UAVs to deliver nuclear, biological, or chemical payloads, set the stage for a new level of proliferation threat—one sharply at odds with a discriminating use of force.

The U.S. use of armed Predators raises important questions, not only about how UAVs will help shape America's current military transformation, but also about to what extent other countries or terrorist groups might emulate U.S. actions and transform their own unarmed UAVs or small manned aircraft into unmanned weapons-delivery systems or crude terror weapons. Recent inspections in Iraq have uncovered a UAV that reportedly is the system that Secretary of State Colin Powell discussed before the United Nations (UN) Security Council in early February 2003 as having been test-flown 500 kilometers (km) around a racetrack, perhaps autonomously.[2] Equipped with sprayers that Iraq is known to have tested, such a UAV could threaten regional targets, and conceivably even U.S. ones, were such a vehicle launched from a ship offshore or covertly transported into the United States.

The Strategic Setting

Although the world's UAV inventory is imprecisely documented, according to one recent study at least 40 countries produce more than 600 different UAVs, nearly 80 percent of which could be flown in one-way ranges of over 300 km, and many substantially farther.[3] Moreover, a small fraction of the world's inventory of anti-ship cruise missiles—primarily first-generation models with substantial airframe volume—could be converted into land-attack missiles with ranges exceeding 300 km. Further, there are inviting loopholes in the Missile Technology Control Regime (MTCR) that permit aerospace firms to sell flight management systems specifically designed to turn small manned aircraft (including kit-built ones) into autonomously guided and armed UAVs. Finally, a country or terrorist group motivated to develop a crude cruise missile or UAV either on its own or with some foreign assistance could readily take advantage of the last decade's quantum leap in dual-use technologies that comprise the chief components of autonomous air-vehicle development. These technologies include satellite navigation and guidance furnished primarily by the U.S.'s Global Positioning System, high-resolution satellite imagery from a growing number of commercial vendors, and digital mapping technologies for mission planning.[4] Indeed, the ability of virtually any person or small group with the appropriate knowledge and skills to build a simple, autonomous, self-guided cruise missile with a significant payload has reached a new and dangerous level. The most egregious example is that of a New Zealand engineer, Bruce Simpson, who runs a popular technical website. To demonstrate explicitly the ease with which such a cruise missile could be built by "almost any person or small group of persons with the necessary knowledge and skills," Simpson has created a website with the title "Do-It-Yourself Cruise Missile," where he is documenting his ongoing effort to build one in his garage for less than $5,000.[5]

The Impact of Proliferation on U.S. Military Dominance

Should cruise missiles and armed UAVs spread widely and become a dominant feature of military operations or terrorist activity in the 21st century, the international security consequences could be profound. Ironically, perhaps the most significant impact would rebound on the United States—doubtless the most advanced nation around the globe in developing and exploiting LACMs and UAVs for military benefit. The proliferation of LACMs and UAVs to complement ballistic missiles could conceivably bolster the capacities of America's adversaries to oppose U.S.-led interventions in strategically important ways. LACMs and UAVs could furnish new military leverage, due in significant part to the capacity of cruise missiles to enlarge the effective lethal area of biological attacks by at least a factor of ten over ballistic missiles (their steady horizontal flight pattern allows them to release agent along a line of contamination).[6] In addition, the potentially high accuracy of LACMs suggests that even conventionally armed missiles may be able to inflict significant damage on exposed targets. To envisage such damage, one need only consider the airbases that U.S.-led coalition forces used during Operation Desert Storm on which aircraft were lined up wingtip-to-wingtip and large tent cities were left open and vulnerable to missile attack.

Cruise missile and UAV proliferation is also likely to create unwanted dilemmas for U.S. missile defenses. The United States is currently spending huge sums to defend against ballistic missile threats. Yet, to the extent that America successfully pursues effective theater and national missile defenses against ballistic missiles, nations and terrorist groups alike will be strongly motivated to acquire LACMs and armed UAVs. For example, the low cost of some cruise missiles and, especially, small airplanes modified to become UAVs, renders the cost-per-kill arithmetic of missile defense exceedingly unfavorable. For example, each Patriot PAC-3 missile costs from $2-5 million, which compares unfavorably with either a $200,000 LACM or $50,000-per-copy kit airplanes transformed into armed UAVs.[7] Because both ballistic and cruise missile defenses for theater campaigns currently depend largely on the same high-cost, high-performance interceptors, cruise as well as ballistic missile attacks, especially saturation attacks and those delivering weapons of mass destruction (WMD) payloads, will present enormous problems for the defender.

Advanced LACMs that fly low and have low observability to air defense radars will raise the cost of cruise missile defense dramatically.[8] Even seemingly easy-to-detect armed UAVs could challenge legacy air defense radars, including the Airborne Warning and Control Systems (AWACS) and some ground-based radars. Around 65 percent of the UAVs deployed today are propelled by reciprocating engines, which means that they fly at speeds of less than 80 knots per hour. Yet expensive air defense radars like AWACS intentionally eliminate slow-flying targets on or near the ground in order to prevent their data processing and display systems from being overly taxed. Although most ground-based air defense radars could probably detect such slow-flying systems, the limited radar horizon of ground-based radars combined with the possibly large raid size of threat means that interceptor batteries could be quickly overwhelmed and their expensive missile inventories rapidly depleted. There are no simple or cheap solutions that readily return the advantage to the defender.

Regional Military Imbalances

Potential or actual adversaries of U.S. military dominance are not merely motivated to acquire long-range missiles to deter or defeat Western-led military interventions. Regional states, rogues or not, may be equally or primarily driven to pursue missile acquisition for uniquely regional reasons. Thus, regional military balances could also be adversely affected by the spread of LACMs and UAVs. Chinese acquisition of M-9 and M-11 ballistic missiles dominates calculations of the China-Taiwan military balance, but with noticeably less fanfare both sides have begun to supplement their arsenals with cruise missiles. Closely timed Chinese cruise and ballistic missiles attacks would severely tax Taiwanese ground-based radars that support their defense of a small number of highly vulnerable airfields.[9]

The already unstable balance of forces between India and Pakistan, too, could be adversely affected by the introduction of cruise missiles and UAVs. According to an Indian report, in early December 2002, a Pakistani reconnaissance UAV violated Indian airspace near the line of control in Kashmir. The flight came immediately after renewed shelling, suggesting that the UAV may have been collecting battle-damage information. Additional Pakistani shelling commenced shortly after the Indian side detected the UAV, probably in an effort to divert attempts to shoot it down.[10] These escalations of tensions in Kashmir have been mimicked in the broader arms-acquisition domain. Pakistan, for its part, is looking to the United States to sell its army either highly sophisticated Predator UAVs or perhaps some less controversial system to replace its own home-grown but limited Vision UAV, in order to improve its monitoring of the Kashmiri line of control.[11]

India is even more active in both its own development and foreign acquisition of cruise missiles and UAVs. Its Lakshya unmanned target drone, which is thought to be capable of delivering a 450-km payload over a 600 km range, will reportedly soon be exported to an unknown country (probably Israel).[12] Israel, in turn, is supplying India initially with two Heron long-range reconnaissance UAVs, with more to follow, to support India's first major UAV base, located at the southern naval command in Kochi.[13] More controversial—because of its potentially unwanted impact on MTCR effectiveness—is India's and Russia's co-development of the Brahmos dual-mode (anti-ship and land-attack) supersonic cruise missile, capable of delivering a 200 kilogram (kg) payload to a range of 300 km. Both partners have openly expressed great interest in large export sales of the Brahmos. The most provocative development, however, derives from reports that Russia has recently agreed to lease India an Akula II nuclear submarine outfitted with 300-km-range Club nuclear-capable cruise missiles. Indian military analysts have already begun to characterize India as possessing a "sea-based nuclear deterrent."[14]

Cruise missiles also figure into tensions in the Middle East. Israel is a major developer of reconnaissance UAVs, has deployed its own Popeye air-launched LACM, and has probably deployed nuclear-armed cruise missiles on its submarines.[15] Of course, ballistic missiles played a central role in the Iran-Iraq 1980-1988 War of the Cities. While both countries have had ongoing ballistic missile development programs, and more recently had cruise missiles and UAVs as a part of their missile arsenals, now (post-Operation Iraqi Freedom), only Iran has an active program. Iran has acquired cruise missile technology—probably from Russia and China—for its own program for developing an anti-ship cruise missile, called the Nur, which comes in both a ground- and air-launched version. China has also exported various versions of the Silkworm anti-ship cruise missile to Iran; older versions, like the HY-2 or HY-4, could be converted into land-attack missiles with ranges of at least 500-700 km.[16] Iraq, for its part, has had a longstanding interest in developing LACMs, including a program in the 1980s to convert the Italian Mirach 600 UAV into an LACM. Evidence is also accumulating that a team of engineers in Yugoslavia had been working on a 1,400-km-range LACM for Iraq, although it reportedly was only in the conceptual stage.[17] More ominous was Iraq's transformation of Czech L-29 trainer aircraft into unmanned drones capable, in theory, of flying to ranges in excess of 600 km, although Secretary of State Colin Powell told the UN Security Council in February 2003 that Iraq had abandoned the L-29 in favor of a home-grown UAV that had been tested on a racetrack flying autonomously for 500 km. Such UAVs, outfitted with the kinds of spray tanks that the Iraqis are known to have experimented with, could have had devastating consequences had they delivered biological or even chemical payloads against regional targets, since an unmanned aircraft's flight stability permits it to effectively release and spray biological agent along a line of contamination. While perhaps only 10 percent of a liquid anthrax payload might survive the explosive impact of an Iraqi-style ballistic missile, nearly the entire capacity of an L-29 spray tank (reportedly containing 300 liters) would be available for dissemination—a factor of 15 better than ballistic missiles.[18]

Defending the Homeland

LACMs and UAVs also have strategic implications for homeland defense. Traditional threat analyses employ "range rings" to show the distance beyond a nation's borders that its missiles can reach. But UAVs can destroy the relevance of range rings. Cruise missiles or armed UAVs might be launched from concealed locations at modest distances from their targets, or brought within range and launched from freighters or commercial container ships—in effect, a "two stage" form of delivery. The mere fact that a ship-launched LACM, fired from outside territorial waters, could strike many of the world's large population centers or industrial areas, ought to factor into decisions about protecting homeland populations against missile attack. In the aftermath of the September 11th terrorist attacks, key U.S. decisionmakers have begun seriously to contemplate such threats.[19] Various National Intelligence Estimates (NIEs) have drawn attention to the covert conversion of a commercial container ship as a launching pad for a cruise missile. There are thousands of such vessels in the international fleet; U.S. ports alone handle more than 13 million containers annually. Even a large, bulky cruise missile like the Chinese HY-4 Silkworm, equipped with a small internal erector for launching, could readily fit inside a standard 12-meter shipping container. Indeed, the latest NIE argues that because such an item, among several others, is less costly, easier to acquire, and more reliable than an intercontinental ballistic missile, a cruise missile attack is more likely to occur than is a ballistic missile strike.[20]

The offshore option is not the only cruise missile or UAV threat to worry about. Absent effective controls on autonomous flight management systems, the prospect of converting small airplanes into weapons-carrying UAVs becomes truly alarming. September 11th provoked a rash of reforms to cope with future terrorist use of a large commercial airliner as a weapon, but these reforms address commercial, not private, aviation. Even though small converted airplanes cannot begin to approximate the effects of using a large airliner, the fact that gasoline, when mixed with air, releases 15 times the energy of an equal amount of TNT means that even small airplanes can do significant damage against certain civilian targets. As we have noted, such means are the best method for effectively delivering biological agents. Most important, because such small airplanes could originate from domestically based terrorists and kit-built airplanes do not need a hardened strip to take-off, they could be launched from hidden locations in relatively close proximity to their intended targets. The notion that a terrorist group might entertain the use of an unmanned attack is by no means far-fetched. One recent accounting of terrorist activity notes 43 recorded cases involving 14 terrorist groups in which remote-controlled delivery systems were "either threatened, developed or actually utilized."[21] Such threats may explain in part why MTCR member states agreed at their last plenary meeting in Warsaw, Poland, to strengthen efforts to limit the risk of controlled items and their technologies falling into the hands of terrorist groups or individuals.[22]

The challenges and prospective costs of defending against both offshore and domestic cruise missile threats are enormous. The North American Aerospace Defense

Command (NORAD) is currently studying the idea of an unmanned airship operating at an altitude of 70,000 feet and carrying sensors to monitor and detect offshore low-flying cruise missiles. Several such airships would be needed together with fast-moving interceptors to cope with perceived threats. An architecture of perhaps 100 aerostats flying at an altitude of 15,000 feet could act as a complementary or alternative system of surveillance and fire control for an interceptor fleet. But additional problems remain. A means of furnishing warning information to the Coast Guard is needed on potentially hostile ships embarking from ports of concern. Sensor data on missile threats must be made able to distinguish between friendly and enemy threats prior to threat engagement. Progress in national cruise missile defense will not occur without corresponding improvements in respective service programs. But the latter efforts lack the necessary funding and are burdened by palpable service interoperability and doctrinal and organizational constraints. The question of affordability looms large: It is safe to say that even a limited defense against offshore cruise missiles would cost at least $30-40 billion, which is never taken into consideration when debate occurs about the costs of national ballistic missile defense. Finally, none of these costs or technical challenges pertains to improved defenses against domestic threats. In the aftermath of the September 11th attacks, NORAD had no internal air picture, nor were its radar assets linked with those of the Federal Aviation Administration (FAA), which controls internal U.S. air traffic. Progress toward making such a linkage has occurred, but major holes remain, especially when dealing with detecting low- and slow-flying air targets.[23] In sum, missile defenses against offshore cruise missiles and domestic terrorist attacks employing small airplanes will remain for at least the next decade operationally and technically problematic as well as financially taxing. The stress on such defenses will grow worse if UAV proliferation gets out of hand.

Trends in UAV Applications

UAVs fit importantly into Secretary of Defense Donald Rumsfeld's view of a transformed U.S. military. Upset with the lengthy time it has taken to build up responses to military crises, Rumsfeld foresees a U.S. military that could conduct decisive action with rapidly deployable, agile, stealthy forces able to respond to various contingencies, large and small, with a minimum of logistical support. More important than the number of weapons platforms would be the quality of networking between sensors and weapon delivery systems (or "shooters," in the military parlance). The ubiquitous employment of microprocessors throughout military systems, remote sensing technologies (as employed on UAVs), advanced data-fusion software, interlinked but physically disparate databases, and high-speed, high-capacity communications networks, would facilitate the precise delivery of force against the most important time-sensitive enemy targets. Sequential fires against these targets, which simply permit the enemy time to recover or hide, would be abjured. Instead, networked sensors and shooters produce simultaneous fires, improving effects by an order of magnitude.

Arming the Predator UAV exemplifies this transformation in targeting. A decade earlier, in Operation Desert Storm, U.S. forces received relatively poor support from overhead reconnaissance and surveillance systems, then the exclusive domain of the national intelligence community. Space-based communications support also produced inadequate results, and such support was critically unavailable to military forces in Somalia in 1993. Circumstances in Afghanistan proved radically different. Operation Enduring Freedom demonstrated the capacity of geographically dispersed forces to perceive simultaneously and substantially the same battle space. This broadly based battle space awareness allowed mass effects to be achieved without the necessity of amassing forces, thereby reducing vulnerability. Near-real-time video data from Predator and Global Hawk UAVs—under the control of military commanders, not the national intelligence community—was relayed via orbiting communications satellites to command centers and individual air controllers on the ground. These air controllers could point their laser binoculars at targets and instantly pass precision bearing and range information (translated into latitude and longitude by a GPS receiver) to command centers and aircraft circling nearby. Combat aircraft armed with Joint Direct Attack Munitions (JDAMs)—relatively cheap modifications to existing unguided bombs, enabling them to be guided precisely by GPS signals to their targets—could then "re-program" their bombs to deliver them with remarkable accuracy. Most impressively, this capacity to broaden battle space awareness through UAVs and space-based communications enabled the U.S. regional commander to direct the battle from his headquarters in Tampa, Florida, while being instantaneously connected to his forward headquarters in Kuwait as well as a subordinate one in Uzbekistan.

What distinguishes armed UAVs from manned aircraft in such roles is their capacity to loiter on-call for periods of 24 hours or more without exposing a piloted and expensive aircraft to enemy fire. As of early November 2002, the U.S. Air Force possessed only about 50 Predators, and only a small percentage of that number is currently equipped to fire Hellfire missiles.[24] The CIA has a small number of armed Predators, too, and new versions are being produced at the rate of about two per month. These drones also have several operational weaknesses, including difficulty flying in bad and icy weather and vulnerability to antiaircraft fire. At least ten Predators have perished during missions over Afghanistan or Iraq since the beginning of Operation Enduring Freedom.

Plans are afoot, however, to develop and produce improved versions of the Predator. The currently flown model, called the MQ-1B, is powered by a simple reciprocating engine, which propels the UAV at a speed of 80 knots. Propelled by a turboprop engine, a much faster (approximately 260 knots airspeed) and higher flying version—the MQ-9B, or Predator B—has already been built, and 3 to 4 more will follow in 2003, with production increasing first to 9 and then to 15 annually thereafter. Another version of the Predator B, with a 20-foot wing extension, will enable it to stay aloft for 42-hour missions carrying two external drop tanks and 1,000 pounds of weapons. And while current Predators are restricted to carrying Hellfire missiles, future versions will carry a variety of more potent weapons, including 250- and 500-pound JDAMs and two different air-to-air missiles. The expected unit cost for newer versions of Predator will be double that of the current model, or roughly $4 million.[25] But in view of the Predator B's capacity to dwell on station for nearly two days without producing pilot fatigue, refuelling, or wear and tear on limited inventories of advanced high-performance F-15s or F-16s, such armed UAVs are considered a bargain, at least for specialized missions requiring persistent air caps and operating in air-defense environments in which manned aircraft would be unduly taxed or vulnerable.

Unmanned combat air vehicles (UCAVs)—armed high-performance aircraft that many analysts say could represent the most profound change in the U.S. style of warfare—constitute a potentially valuable but less certain complement to the U.S. military transformation than armed UAVs or more flexibly targeted LACMs. The Pentagon's Defense Advanced Research Projects Agency (DARPA) and the U.S. Air Force are currently co-sponsoring a Boeing UCAV prototype, the X-45A, which had conducted five test-flights through the end of 2002. Although the primary stated mission of the UCAV prototype is air defense suppression, others have been mentioned, including delivery of directed energy weapons and even conventional weapons such as JDAMs. At such an early stage in its development, it should come as no surprise that great uncertainty characterizes UCAV development. Some, including the Secretary of the U.S. Air Force, are concerned that such a highly dynamic mission as air defense suppression requires a pilot and that less active missions such as strategic bombing may be more suitable for future UCAVs. Also muddying the waters are discussions within the Pentagon about merging the X-45A with U.S. Navy requirements into a multi-service UCAV program along the lines of the Joint Strike Fighter project.[26] Close allies of the United States, in particular the United Kingdom (UK), have begun to see a more prominent role for both UCAVs and UAVs. The UK is exploring opportunities to become involved in U.S. UCAV development and has begun a program for its own UAV, the Watchkeeper, which has many of the features of the Predator. One of several motivating factors driving the UK program is keeping pace with the U.S.'s emerging doctrine of network-centric warfare.[27] Still, UCAVs, as distinct from UAVs and LACMs, are likely to remain a desideratum rather than a practical reality until numerous bureaucratic, doctrinal, and industrial challenges are overcome.

Both technological and policy factors will shape the pace and scope of future UAV prospects. Enormous advances in computer processing power, sensor technology, communications, and imagery processing and exploitation have greatly advanced UAV performance. But technological push is constrained as well as driven by policy considerations. LACMs like the Tomahawk languished for nearly two decades before they came into prominence during Operation Desert Storm. Although Firebee reconnaissance drones flew thousands of sorties during the Vietnam War, there was a significant lag before the technological leap to the Predator was achieved. Service resistance, determined in part by a continued preference for manned platforms, will remain an important constraint. Nevertheless, new requirements for so-called battlefield awareness, increased pressure by public and political leaders alike to avoid casualties, and technological momentum have converged to accelerate UAV applications.

POLICIES AND POLICY OPTIONS

Cruise missiles have been understood for many decades, but modern UAVs—and especially armed UAVs and

UCAVs—were at best still on the drawing boards when major international security policies were negotiated. The focus of policymakers on ballistic missiles has also affected the coverage—or the lack of such coverage—of UAVs in international policies. Notoriously, UAVs and cruise missiles were omitted from the list of proscribed systems in UN Security Council Resolution 687, the ceasefire terms after the first Gulf War against Iraq. This omission was not fully corrected until the UN Security Council passed Resolution 1441 nearly 12 years later.

We shall now review four policies (or classes of policies) that could affect future commerce in UAVs. In appropriate cases we shall also discuss policy options. In ascending order of difficulty these policies are:

- Arms control treaties
- Export controls in general
- The Wassenaar Arrangement (WA)
- The MTCR .

Arms Control Treaties

Armed UAVs and UCAVs did not exist when negotiations were completed for START I (1991)[28], START II (1993)[29], the Treaty on Conventional Armed Forces in Europe (CFE; 1990)[30], and the INF Treaty (1987)[31]. However, armed UAVs and UCAVs are arguably similar in some respects to cruise missiles and to combat aircraft, which these treaties do restrict.

We cannot pinpoint any current controversies regarding the coverage of armed UAVs and UCAVs by these treaties. However, such controversies would be treated with diplomatic confidentiality if they arose. The U.S. Defense Department reviews armed UAV and UCAV programs for treaty compliance:

> Initiatives to modify existing reconnaissance UAVs to deliver ordnance or to develop new unmanned combat aerial vehicles (UCAVs) for flight testing or deployment as a weapon—that is any mechanism or device, which, when directed against any target, is designed to damage or destroy it—must be reviewed in accordance with DoD Directive 2060.1 for compliance with all applicable treaties. Examples of treaties that may be considered include: 1) the 1987 Intermediate-range Nuclear Forces (INF) Treaty, 2) the 1990 Conventional Armed Forces in Europe (CFE) Treaty, and 3) the 1991 Strategic Arms Reduction Treaty (START). As is the practice for all programs, determinations will be made on a case-by-case basis with regard to treaty compliance of armed UAVs or UCAVs.[32]

On theoretical grounds we can identify under which provisions of the treaties controversial issues might arise.

The START treaties, between the United States and the Soviet Union (later Russia), restrict the numbers of "long-range [more than 600 kilometers] nuclear ALCMs." The START I Treaty also restricts "nuclear armaments [on] an aircraft that is not an airplane, but that has a range of 8000 kilometers or more,"[33] identified in the Ninth Agreed Statement as "lighter-than-air aircraft such as balloons, drifting aerostats, and dirigibles."[34] In the event that an armed UAV or UCAV were 1) air-launched, deemed to be a cruise missile, and nuclear armed or 2) lighter-than-air and nuclear armed, it could run into START controversies. However, the distinctions between armed UAVs or UCAVs on the one hand and "cruise missiles" on the other hand, discussed below with respect to the INF Treaty, may mitigate these controversies. An armed UAV or UCAV may, after all, be considered an "aircraft" rather than a "cruise missile." However, this interpretation will not relieve an armed UAV or UCAV of all treaty restraints. The CFE Treaty restricts "aircraft."

The CFE Treaty, between the United States, the Soviet Union, and European states restricts the numbers of "combat aircraft" based in Europe. The Treaty defines "combat aircraft" as "fixed-wing or variable-geometry aircraft armed and equipped to engage targets by employing guided missiles, unguided rockets, bombs, guns, cannons, or other weapons of destruction, as well as *any model or version of such aircraft* which performs other military functions such as reconnaissance or electronic warfare"[35] (italics added). The definition says nothing about whether the aircraft are manned or unmanned. Consequently, and theoretically, this definition could apply to armed UAVs or UCAVs based in Europe. In addition, the italicized language could theoretically apply to other types of UAVs based in Europe. Similar CFE restrictions apply to various types of rotary wing aircraft.[36] But we have seen no indication that unmanned systems were envisioned when the treaty was negotiated. The CFE numerical limits are high, dating from the last years of the Cold War: 13,600 combat aircraft and 4,000 attack helicopters based in Europe—with various regional and country sublimits. So the restrictions, if any, on armed UAVs, UCAVs, and other UAVs may not be onerous.

The INF Treaty, between the United States and the Soviet Union, eliminates "ground-launched cruise missiles" with a range capability of 500 to 5,500 kilometers and tested as weapon-delivery vehicles. Does it apply to armed UAVs and UCAVs? Arguably, an armed UAV or a UCAV is not a cruise missile; it is recovered after use. Moreover, a UCAV is arguably not "launched"; it "takes off" from a runway like an airplane rather than being launched from a "launcher," which is defined in the treaty as "a fixed launcher or a mobile land-based transporter-erector-launcher mechanism for launching a GLCM."[37] The range of an armed UAV or UCAV adds another distinction from cruise missiles; the Treaty defines the range capability of a GLCM as "the maximum distance which can be covered by the missile in its standard design mode flying until fuel exhaustion, determined by projecting its flight path onto the earths [sic] sphere from the point of launch to the *point of impact*"[38] (italics added). Because an armed UAV or UCAV does not have a "point of impact," it may not fall into the range restrictions of the treaty.

All of these treaties have fora in which compliance issues can be discussed. Moreover, the United States can withdraw from any of these treaties on six months' notice (150 days for the CFE Treaty). But, as discussed above, it is not at all clear that the treaties will ultimately restrict armed UAVs or UCAVs.

On the other hand, we should remember that the legal profession is currently debating whether the relatively new technology of e-mail messages should be regulated as telephone conversations, letters sent through the postal system, or—in the case of wireless e-mail messages—broadcast media. The even newer technologies of armed UAVs and UCAVs may offer equally fertile opportunities to adapt restrictions similar to those applied to older systems. But the fact that armed UAVs and UCAVs may not have been in the minds of treaty negotiators offers an argument that they are not covered by the treaties at all. They may ultimately be deemed to be neither cruise missiles nor aircraft, but rather entirely new systems different from both.

Export Controls in General

In most governments, export controls are divided into controls on military items and on civil (or dual-use) items. In the United States, the former are administered by the State Department and the latter by the Department of Commerce (DoC).

Up to the present time UAVs have been largely military—but not exclusively so. Japan, South Korea, and Russia manufacture UAVs for crop dusting. The United States anticipates an emerging market for UAVs with a variety of civilian applications. Under present export control practices, these "civil" UAVs would be controlled by the DoC or its equivalent in other governments.

This situation creates a potential security problem. "Civil" UAVs can be used to deliver military payloads. Given the interest of the 9/11 hijackers in crop dusters, any air vehicle capable of dispensing an aerosol is a potential threat. Should such systems be controlled by the DoC?

The controversy over space satellite exports controlled by DoC highlighted the concerns about leaving such controls in an agency devoted to fostering exports. The State Department's export controls are generally regarded as tougher than those of the DoC, which is why exporters favor the latter. The same concerns would be applicable to "civil" UAVs in all governments. The DoC is supposed to refer export applications covered by the MTCR for comments by the Defense and State Departments, but there are exceptions. If DoC denies the export outright, it does not need to be referred; in such a case the "no undercut" rule applicable to MTCR decisions (see below) may fail to be imposed. Also, DoC does not require an export license for missile-related exports to Canada—one example among 98 pages of DoC "license exemptions."[39]

The problem of "civil" exports for which licenses are not required is most acute in "license-free zones." Members of the European Community do not require export licenses for dual-use items traded among themselves. This creates an "Nth exit problem," in which the number of possible exporters increases and the opportunities for unwise exports increase as well.

In the United States is a current proposal to move into the State Department the control of all UAVs—military or civil—capable of delivering a 500-kg payload to a 300-km range. That move still leaves lesser "civil" UAVs under the control of the DoC. As the discussion below indicates, these lesser UAVs are the subject of increasing international concern. Consequently, the responsibility for controls over UAVs is likely to be an issue for some time. At present the issue appears to be confined to those nations marketing crop-dusting UAVs. U.S. government officials can remember no case in which the DoC has received an application for a UAV export.

The Wassenaar Arrangement

With the end of the Cold War the structure of export controls directed against the Iron Curtain nations seemed too many to be an anachronism. Those controls were administered by the multi-national Coordinating Committee (COCOM), which gave members a veto right on munitions and dual-use exports.

COCOM administered controls on items, such as munitions and electronics, that were still sensitive even in the post-Cold War world and that were not covered by nonproliferation export controls. Therefore, in 1996 a larger group of governments (including Russia) formed a new regime, the Wassenaar Arrangement, to promote "transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilizing accumulations."

The WA[40] sets out its guidelines in "Initial Elements," revised three times since the original policy, and includes control lists of munitions and dual-use items. UAVs are controlled on Item ML10(c) of the munitions list:

> c. Unmanned airborne vehicles and related equipment, specially designed or modified for military use, as follows, and specially designed components therefor:
> 1. Unmanned airborne vehicles including remotely piloted air vehicles (RPVs) and autonomous programmable vehicles;
> 2. Associated launchers and ground support equipment;
> 3. Related equipment for command and control.

Also controlled on Item 9.A.12 of the dual-use list:

> 12. Unmanned aerial vehicles having any of the following:
> a. An autonomous flight control and navigation capability (e.g., an autopilot with an Inertial Navigation System); <u>or</u>
> b. Capability of controlled-flight out of the direct vision range involving a human operator (e.g., televisual remote control).
> <u>*Note*</u> *9.A.12 does not control model aircraft.*

These dual-use controls are limited by a "Validity Note" and a "Statement of Understanding."

> <u>Validity Note:</u> The control of unmanned aerial vehicles described in 9.A.12. is valid until 5 December 2004 and its renewal will require unanimous consent.
> <u>Statement of Understanding</u>
> Participating States understand a model aircraft as intended for recreational and competition purposes.

Therefore, the WA's dual-use controls on UAVs are subject to a sunset clause and may expire in less than two years.

UAV technology and associated software are also covered by the WA's controls. Moreover, WA dual-use controls are graded at three levels. UAV hardware, in Item 9.A.12 above, is subject to the lowest grade of dual-use controls. However, the highest level of dual-use controls ("very sensitive") apply to certain UAV software:

> 9.D.1. "Software" specially designed or modified for the "development" of equipment or "technology" in 9.A. or 9.E.3. of this Annex.
> 9.D.2. "Software" specially designed or modified for the "production" of equipment in 9.A. of this Annex.

The quotes in the "very sensitive" items refer to terms defined by the WA, and Item 9.E.3. refers to jet engine technology.

What is the net effect of these controls? They are not nearly as tight as the MTCR controls, described below. The WA controls basically involve only a requirement to conduct export reviews and to make international notifications. Every six months, for deliveries and denials to nonparticipating states, the WA requires notifications of deliveries of munitions items and of denials of the least sensitive (e.g., UAV equipment) dual-use items. With respect to exports beyond the participating states of the most sensitive dual-use items (e.g., UAV software), the rules require "extreme vigilance," delivery notifications "on an aggregate basis" every six months, and denial notifications within 60 days. Participating states are to notify each other within 60 days of an export undercutting a denial notification.

On the other hand, the WA deals with UAVs of very short range, "out of the direct vision range"—a control coverage much more extensive than that of the MTCR's range of at least 300 kilometers. And a January 2003 U.S. proposal to the WA would go further beyond the MTCR by adding, as an "anti-terrorism" measure, controls on kits to convert manned civil aircraft to "poor man's" UAVs:

> PROPOSED TEXT: 9.A.13. Equipment and systems, and specially designed components therefor, designed to convert manned civil aircraft into Unmanned Aerial Vehicles (UAV's) controlled by 9.A.12.a or 9.A.12.b.

The WA's controls may grow in effectiveness as the regime continues to be modified, and UAVs may become increasingly affected by the regime. But this has not happened yet. At present, the lack of strong denial rules and the sunset clause on UAV dual-use controls leaves the WA as a second tier of international UAV controls behind the main control policy, the MTCR.

The Missile Technology Control Regime

The MTCR[41] was announced in 1987 by the G-7—the United States, Canada, France, Germany, Italy, Japan, and the United Kingdom. It was a new nonproliferation export control regime to "limit the risks" of nuclear proliferation by controlling transfers that could contribute to unmanned delivery systems for nuclear weapons.

Over the subsequent years the MTCR's scope was expanded to cover unmanned delivery systems for nuclear, biological, and chemical weapons. And the membership expanded to include all members of NATO, the European Community, the European Space Agency, Australia, New Zealand, Argentina, Brazil, Russia, Ukraine, South Africa, Poland, Hungary, the Czech Republic, and the Republic of Korea. Moreover, Israel, Romania, Bulgaria, and Slovakia have made a political commitment unilaterally to observe the MTCR rules. Other candidates for European Union (EU) membership, such as Cyprus and Malta, must adopt MTCR controls as part of the EU package but have not yet made a political commitment to the MTCR. China has adopted some elements of the MTCR, but there are troublesome differences between the letter and practice of China's policies and the MTCR.

The regime controls exports for two categories of items. Category I consists of items of greatest sensitivity, which are subject to the most stringent controls. UAVs are covered in Category I, Item 1.A.2.

> Complete unmanned air vehicle systems (including cruise missile systems, target drone and reconnaissance drones) capable of delivering at least a 500 kg payload to a range of at least 300 km.

Formulated in the original version of the regime, the 500- kg payload was considered the minimum payload for a relatively unsophisticated nuclear weapon, and the 300-km range was considered the relevant range for the most compact theaters in which nuclear weapons might be used. Range/payload tradeoffs are taken into account in determining the capability of a UAV, and in 2002 "range" and "payload" were specifically defined. (The definitions were weakened, however, by a regime statement that the determination of range is the sole responsibility of the exporting government.) Category I controls are also applied to production facilities and design and production technology for UAVs with a 500-kg/300-km capability. Complete guidance sets of a specified accuracy for UAVs—and their production facilities, production equipment, and technology—are also covered under Category I, Item 2.

Category II consists of equipment, components, materials, and technology that, while generally dual-use, could make a contribution to Category I systems. For UAVs these include most of the 18 Category II items ranging from jet engines to composites to flight control equipment and avionics to stealth materials and test equipment.

In 1993, in order to cover systems capable of delivering chemical or biological weapons, using lower payloads than would be needed for nuclear weapons, the regime added Item 19.A.2. (for UAVs):

> Item 19.A.2. Complete unmanned air vehicle systems (including cruise missile systems, target drones and reconnaissance drones) not specified in 1.A.2., capable of a maximum range equal to or greater than 300 km.

That is, the regime now includes, in Category II, unmanned systems capable of delivering *any payload* to a range of 300 km. Several levels of rules apply to these items:

- *Absolute prohibition (until further notice)* on the transfer of Category I complete production facilities or the technology for such facilities. It obviously does not make sense to have a nonproliferation regime that allows the creation of new suppliers.
- *Strong presumption to deny transfers* of Category I items. This strong presumption of denial also applies to missiles of any range or payload, or any MTCR-controlled item, for which the purpose is deemed to be the delivery of nuclear, biological, or chemical payloads. Transfers of Category I items may be made. But they are to be "rare" and may only be made if there are (1) binding government-to-government assurances with respect to the end-use and end-user and (2) supplier, and not just recipient, responsibility for the end use.
- *Case-by-case review* of export applications for all controlled items.
- *No-undercut provision* according to which MTCR partners will respect each others' export denials or consult before undercutting a denial.
- *Information exchanges* to enforce these rules.
- *Catch-all provisions*, observed by most partner governments, under which export reviews will be required for missile-related transfers, whether or not on the MTCR control list, to any destination engaged in Category I programs.

Because, under international law, a policy (such as the MTCR) cannot supersede a treaty, the MTCR's rules do not restrict transfers required by the treaties establishing NATO, the European Community, or the European Space Agency. The license-free zone established within the European Community for dual-use transfers allows free trade in many Catgory II items within the community. In addition, there is a diversity of practices with respect to transfers among MTCR partners. For instance, in 1989 the British established an Open General Export License waiving the requirement for case-by-case reviews of dual-use Category II transfers to other regime members.

The MTCR, which is an export control regime, does not restrict indigenous programs. However, the United States insists that a candidate government forego "offensive" Category I programs (a definition that has become increasingly loose over the years) before the United States will approve it as a new member. And the MTCR members have synchronized their diplomacy against indigenous missile programs in nations of proliferation concern—leading to a recent 106-nation International Code of Conduct loosely discouraging ballistic missile (but not cruise missile or UAV) programs.

MTCR Coverage of UAV Technology

The MTCR's control list is revised frequently. With respect to complete UAV systems, the controls have expanded from systems with the 500-kg/300-km capability (subject to a strong presumption of export denial) to systems of any payload with a 300-km range (subject to case-by-case review). A current proposal, now awaiting approval under a six-month "silence" procedure, would expand the Category II coverage to something closer to the WA's "autonomous" and "out of the direct vision range" criteria:

> Item 19.A.3. Complete unmanned aerial vehicle systems, not specified in 1.A.2. or 19.A.2., designed or modified to dispense an aerosol, capable of carrying a particulate or liquid of a volume greater than 20 litres, and having any of the following:
> a. An autonomous flight control and navigation capability; or
> b. Capability of controlled flight out of the direct vision range involving a human operator.
> Technical notes:
> 1. Complete systems in item 19.A.3. comprise those UAVs already configured with or already modified to incorporate, an aerosol delivery mechanism. An aerosol consists of a particulate or liquid dispersed in the atmosphere. Examples of aerosols include liquid pesticides for crop dusting and dry chemicals for cloud seeding.
> *Notes:*
> 1. Item 19.A.3 does not control model aircraft intended for recreational or competition purposes.
> 2. Item 19.A.3 does not control UAVs, designed or modified to accept multiple payloads (such as remote sensing equipment, communications equipment), that lack an aerosol dispensing system/mechanism.

There are other control list expansions that might be appropriate to help limit the proliferation of UAVs capable of delivering nuclear, biological, or chemical payloads:

- Flight control systems for the conversion of manned aircraft to unmanned vehicles (the WA proposal)
- Complete UAVs with a given stealth capability
- Other UAV penetration aids, such as towed decoys and terrain-bounce jammers specially designed to match the delivery system they are aiding
- A wider range of jet engines, now exempted as being for manned aircraft but suitable for UAV use.

These control list expansions would limit all UAVs—the Category II models (80 percent of all UAVs now on the market) that can deliver any payload to a range of 300 km, and the Category I models that can deliver a 500-kg payload to that range. The smaller, Category II UAVs are real threats in terrorist hands—delivering kilogram quantities of biological agents—or in professional military hands—saturating defenses. But the most vexing question concerns the growing use of Category I UAVs for surveillance and, as armed UAVs or UCAVs, combat use.

The Problem of Large UAVs

Category I UAVs can deliver nuclear payloads or such large quantities of chemical or biological agents that meteorological uncertainties can be swamped. The 500-kg (or greater) payloads of such systems can be used to penetrate defenses in a variety of ways—with some payload devoted to penetration aids or, if necessary, with some payload devoted to more fuel to allow on-the-deck flight profiles or round-about routing to approach targets from all azimuths.

The MTCR prescribes "a strong presumption to deny transfer" of such systems. But these systems are in increasing demand. This demand raises the threat that Category I UAVs may become a route to cruise missiles for the delivery of weapons of mass destruction. But, on the other hand, the demand is currently driven by the use of UAVs to apply military force with great discrimination—just the opposite of a mass destruction threat. Early in 2002 the Bush administration established a confidential interim policy governing the export of such Category I systems.[42] But what should be the policy over the longer term?

The danger of any loosening of Category I controls—in effect for nearly 16 years—is specifically that of the proliferation of UAVs usable as cruise missiles, and more generally that of a slippery slope with respect to other Category I controls. The next point down the slippery slope would probably be a loosening of controls on space launch vehicles—the hardware, technology, and production facilities of which have long been recognized as being interchangeable with those of long-range ballistic missiles.

Given that the MTCR's current Category I rules allow for some flexibility for "rare" transfers, the cause of nonproliferation would seem best served by retaining these rules and working within them. This would avoid the weakening of a 16-year-old nonproliferation standard and would minimize the risk of slippery slopes that could exacerbate the proliferation problem.

Given the alternatives and the dangers of cruise missile proliferation, only as a last, reluctant resort would nonproliferators want to consider modifying the export rules with respect to Category I UAVs. The basis for such a modification of rules could be to ensure that Category I UAV transfers were substantially more expensive than Category I cruise missile transfers—so that the recipient nation could afford far fewer UAVs than cruise missiles. This is a difficult criterion to meet because, if the MTCR works as intended, some nations might not be able to obtain Category I cruise missiles at any price. But the criterion can be approached by taking advantage of a UAV's extensive infrastructure requirement. A new UAV policy along these lines might read as follows:

> The transfer of Category I equipment for a complete unmanned air vehicle system (Item 1.A.2.) may be considered more favorably if all of the following conditions are met:
> 1) All of the Guidelines requirements are satisfied, except for the strong presumption to deny the transfer.
> 2) The system is not specially designed for internal or external ordnance delivery.
> 3) The system is specially designed for recovery and reuse.
> 4) Upon completion of the proposed system transfer, the recipient will have installed full capabilities integrated with the proposed system to
> A) Command and control system flight and recovery,
> B) Retrieve data transmitted by the system, and
> C) Analyze the retrieved data.

The only modification of the MTCR's Category I rule would be to "consider more favorably" such a transfer and to be prepared to overcome the "strong presumption to deny." This modification, however, is a change in the central rule of missile nonproliferation, so it would be something to be considered only after trying to live with the less radical alternatives. The modification could be expected to unleash pressures for similar provisions with respect to space launch vehicle transfers. Therefore, looser rules on Category I UAV transfers could facilitate both cruise and ballistic missile proliferation.

Moreover, this modification would not ease the transfers of Category I armed UAVs or UCAVs. Given that their purpose is to deliver ordnance, they pose the same proliferation threats that cruise missiles do. The policy language for "treating more favorably" UAV exports may only be kicking the armed UAV and UCAV cans down the road. But it is difficult to foresee any reasonably safe way to loosen controls on large armed UAVs or UCAVs.

A safer option¾supplementing the policy of working within the Category I rules¾might be to develop the UAV industry in a manner similar to that of the space launch industry. This would involve providing "services" but not the transfer of hardware beyond the jurisdiction or control of the state considering a sale. In all but the most advanced nations, many elements of UAV operations¾such as satellite imagery for the selection of operating areas and satellite communications for retrieval of data¾are already provided on a service rather than an ownership basis. UAV services would extend this principle by having the supplier nation maintain and operate UAVs while the recipient nation directed the operations and received data gathered by the UAV.

This would be a cultural change for the young UAV industry, but it might make military sense. As Thomas Cassidy, president and CEO of General Atomics Aeronautical Systems, said with respect to the Predator system (which is growing over the Category I threshold), "The last thing [a forward commander] needs is to maintain and operate airplanes. What he needs is intelligence support—somebody looking and then piping video directly to him on a little TV set that we've already made for the special forces people."[43]

Another aerospace veteran, speaking off the record, anticipates that UAV services could be a lucrative business model. Such services would resemble the early and profitable IBM decision to market computer services in preference to hardware sales. UAVs might be painted in the colors of the nation purchasing the services. But the exporting government could retain jurisdiction and control of its UAVs by licensing its own nationals to maintain and operate the vehicles in and over territories approved in an export license.

The Israeli Air Force, as described by a senior defense ministry official, is buying "visint [visual intelligence] by the hour" from a civilian Israeli firm, Aeronautics Unmanned Systems. The firm owns, maintains, and launches an Aerostar UAV, hands it off to military operators when it is over the target area, and retrieves it from the military operators 12-14 hours later. The firm also conducts the entire UAV operation for the Israeli police, turning over to the police only real-time imagery collected by the vehicle.[44]

The U.S. military itself has considered hiring UAV services from a foreign supplier. As of November 2002, Pacific Air Forces (PACAF), after losing a satellite that was monitoring Pacific Ocean weather, requested the assistance of the Australian firm Aerosonde for weather-monitoring UAVs. Aerosonde leases such UAVs in units of three for about $700,000—air vehicles, service, and support staff included.[45]

CONCLUSION

UAV services are analogous, not only to space launch services—which meet the objectives of missile nonproliferation, but also to uranium enrichment services—which meet the objectives of nuclear nonproliferation. In both cases, a recipient's insistence on hardware rather than services is a strong indicator of a nefarious purpose. And in both cases multinational institutions, not just national sources, may provide part or all of the service.

There are downsides to UAV services. Some supplier governments might not be assiduous in retaining jurisdiction and control of the vehicles. And, even if the hardware were kept physically secure, technical and operational insights of value for cruise missile programs would almost certainly leak out.

And there is the question of whether a contractor would be forbidden to fly a UAV into a combat zone on the grounds that he could become a "combatant in war." The legalities of this situation would need to be thrashed out. There might be alternatives, such as allowing military personnel from the recipient state to operate imaging shutters or to launch ordnance from the UAV without gaining hands-on access. Or the supplier state might provide military personnel to manage "combatant functions," an extension of U.S. Defense Department physical security provided for certain sensitive transfers or U.S. operation of Patriot missile batteries on loan.

But the upsides of UAV services are intriguing. Proliferation hazards would be constrained compared to the alternatives. The precedent of looser controls on space launch vehicles could be avoided. The practice of "dumbing down" exports in order to meet nonproliferation constraints might no longer be necessary. Subject to the end uses approved in export licenses, the benefits of large armed UAVs and UCAVs might be shared with other nations. In short, while meeting the nonproliferation objectives of the MTCR, UAV services would allow the military benefits of the technology to be shared without undue interference from the constraints of the MTCR.

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1 This paper was originally commissioned by the Non-Proliferation Education Center (NPEC) for presentation before a group of U.S. government officials, Capitol Hill staffers, and press representatives at an NPEC-hosted dinner on March 17, 2003. The authors are grateful for the many comments offered by group participants.

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4 For details on these and other possible proliferation paths, see Dennis M. Gormley, *Dealing with the Threat of Cruise Missiles*, Adelphi Paper 339 (Oxford: Oxford University Press for the IISS, 2001), pp. 17-41.

5 As of this writing, Simpson has completed Phases 1 and 2, involving the procurement of necessary components and airframe design. See http://www.interestingprojects.com/cruisemissile/. The website includes a project diary. Simpson's popular technology website can be found at http://aardvark.co.nz/.

6 Such results are demonstrated in extensive modeling and simulation of biological attacks. Dr. Gene McClellan, private communication with the author**, [LOCATION?],** August 22, 1997.

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