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CRUISE MISSILE AND UAV THREATS TO THE UNITED STATES

HEARING

BEFORE THE

INTERNATIONAL SECURITY, PROLIFERATION AND FEDERAL SERVICES SUBCOMMITTEE

OF THE

COMMITTEE ON GOVERNMENTAL AFFAIRS UNITED STATES SENATE

ONE HUNDRED SEVENTH CONGRESS

SECOND SESSION

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CRUISE MISSILE AND UAV THREATS TO THE UNITED STATES

TUESDAY, JUNE 11, 2002

U.S. SENATE,
INTERNATIONAL SECURITY, PROLIFERATION,
AND FEDERAL SERVICES SUBCOMMITTEE,
OF THE COMMITTEE ON GOVERNMENTAL AFFAIRS,
Washington, DC.

The Subcommittee met, pursuant to notice, at 10 a.m., in room SD–342, Dirksen Senate Office Building, Hon. Daniel K. Akaka, Chairman of the Subcommittee, presiding.

Present: Senators Akaka, Cochran, and Stevens.

OPENING STATEMENT OF SENATOR AKAKA

Senator AKAKA. The Subcommittee will please come to order. Good morning to all, especially our witnesses. I would like to thank our witnesses for being with us today to discuss cruise missiles and unmanned aerial vehicles, or UAV, and their threats to the United States.

During the early days of Operation Enduring Freedom, United States and coalition troops found an American manual on how to operate a remotely-controlled unmanned helicopter in an al Qaeda safe house in Afghanistan. And just 2 weeks ago, the intelligence community issued a terrorist alert to the airline industry because of a portable shoulder-launched missile casing that was found abandoned outside an airfield in Saudi Arabia. While remotely-controlled helicopters and so called "man-pads" are not cruise missiles, they demonstrate the threats we face, both at home and abroad, from cheaper and easier-to-use and long-ignored alternatives to ballistic missiles.

During the Subcommittee hearing on the National Intelligence Estimate on Foreign Missile Developments, we learned that between one and two dozen countries will possess a land attack cruise missile capability by the year 2015 through indigenous development, acquisition, or modification of other systems, such as anti-ship cruise missiles or UAVs.

In fact, in every hearing I have chaired in the past year on weapons of mass destruction proliferation, the subject of cruise missiles was raised. For this reason, I believe it is necessary to examine the cruise missile threat to America and the extent of cruise missile proliferation. I have included UAVs both because of the apparent interest by al Qaeda terrorists and because an armed UAV technically is a type of cruise missile.

Cruise missiles are any unmanned, self-propelled, and guided vehicle whose primary mission is to place a special payload on a target. Cruise missiles vary greatly in their speed and range and are often an afterthought to ballistic missile concerns.

In many ways, cruise missile proliferation is more difficult to tackle than ballistic missiles. They share many features with commercial aircraft which have legitimate uses and are less expensive to build. These similarities make it difficult to inhibit cruise missile proliferation without impacting the aircraft industry.

The Missile Technology Control Regime, or MTCR, was established by the United States and our G–7 partners in 1987 to restrict the proliferation of long-range ballistic and cruise missiles and to delegitimize their sale. Currently, 33 nations belong to the MTCR. However, the MTCR is only as effective as the effort member nations put into implementing it and ensuring that it is comprehensive in the technology it controls.

During our Subcommittee hearing last week on Russian export controls, we learned that Russian officials drafted license requests so that cruise missile sales intended for India would fall just under the MTCR guidelines. India has the capability and history of modifying these missiles to then exceed the range and payload limits.

This practice, which is not limited to Russia, shows that unlike ballistic missiles, there is not strong consensus between MTCR member states that cruise missiles are sufficiently dangerous to warrant tighter controls. There is not even agreement on which items or technologies need to be controlled.

The willingness of member states to export cruise missile and UAV technology is proof of this. The United States also is caught between national security concerns and the profitable world of cruise missile and UAV sales.

The administration has asked the producers of the Predator UAV for a new version for export to non-NATO allies. The new version would have modifications that would make it impossible for the buyer to arm or augment it into a system that would violate the MTCR. But do MTCR limitations on cruise missiles address our security concerns and are other MTCR members making similar efforts in their export of cruise missiles and UAVs? That is a question.

I look forward to discussing these important questions with our witnesses and I welcome Vann Van Diepen, Deputy Assistant Secretary of State for Nonproliferation, our first panel's sole witness. He will discuss the global interest in cruise missiles and UAVs, how the MTCR addresses this threat, and what measures the administration is pursuing other than the MTCR to stem cruise missile proliferation.

Mr. Van Diepen has returned recently from the April MTCR working group meeting in Paris. I hope he will share with us the discussions on cruise missiles and whether our MTCR partners share our concerns. So I look forward to that.

I would like to call on my friend and partner here, Senator Cochran, for any statement he may have.

OPENING STATEMENT OF SENATOR COCHRAN

Senator COCHRAN. Mr. Chairman, thank you very much, and thank you for convening the hearing. I join you in welcoming our witnesses this morning to this hearing and hope that we will learn about the nature of the threat to the United States and our security interests from unmanned aerial vehicles and cruise missiles.

We have had hearings and have taken steps to try to develop legislation to improve our defenses against ballistic missiles. The threat seemed to be more clear and present in connection with ballistic missiles because up to 35 nation states have the capability of using ballistic missiles to threaten our troops in the field and Americans around the world, as well as our homeland.

I am advised that up to nine nation states have the capability of using land-attack cruise missiles. Unmanned aerial vehicles are similar in that they can be converted to cruise missiles, as I understand the technology. But we will learn more about the details from these witnesses and I am sure we will be better positioned in terms of our understanding of the nature of the threat to take whatever action the Congress deems appropriate to be sure that we are capable of defending against these threats as well as ballistic missile threats.

Thank you for being here, Mr. Van Diepen. I look forward to your testimony.

Senator AKAKA. Thank you very much, Senator Cochran.

Mr. Van Diepen, we welcome you here and welcome any statement you may have. You may proceed.

TESTIMONY OF VANN H. VAN DIEPEN,[1] ACTING DEPUTY ASSISTANT SECRETARY, BUREAU OF NONPROLIFERATION, U.S. DEPARTMENT OF STATE

Mr. VAN DIEPEN. Thank you, Mr. Chairman and Senator Cochran. It is my privilege to testify before you on the important subject of the proliferation implications of cruise missiles and unmanned air vehicles, or UAVs. These systems provide important capabilities to the United States and our friends and allies, but in the hands of our adversaries can pose substantial threats. I will discuss briefly the threat potential of cruise missile and UAV proliferation and then describe the steps that the United States and our partners have been taking to impede that threat.

Unmanned air vehicles is the term used in the Missile Technology Control Regime, the MTCR, to refer to unmanned systems that fly within the atmosphere and are not rocket propelled. Different terms may be used in other contexts, but for MTCR purposes, this term includes cruise missiles as well as target drones, reconnaissance drones, and other forms of unmanned air vehicles, be they military or civilian, armed or unarmed. UAVs can be as large as a jetliner or as small as a model airplane.

UAVs have been in military service since at least the use of the V–1 cruise missile in World War II. Since then, their use has grown dramatically in land attack, reconnaissance, as targets, and even in some civilian applications, such as crop dusting. As UAVs

[1] The prepared statement of Mr. Van Diepen appears in the Appendix on page 23.

become more capable, they are taking on more missions that had exclusively been borne by manned aircraft.

The same attributes that make UAVs so useful for the U.S. military make UAVs threatening in the hands of our adversaries. UAVs are potential delivery systems for weapons of mass destruction and they are ideally suited for delivering chemical and biological weapons. As you have noted in your statement, Mr. Chairman, there is a potential for terrorist groups to produce or acquire UAVs.

U.S. efforts to impede threats stemming from the proliferation of UAVs and UAV technology encompass a broad spectrum of measures. As in the other nonproliferation areas, the U.S. attempts to aggressively use all the following tools that I will briefly describe to affect various aspects of the UAV proliferation threat.

First, norms such as the Nuclear Nonproliferation Treaty, the Biological Weapons Convention, the Chemical Weapons Convention, and the MTCR guidelines help dissuade new countries from getting into the WMD delivery business, including via UAVs. They impede and delegitimize WMD proliferation and the proliferation of UAVs for WMD delivery. And, these norms help support our other nonproliferation measures.

Export controls, both national and multilateral, help deny proliferators access to technologies that might be misused to develop WMD delivery systems and they help slow down adversary UAV programs, make those programs more costly and less effective and less reliable than would otherwise be the case.

The key export control instrument is the Missile Technology Control Regime, which from its beginning in 1987 subjected exports of unmanned air vehicles inherently capable of delivering a payload of at least 500 kilograms to a range of at least 300 kilometers, so-called Category I UAVs or MTCR-class UAVs, and their directly associated technology to an unconditional strong presumption of denial. Exports of the specially designed production facilities for Category I UAVs are prohibited.

Key components and materials usable in producing MTCR-class UAVs, as well as many UAVs not captured under Category I, are controlled under the MTCR as so-called Category II items, the export of which are reviewed on a case-by-case basis against specified nonproliferation criteria.

In addition to MTCR controls, military UAVs, their components, and a wide range of materials and equipment useful in producing military UAVs are controlled under the so-called Wassenaar Arrangement, the nonproliferation regime for conventional arms and associated dual-use items.

Now, there are a large number of items relevant to the production of UAVs that are not controlled under either the MTCR or Wassenaar, mostly because of their broad civil uses. On a national basis, the United States and most of the other members of the nonproliferation regimes have enacted so-called "catch-all" controls that give them a legal basis to control exports of these unlisted items when they are intended for use in WMD delivery.

Related to the export control tool are the very extensive export control assistance programs that the United States has to help other countries to enact and enforce export controls that are compatible with those of the MTCR and the Wassenaar Arrangement.

Now, in addition to its export control role, the MTCR also serves as a forum where member countries can share information and concerns and coordinate their national missile nonproliferation efforts, and over the past several years, UAVs have taken on an increasing prominence in the discussions of the MTCR.

Another tool we use is interdiction. The United States has a longstanding program of identifying potential exports of proliferation concern and working with other countries to investigate and, if warranted, stop such exports.

Another tool are sanctions. A variety of U.S. domestic laws require sanctions against foreign governments or entities involved in certain activities, including proliferation activities related to UAVs. The threat of sanctions can act as a deterrent to proliferation activity, and in some cases, the diplomacy surrounding sanctions or sanctions waivers can result in positive nonproliferation progress.

Another important tool is our military efforts, which, of course, go beyond my scope as a State Department person. Nonetheless, our efforts to try to defend against adversary UAVs, to defend against the WMD they might deliver, as well as to be able, if necessary, to destroy adversary UAV holdings or to retaliate against the use against us by adversaries of UAVs or WMD delivered by UAVs all help to deter the use of UAVs against us and our friends and help to make the UAVs a less attractive option for our adversaries to pursue.

Good intelligence is central to nonproliferation, and this is a very important nonproliferation tool. The U.S. intelligence community has done a very good job in building awareness of the UAV threat, in supporting U.S. nonproliferation efforts, in facilitating interdictions, and in assisting other countries' enforcement of their export controls.

Finally, all the tools that I have mentioned are enabled by active U.S. diplomacy, and not only is diplomacy a tool that enables the others, there are times where we can use diplomacy directly, independent of the other tools, to promote good behavior and dissuade irresponsible behavior.

Energetic U.S. use of all these tools and intensive cooperation with our friends and allies have had a positive impact in impeding the UAV proliferation threat. Adversaries' efforts to acquire UAVs have been complicated and made more time consuming and expensive. To the extent that they have been able to acquire UAVs, our adversaries have had to settle for systems that are less effective and less reliable than if our nonproliferation efforts had not existed.

In conclusion, Mr. Chairman, just as UAVs provide real opportunities for U.S. and allied militaries, they also provide opportunities for our adversaries to threaten us. Dealing with the UAV threat has been a part of U.S. nonproliferation efforts for over 15 years and we have been strengthening our ability to impede and cope with it, including by broadening MTCR export controls, adding catch-all controls, and improving our military and intelligence capabilities. But we will need to keep working hard to keep pace with the threat, not only because our adversaries are determined, but because the increasing reliance on UAVs worldwide and the dual-

use nature of much UAV technology will make our job more difficult in the future. Thank you.

Senator AKAKA. Thank you very much, Mr. Van Diepen.

Senator AKAKA. I would like to ask Senator Stevens if you have any comments.

Senator STEVENS. I am sorry to be late and I have no opening statement. Thank you very much.

Senator AKAKA. Thank you very much for being with us.

Mr. Van Diepen, we are certainly interested in the meeting you had in July 2000 with MTCR members. We understand that you were there to discuss ways of reducing ambiguities over limits on cruise missile technologies and also to forge a consensus over how the regime's provisions apply to cruise missile transfers. My question is, when will the MTCR announce new guidelines for cruise missile technologies?

Mr. VAN DIEPEN. Thank you, Senator. I do not think that that is exactly corresponding to what is going on in the regime. First of all, as I indicated in my statement, the basic controls on cruise missiles themselves have been in place in the regime since 1987 and additional cruise missiles were added to Category II controls in 1994. A number of key items useful in making cruise missiles, certain types of turbo-jet and turbo-fan engines, certain Global Positioning System receivers, guidance systems, composite materials, and so on have been subject to MTCR control from the very beginning.

What has been going on in the regime over the past few years as part of the overall effort of reviewing the entire MTCR annex, the list of equipment and technologies that the regime controls, to make sure they are up to date, to make sure that any loopholes are closed, to expand the list where it is warranted. Part of that has been to look at that effort with the cruise missile threat, the UAV threat, and the associated threat of CBW delivery, for which UAVs are especially interesting, in mind.

And so, for example, we are refining the controls on the turbo-jet and turbo-fan engines that are the primary propulsion means for cruise missiles to make sure that they are adequate. We are trying to expand the universe of the Global Positioning System receivers that are of the highest threat potential for use in cruise missiles. We are trying to refine the definitions of range and payload as used in the MTCR, not just for UAV purposes but for ballistic missile purposes, as well.

So there is an ongoing effort underway to refine the controls to try and make sure they are as effective as possible. Part of that is a cruise missile focused effort, but it is a broader effort, as well, and as these individual decisions are taken, they are announced when they are taken and they get reflected in the United States in changes to usually the Commerce Control list that are published in the Federal Register.

Senator AKAKA. When do you think these changes will be announced?

Mr. VAN DIEPEN. I think these sort of dribble and drabble out as consensus is reached, and with a 33-nation regime, sometimes reaching consensus can be a challenge. I would guess that we will

probably have some of those items agreed at the next MTCR plenary, which will be at the end of September in Warsaw.

Senator AKAKA. Talking about payloads, let us go back to 1993. In 1993, the MTCR members were directed to assess whether recipient states could modify missiles to meet longer range and larger payload limits before permitting missile exports. This change is especially important for cruise missiles because they can be easily altered.

The question is, how do member states judge whether a potential recipient has the capability and intent to modify a missile, and has this change resulted in an increase or decrease in the number of export licenses by MTCR states?

Mr. VAN DIEPEN. Well, first of all, the 1993 decision basically made explicit what had been implicit in the MTCR from the beginning, the idea that in judging the capability of a system to exceed the Category I range/payload parameters, 300 kilometers, 500 kilograms, that one has to apply what we like to call in the United States the inherent capability principle, that one needs to look at the inherent technical capability of the system to exceed a range of 300 kilometers with a 500 kilogram payload regardless of whether the system is actually deployed in that configuration, regardless of whether it is advertised to meet those parameters, so on and so forth. Part of that is taking into account the so-called trade-off principle, the ability to trade off range and payload. Part of it, as you know, is to take into account the potential for the item to be modified.

As with all decisions in the MTCR, as noted in the MTCR guidelines themselves, it is ultimately the sovereign national decision of the exporting country and so it is a national responsibility of each MTCR partner to implement these various provisions. For our part, we subject applications to export UAVs to very intensive technical analysis, usually working with the companies involved to make sure we understand the configuration of the system, just what its inherent capability it is, how modifiable we believe it to be, and we combine that with the judgments of the intelligence community in terms of what the intentions and capabilities of the recipient might be in terms of modification.

Overall, it is certainly my impression that the regime partners have been very responsible in their exports, certainly of Category I items, and I think the adding of smaller Category II UAVs to control starting in 1994 has had a positive impact on the responsible nature of the decisions, as well. I am not in a position to know whether the number of approvals has gone up or down as a result of the 1993 and 1994 decisions, but it is my sense that, by and large, the regime members have been acting responsibly.

Senator AKAKA. Before I defer to Senator Cochran, in 1994, the Defense Science Board stated that it will be very difficult for the intelligence community to provide timely estimates of cruise missile and UAV threats. What has been done since 1994 to rectify this intelligence gap? Why is there not a consensus among our allies and MTCR partners that cruise missile exports need tighter controls?

Mr. VAN DIEPEN. Senator, I am not sure I am in a good position to address what the intelligence community has been doing, and

frankly, would not know what would be appropriate to say in an unclassified forum on that subject.

I would note, though, as I said in my statement, at least internally, we believe the intelligence community has done a good job of raising our awareness of the threat and helping us come up with proposals in the MTCR for dealing better with that threat. We have made a number of presentations over the years in the so-called information exchange portion of MTCR plenaries on the cruise missile threat to do our part to raise the awareness of other countries of the issue.

I guess I do not agree with the concept that there is not a shared understanding or shared appreciation of the cruise missile threat in the MTCR. Now, obviously, different countries have different national policies in terms of their own exports of cruise missiles, just as they do with their own exports of arms more generally. But I think that is different than saying that somehow shows that the countries have a different appreciation of the generic threat that is posed by cruise missiles.

Senator AKAKA. Thank you very much. Senator Cochran.

Senator COCHRAN. Thank you, Mr. Chairman.

How would you assess the effectiveness of our export controls in helping to reduce the amount of proliferation from missile technology, whether we are talking about ballistic missile or cruise missile technology?

Mr. VAN DIEPEN. Well, first of all, in terms of the United States, I think our export controls, both the multilateral MTCR controls and our national controls, like our catch-all controls, have been substantially effective in more or less walling the United States off as a source of controlled technology for use in cruise missile programs.

Now, obviously, there are other sources of technology, including sources in places like China that are not members of the MTCR, and so our national controls have a limited utility in dealing with that avenue. But the most technology, the best technology is in the United States, is in Western Europe, is in Japan, and the MTCR export controls have gone a long way toward making it very difficult for proliferators to get technology from those places, and so they have had to resort to very intricate, expensive, time-consuming covert acquisition. They have had to settle for the kinds of technology they can get from places like North Korea and China.

So while we have not stopped the proliferation problem, what we have done is impeded those programs, make them cost more, make them take longer, and make the missiles that these guys are able to ultimately come up with less threatening than would be the case if we were not applying these nonproliferation measures.

Senator COCHRAN. There has been a good deal of effort by our administration in conversations with the Russians and the Chinese to try to get a higher degree of cooperation in this proliferation reduction area, specifically with ballistic missile parts and technologies and the like. Have we extended that to the cruise missile area with respect to China and Russia? Have we tried to use the same kind of influence in keeping down their exporting and transferring technologies and components?

Mr. VAN DIEPEN. I guess a fair answer is yes and no, in a sense that much of our dialogue with both of those countries is more generic. It is not focused on ballistic missile versus cruise missile proliferation. It is focused on missile proliferation, on meeting MTCR requirements, which covers both ballistic and cruise. But there has been relatively little direct engagement on the question of cruise, I think in part because we see it as subsumed in this larger question.

Senator COCHRAN. Why have more nations not elected to develop or obtain cruise missiles? When we note the comparison between the 9 nations that are said to have cruise missile capabilities and 35 nations that have ballistic missile capabilities, why the big disparity there, do you think?

Mr. VAN DIEPEN. By definition, any answer has to be speculative. I would like to say it was because of our nonproliferation efforts, but I am not sure that that is a fair answer. I think it is probably a combination of things.

I think a number of countries' military objectives are such that the fast flight time and assured arrival, difficulty of interception of ballistic missiles is attractive to them in meeting those objectives. I think a number of countries see as both a political threat and an item of political prestige big ballistic missiles that they can parade around, and cruise missiles do not necessarily meet that bill.

I think that, for some, what is most readily available on the open market are North Korean Scud-based missiles. They are available, they are relatively inexpensive, they are proven, and so to a certain extent, it is because this is what is readily available on the market. So I think it is probably a combination of those things.

Now, as the Chairman noted in his statement, our expectation is that, over time, more and more countries will probably be interested in acquiring some sort of land attack cruise missile or land attack UAV capability, but I think many countries can meet a lot of their objectives in pursuing WMD programs in the first place by using the tried and true and relatively available ballistic missile.

Senator COCHRAN. Can you tell us in this open hearing whether you know of any countries that are developing an intercontinental capability with cruise missiles that could attack the United States?

Mr. VAN DIEPEN. A literal intercontinental capability in terms of a cruise missile with a range sufficient to reach the United States from Eurasia, I would be surprised if anybody was working that direction right now.

There are a number of countries that are working on what we call long-range cruise missiles, missiles with a range of 1,000 or 2,000 kilometers, and to reach the United States with missiles like that, one would have to have some sort of forward delivery platform, whether it was concealing them on a merchant ship, concealing them in an aircraft, something like that. But, of course, even these shorter-range missiles pose a direct threat to our forward-deployed forces in places like the Middle East and to our friends and allies abroad.

Senator COCHRAN. Are we fully capable of defending against those attacks now in the case of deployed troops?

Mr. VAN DIEPEN. I am probably not the best one to answer that question. I mean, certainly, we have air defenses of various sorts

that would have some degree of utility against incoming cruise missiles, but I should probably not answer that question definitively.

Senator COCHRAN. Is this the same kind of threat that we saw used in the war between Argentina and Great Britain when the Exocet missile struck a British ship?

Mr. VAN DIEPEN. That is certainly one aspect of it. The most widely deployed cruise missiles right now are, in fact, not land attack missiles but anti-ship missiles, and a lot of the attributes that make those missiles interesting as anti-ship missiles also make them potentially interesting as land attack means.

They are relatively small. They are hard to detect. They are hard to shoot down. They can be very accurate, accurate enough to hit a ship. With the appropriate other type of guidance system, they could be very accurate against specific land targets. That could begin to make it more feasible to use these things in militarily effective ways with conventional payloads.

Right now, with the ballistic missiles that are out there, most of them pretty much—all that they are good for, the ones in the hands of proliferating countries, are delivery with WMD, and while that is obviously a major threat, if a proliferant also had a capability to hit what he was shooting at with conventional ordinance, that would expand the types of threats that our forces would face and land attack cruise missiles offer that potential.

Senator COCHRAN. Your testimony has been quite helpful and interesting and we appreciate very much your being here today and helping us understand this threat.

Senator AKAKA. Thank you very much.

You said that Predator exports would be fixed so that it cannot be armed. If that is so, how do you do that?

Mr. VAN DIEPEN. I think it probably would not be appropriate for me to comment on any specific type of American UAV system because I do not want to get into any sort of commercial confidentiality or proprietary information issues, but as a general matter, you would look at the aerodynamics of the system, its internal configuration, the center of gravity, and you would look at are there ways of mounting additional weight, for example, under the wings and could you find ways of making that more difficult to do.

Not having hard points already installed on the wings of the cruise missile, for example, would make it more difficult to put weapons underneath. If you knew that putting additional weight on those places would disrupt the center of gravity of the missile and make it more difficult to fly, you would have some confidence that it could not be armed in that way. Finding various ways of sealing in or having a tamper-evident capability on the removal of the non-weapons payload that the missile or the UAV was issued.

So there are a number of techniques that one could use, but it is highly dependent on the specific design of the specific UAV and you really have to look at these things in detail, case by case.

Senator AKAKA. In your testimony, you mentioned delivery services. You think that UAVs are ideally suited for the delivery of chemical and biological weapons. Nations exporting UAVs and cruise missiles capable of carrying smaller payloads, such as a biological or chemical weapon, are limited by the MTCR if the system's intended use is to carry weapons of mass destruction.

Has the United States been asked by exporting nations to provide assistance either through intelligence or through guidance to determine the intent of potential UAV buyers?

Mr. VAN DIEPEN. Not in as direct a way as your question implies. When we agreed in the MTCR back in 1993–1994 to put these new controls on, part of the package is that there is an agreement to have enhanced information sharing to help other members apply these various controls.

And so for our part, since that time, we have been providing enhanced information on the identity and status of the WMD programs in countries that are also interested in acquiring missiles and UAVs so that, for example, licensing officers in another MTCR country can have that kind of crosswalk. They can know that this country or this end user is also involved in WMD and so they can make that link-up between the potential risk that the UAV in question would be diverted for WMDs.

Then in addition, most of the countries that are in the MTCR are also members of the Australia Group, the chemical-biological regime, and the Nuclear Suppliers Group, and so they have access there to information on the WMD side of the WMD–UAV interrelationship.

Senator AKAKA. There have been concerns expressed about UAV exports. The administration has proposed expanding UAV exports to non-NATO allies on a case-by-case basis. Does the administration think we need looser restrictions on UAV exports?

Mr. VAN DIEPEN. Certainly not at this time, Senator. What we have done, and I cannot get into the details because they are classified, but the MTCR guidelines make clear that exports of Category I items are subject to a strong presumption of denial. As is clear in the guidelines themselves, that means that such items theoretically can be sold, but only on rare occasions, and that is the language used in the guidelines, rare occasions that are particularly well justified in terms of five specific nonproliferation and export control factors.

What the Executive Branch has done is come up with an internal definition of what would warrant being a rare occasion under which a Category I UAV could be sold, at least for the MTCR part of the equation. Now, assuming a decision was made that it was possible in a particular case to overcome the strong presumption of denial, at that point, the export would be handled just like any other arms export and all the myriad considerations that would go into whether or not ultimately to make that export would pertain.

So this is really coming up with an agreed way of answering that very first question that one has to answer in the case of a Category I UAV. Is it or is it not going to be able to overcome the strong presumption of denial? We now have an agreed internal definition as to when the answer to that question is yes. Now, when the answer to that question is yes, that does not mean, OK, it is rolling out the door. That means at that point, then, it is subject to all the other considerations that any arms sale is subject to in ultimately determining whether or not it will take place.

Senator AKAKA. Before I defer to Senator Cochran for any second round questions, as you know, Mr. Van Diepen, cruise missiles can be easily modified to expand their range or payload. Beyond MTCR

limits, the resale of cruise missiles is not well regulated. These are serious problems. Could these issues be addressed through an inspection regime? How does the United States verify that our missile exports are not resold after delivery or modified to violate the MTCR?

Mr. VAN DIEPEN. Well, first of all, the extent to which a missile that is below the Category I threshold could be modified to exceed the Category I threshold again depends very much on the nature of the missile in question. Some have that potential. Others clearly do not, and so it would be a case-by-case situation.

Because these are munitions, their sales would be subject to all the standard conditions of any munitions sale, including a commitment from the recipient government that the item not be re-transferred without U.S. permission. In addition, we have the so-called Blue Lantern program, where there are periodic checks made, both on a random basis and on a targeted basis determined by intelligence, to actually go from time to time to places and look at the items in question and make sure that they are where they are supposed to be and see what is happening with them.

Usually also, if it is a U.S. munition that is being provided, there is almost always some degree of spare parts support or servicing or other activities that would go on and those activities would provide a source of information, again, as to whether or not the item is where it is supposed to be and whether or not someone has played around with the item.

Senator AKAKA. Senator Cochran.

Senator COCHRAN. Mr. Chairman, I have no other questions. I appreciate very much your help to us in this hearing.

Mr. VAN DIEPEN. Thank you.

Senator AKAKA. Thank you very much, Mr. Van Diepen, for your testimony and for your time this morning. The Members of the Subcommittee may submit questions in writing for you and we would appreciate a timely response to any of those questions.

We will now proceed to the second panel, so thank you very much again.

Mr. VAN DIEPEN. Thank you.

Senator AKAKA. I would like to call Christopher Bolkcom and Dennis Gormley to take their places at the witness table. Mr. Bolkcom is an analyst in the Defense and Trade Division of the Congressional Research Service. Mr. Gormley is President of Blue Ridge Consulting and a senior fellow at the International Institute for Strategic Studies in London.

You have been asked to discuss the features that make cruise missiles and UAVs attractive weapons for nations of concern or terrorist groups, how aggressively they are pursuing cruise missiles, the threat these systems pose to the United States, and how well the MTCR is addressing cruise missile proliferation concerns. Your full testimony will be submitted into the record and I look forward to hearing your statements.

Mr. Bolkcom, you may give your statement now.

TESTIMONY OF CHRISTOPHER BOLKCOM,[1] ANALYST IN NATIONAL DEFENSE, FOREIGN AFFAIRS, DEFENSE, AND TRADE DIVISION, CONGRESSIONAL RESEARCH SERVICE

Mr. BOLKCOM. Thank you, Senator. Mr. Chairman, Senator Cochran, thank you for inviting me to speak today about cruise missile proliferation. I have submitted my testimony, as you mentioned, and I would like to take a moment just to emphasize three key points that you will find in that testimony.

First, I would like to make a few observations about today's cruise missile threat. Over 80 countries today own cruise missiles of some kind and 18 of these countries manufacture cruise missiles domestically. The most advanced cruise missiles, those with the longest ranges, the heaviest payloads, the highest degrees of accuracy, stealthy features, these tend to be in the hands of our allies and friendly countries.

Our adversaries, countries like Iran, Iraq, Libya—these countries tend to operate anti-ship cruise missiles, although they are fielding and developing land attack cruise missiles, as well. These tend to be of theater range, tens to hundreds of miles, typically armed with conventional high-explosive warheads and capable of attacking known and fixed targets, such as ports, airfields, and cities.

Today's cruise missiles appear to be most threatening to our allies and friendly countries and to forward deployed U.S. military forces, especially the Navy, which must deal with the threat of sea skimming anti-ship cruise missiles.

A cruise missile attack on the continental United States today, however, is technically possible. The intelligence community has testified, however, that they do not believe such an attack is likely. They argue that terrorists do not need cruise missiles because they already have access to a variety of weapons and methods that they find very effective, such as truck bombs, letter bombs, suicide bombers, hijacking airplanes and cruise ships, and using firearms to kill people. Yet, it cannot be ignored that cruise missiles do have many attributes that could make them attractive to terrorists who may acquire them and use them in ways that we currently cannot foresee.

My second point is that a key aspect of cruise missile proliferation is that it is highly unpredictable and the current threat could change very rapidly. Cruise missile threats can emerge quickly because manufacturers do not have to start from scratch. Instead, manufacturers can exploit existing platforms. Manned aircraft have been turned into cruise missiles. UAVs, or unmanned aerial vehicles, have been turned into cruise missiles. And anti-ship cruise missiles have been modified to attack targets on the land.

As I mentioned a moment ago, of the 80 cruise missile countries today, 18 of them manufactured their own domestically. However, 22 other of these countries appear to have the industrial and technological infrastructures that are required to make cruise missiles if these countries decided to pursue those sort of programs. The status of these threshold manufacturers could have a significant effect on the global supply, demand, and inventory of cruise missiles.

[1] The prepared statement of Mr. Bolkcom appears in the Appendix on page 28.

As Senator Akaka mentioned a moment ago, the Defense Science Board, which is DOD's premier body of technical advisors, has pointed out and recognized the inherent unpredictability of cruise missile proliferation. As Senator Cochran mentioned, they have written that the cruise missile threat can be expected to evolve both in function and severity. The threat could evolve rapidly and it would be very difficult for the intelligence community to provide timely estimates of cruise missile threats.

So why is the proliferation of cruise missiles so difficult to monitor and predict? Well, the answer lies in my third and final point, and that is that most cruise missile technologies are inherently dual use. Most cruise missiles exploit well understood and well established technologies that are found throughout the civil aviation industrial base. Missile airframes, navigation systems, jet engines, satellite maps, mission planning, computers and software all can be found on the commercial market. Thus, identifying a military program can be difficult because the technology hides in plain sight.

Also, the commercial nature of cruise missile technologies keeps the costs of these weapons systems low and makes them accessible to a wide range of nations and potentially non-state actors.

The commercial availability of cruise missile technologies may be the biggest obstacle to controlling the spread of these systems through export controls alone. Many argue that there is currently a civil aviation loophole in the Missile Technology Control Regime that allows technologies applicable to cruise missiles to slip through that agreement.

Also, industry groups remind us that the legitimate export of military and civil aviation products is big business and these industry groups are arguing for the liberalization and streamlining of export controls, not for stricter rules.

So recognizing these challenges and in conclusion, I would like to point out that successfully dealing with cruise missile proliferation will likely require a multi-faceted strategy. Such a strategy could include steps such as attempting to reduce the supply of cruise missiles by negotiating more robust export controls, attempting to reduce the demand of cruise missiles with disincentives to potential importers, and improving our military capabilities, such as improving our theater air defenses and potentially continental United States air defenses and our counterforce targeting capabilities.

So, Mr. Chairman, Senator Cochran, this concludes my verbal testimony. I look forward to any questions you may have.

Senator AKAKA. Thank you very much. Mr. Gormley, you may proceed with your testimony.

TESTIMONY OF DENNIS GORMLEY,[1] SENIOR FELLOW, INTERNATIONAL INSTITUTE FOR STRATEGIC STUDIES

Mr. GORMLEY. Thank you, Mr. Chairman. Mr. Chairman, Senator Cochran, it is a pleasure to appear before you once again, this time to offer my suggestions on ways to deal with the emerging

[1] The prepared statement of Mr. Gormley appears in the Appendix on page 59.

threat of cruise missiles and unmanned aerial vehicles as they could affect U.S. interests abroad as well as at home.

This issue has only just begun to emerge and attract the kind of scrutiny it so desperately deserves. In part, this is because the terrible events of September 11 have reminded us of the dangers of focusing obsessively on a narrow range of familiar threats at the expense of perhaps more likely ones.

Land attack cruise missiles and UAVs have yet to spread widely. However, CIA Director Tenet has testified that by 2010, land attack cruise missiles could pose a serious threat not only to deployed forces, but possibly also to the U.S. homeland. As America successfully pursues effective theater and national ballistic missile defenses, nations and terrorist groups will be even more strongly motivated to pursue cruise missiles. For example, the low cost of small airplanes modified to become autonomous vehicles, and other propeller-driven and UAVs make the cost-per-kill arithmetic for missile defenses generally very stark. Simply put, large numbers of low-cost cruise missiles could overwhelm the best of defenses.

The emergence of the cruise missile threat confronts American military forces with enormous challenges. Some existing air defenses have substantial capability against large land attack cruise missiles flying relatively high flight profiles. But once cruise missiles fly low, or worse, add stealth features or employ countermeasures, severe difficulties arise. Indeed, even defending against easily observable cruise missiles flying relatively high is challenging and that is because air defenses could mistake them for friendly aircraft returning to their air bases and shoot them inadvertently down.

Large numbers of weapons-carrying UAVs or converted kit airplanes flying at very low speeds also threaten current air defenses which were designed to detect high performance and fast flying Soviet aircraft. Sophisticated look-down radars eliminate slow moving targets on or near the ground in order to prevent their data processing and display systems from being overly taxed. Thus, propeller-driven UAVs flying at speeds under 80 knots would be ignored as potential targets.

Cruise missiles are also attractive alternatives for states or terrorist groups lacking the resources or technical skills to build or deploy intercontinental ballistic missiles. Various national intelligence estimates have drawn attention to the conversion potential and use on a commercial container ship, of which there are thousands in the international fleet, as a launch platform. Such a ship-launched cruise missile could be positioned just outside territorial waters to strike virtually any important capital or large industrial area, and this could occur anywhere around the globe.

While the latest NIE draws attention to this among several attack options, equally worrisome, in my view, is the conversion of small manned airplanes into weapons carrying, autonomously flown attack vehicles. Terrorists' use of large commercial airliners on September 11 came as a complete shock to American planners. While small aircraft cannot begin to approach the carrying capacity of a jumbo jet's 60 tons of fuel, the mere fact that gasoline when mixed with air releases 15 times as much energy as an equal weight of TNT suggests that small aircraft can do significant dam-

age to certain civilian and industrial targets. Such an autonomous delivery system in the hands of a domestic terrorist threat means that launches could take place from hidden locations in close proximity to their intended targets.

What should one make of the effect of nonproliferation policy in stopping or slowing the evolution of the cruise missile threat? The existing MTCR provisions are surely in need of revision to cope more effectively with cruise missiles and UAVs. The regime's provisions have simply not kept pace with the rapid expansion in commercially available technology facilitated by today's globalized economy. The matter of small aerospace companies being formed to provide fully integrated flight management systems to enable the transformation of manned aircraft into entirely autonomous UAVs is only the most egregious example.

I outlined five specific reforms in my prepared statement for my February 12 appearance before you. None of these is conceivable without a determined U.S. effort to work closely with the founding G–7 partners of the Missile Technology Control Regime. This core group must convince the broad MTCR membership of the necessity of enhanced controls.

During the Cold War, arms control and military deployments played complementary roles in maintaining nuclear stability. Today, the two policy domains still have mutually reinforcing roles to play. Absent amending of the MTCR, cruise missile threats are certain to spread and inevitably make missile defenses more expensive and problematic. But if the MTCR can become as effective in limiting the spread of cruise missiles as it has with more advanced ballistic missiles, missile defenses can conceivably keep pace with evolutionary improvements in both missile categories. This will not happen without the committed leadership of both the Congress and the Executive Branches. Thank you.

Senator AKAKA. Thank you very much, Mr. Gormley.

We have some questions for both of you. Mr. Bolkcom, first, let me thank you for the map you provided in your testimony of estimated global cruise missile capabilities around the world. Thank you for that. Your map separates countries into indigenous manufacturers, threshold manufacturers, and operators. What separates an indigenous capability from a threshold manufacturer? Is it critical technology, infrastructure, training, money, or something else?

Mr. BOLKCOM. Thank you, Senator. That is a very good question. If you look at the 18 countries today who are manufacturers, their technological and industrial infrastructures are not that different than many of the threshold manufacturers, which is exactly my point. The technology, the capabilities, the knowledge required to manufacture cruise missiles are spread throughout the globe, frankly, and I believe the main difference between being a manufacturer and a threshold manufacturer is desire.

I think that many of the threshold manufacturers could manufacture cruise missiles quite soon, today, perhaps. In fact, Argentina is one example, but for various reasons, as Mr. Van Diepen said, their efforts may have been focused elsewhere. But I think it is simply a matter of desire and focus.

Senator AKAKA. Mr. Gormley, as indicated in your testimony, the draft International Code of Conduct on Ballistic Missiles does not

include cruise missiles. How could the draft document be amended to include cruise missiles? For example, would it be useful for member states to declare their cruise missile and UAV stockpiles?

Mr. GORMLEY. Senator, I think, first of all, the absence of cruise missiles from the draft Code of Conduct just simply reinforces the lack of consensus with respect to what the most worrisome threats are, in my view. To amend the existing Code of Conduct, and that would assume on my part that I agree that it is an important document to establish norms, which I think is another question, but assuming that it was worthwhile to pursue this Code of Conduct, the addition of cruise missiles and UAVs would be a simple language change.

In fact, I was at an International Missile Conference in Southampton, England, 2½ weeks ago in which many of the non-U.S. MTCR members were present and this issue of addressing the cruise missile and UAV issue in the Ballistic Missile Code of Conduct came up. The general approach is to encourage not only MTCR member states who are part of the roughly 80 nations who attended the meeting in Paris, but all participating states, to submit suggested changes to the Code of Conduct. So that it seems to me appropriate for at least several of those states to include recommended changes in the language to address cruise missiles.

In my view, this will not happen for reasons that I simply cannot really come to grips with. But it strikes me that the focus is on ballistic missiles. There has been an intentional decision not to include language addressing cruise missiles and UAVs and I am not aware of what state or states what might be behind the effort not to include that language in the Code of Conduct, but I think it is shameful.

Senator AKAKA. This question is for both of you. The United States has asked the manufacturer of the Predator UAV to develop a version for export to non-NATO allies that cannot be armed or modified to exceed MTCR guidelines. Is this a realistic request? Is it possible to construct a UAV so that it can never be modified to carry a weapon? Mr. Gormley or Mr. Bolkcom?

Mr. GORMLEY. I will start, Mr. Chairman. I think Mr. Van Diepen addressed the issue of the difficulty and I think the major issue that he pointed out that struck me as particularly relevant is every missile that is transferred has to be dealt with on a case-by-case basis because every missile is fundamentally unique from an engineering standpoint.

That said, I would also argue that it is technically difficult to make these kind of changes. There are particular safeguards that one could employ, even the notion of trap doors, devices that the recipient is simply not aware of, all of which raise difficult issues in the negotiation to purchase these missiles because, obviously, the recipient nation does not want anything that might inhibit its potential use, even to include modifying it in violation of whatever end use assurances we might place on that subsequent modification.

But there is a larger issue that I think is important because this issue came up in what has been the most embarrassing cruise missile transfer, that is a stealthy cruise missile, the Apache or Black Shahine. That was a decision made by both the French and the

U.K. governments to transfer what is decidedly a Category I missile, but also a stealthy one, raising other concerns about the potential defense against such a missile. They decided to do it nonetheless and they brought up this issue of applying safeguards.

But the issue is one that becomes difficult in terms of establishing a precedent. Once you establish a precedent that you can come up with all these fixes, then it creates a major incentive on the part of other MTCR members to practice the same behavior, to come up with these technical fixes that allow for these transfers to occur, and that is the ultimate problem that I think the case of the Black Shahine transfer to the UAE creates. That is, it creates an incentive for Russia, and, indeed, MTCR adherent states like China, to make decisions that might be inconsistent with the wishes of all the MTCR member states.

Senator AKAKA. Would you want to comment on that, Mr. Bolkcom?

Mr. BOLKCOM. Yes, sir. I agree with Mr. Gormley. It really needs to be looked at on a case-by-case basis, how feasible is it to change a missile or a UAV so that it cannot be tampered with. But generally speaking, I think that, yes, I think that one can envision for most cruise missiles and UAVs a means or methods of making them tamper-resistant. The question is, would the customer want it? Would you have to go to such a degree that the missile would be so dumbed-down that it would not offer them the sort of capabilities they want? And the answer is, probably.

I also agree with Mr. Gormley that there is a larger issue with the Predator's sale or those sorts of sales and the norms they establish, and the issue for me is one of U.S. credibility. We have talked a lot about export controls and supply side efforts to quarantine the spread of this technology, but we need to recognize that there is a flip side to that coin and that is reducing the desire of importers to try to give them disincentives.

In countries like China, Russia, France, they look at us and I think they can oftentimes say that we are inconsistent or we are talking out of both sides of our mouths when we, the United States, are a large exporter of cruise missiles. The Harpoon, for instance, is a very successful export product. And, of course, the United States is one of the leading users of UAVs and cruise missiles.

So when we think about what we want to do in terms of export controls and stopping the spread, we also have to look at how others may perceive us and our exports.

Senator AKAKA. Let me ask you, Mr. Bolkcom, whether you agree with this assessment: The National Intelligence Estimate on Future Missile Threats estimated that one or two dozen countries will possess a land attack cruise missile capability by the year 2015 via indigenous development, acquisition, or modification of other systems, such as anti-ship cruise missiles or UAVs. Do you agree with this assessment? What are the most important factors affecting cruise missile acquisition?

Mr. BOLKCOM. Well, sir, the intelligence community certainly has a lot of resources that I do not have access to and I tried to focus on capabilities. I have looked at the paths through which countries have historically acquired cruise missiles and just focused on those sort of capabilities. So in terms of intent or countries' desires, I

cannot really say. But looking at the capabilities that I see today, I think that sort of estimate is entirely plausible. It is entirely plausible.

Senator AKAKA. Mr. Bolkcom, the last National Intelligence Estimate on Future Missile Threats does not include UAVs. During our hearing on the subject in March, National Intelligence Officer Robert Walpole told this panel that UAVs will be included in future threat assessments. In your testimony, you described in detail the challenges of assessing UAV capabilities. Do you believe that a threat assessment can be done?

Mr. BOLKCOM. Sir, I do not know enough about threat assessments to know if they are feasible on UAVs, but I can tell you that other experts have made recommendations for how to improve our capabilities in forecasting and providing good intelligence. I do not know if these sort of recommendations have been acted upon, but I will share one with you.

The Defense Science Board, which you mentioned, and a body with which I am familiar, recommended 8 years ago that the intelligence community should not only put a higher emphasis on cruise missile and UAV proliferation, but they made recommendations on how they should put a greater emphasis on this problem and one approach they recommended was what they call a "skunk's work" or "red teaming" approach.

This approach is one where if you are unsure if a country has the ability to manufacture UAVs or cruise missiles or weaponize them, what you do is you take a bunch of people, oftentimes military officers with the sort of expertise you find in the country in question: Engineering, aeronautical engineering, computer science, and what not, and you isolate these people with the sort of technologies and processes you believe that country possesses and see what they can do. It is called a red team or a skunk's work approach. It is a very effective way of finding out empirically whether these sort of capabilities could be kluged into a cruise missile or UAV.

To my knowledge, the intelligence community has not taken on this approach. That does not mean they have not, but I do not know of any such efforts.

Senator AKAKA. Mr. Gormley, would you want to comment?

Mr. GORMLEY. Yes, I would, Chairman. On the 12 to 24 nations by 2015, that is really, I mean, it is like hoping that you can pull a rabbit out of a hat and be relatively close and that is, I trust, a product of, I would hope, rigorous threat assessment and looking at where capacities exist.

I would only footnote it by saying that given the pronounced effectiveness and thereby the interest that is driven by it in Predator's use in Afghanistan as a weapons delivery platform, it strikes me that the 40 nations that now produce UAVs, half of which are not MTCR members, might be inclined to put a weapon on their existing UAVs. This isn't easy, but by 2015, it would seem to me that the potential for that is certainly there.

We have looked very systematically in a study sponsored by the government at a body of about just under 700 UAVs produced by a large number of countries and found that 80 percent of them, nearly 80 percent of them, were capable of meeting the Category

II provisions of the MTCR. That is, they could fly with a small payload out to and beyond 300 kilometers. In fact, roughly about 20 percent of them could fly as far as 1,000 kilometers. So there is significant capability in today's UAV infrastructure.

All that said, you asked a question about factors affecting the acquisition of cruise missiles and UAVs. I would add a cautionary note. There is a tendency to just look at the technology and look at popular interest in these weapons platforms, but if you look at a country like Iran and examine where it spends its resources, it is still buying tanks, planes, and ships. So it raises the question of how much can they afford and how do they trade off decisions to buy cruise missiles for land attack missions versus ballistic missiles in the context of limited resources when they still intend to flesh out a conventional army with tanks, ships, and airplanes.

So it is a difficult proposition to think out to 2015. Just in terms of technology, you can come up with some relatively straightforward answers, but you have to set it in a broader, richer context before you can make careful predictions on the future.

Senator AKAKA. Mr. Gormley, the Missile Technology Control Regime demonstrates how cruise missiles are often an afterthought to ballistic missiles. But are cruise missile performance and technology sufficiently different from ballistic missiles to warrant a new international agreement solely for cruise missiles and UAVs?

Mr. GORMLEY. No. The answer is definitely not. I am a very strong adherent of not allowing the best to become the enemy of the good.

Many people in various positions, high and low, criticize the Missile Technology Control Regime for not being an adequate tool in stemming the spread of missiles generally, ballistic and cruise. I would look at the glass as half filled and suggest that with modest changes and reforms to the MTCR, we can do a reasonably good job at stemming the tide of the most sophisticated cruise missiles and UAVs getting into the hands of our potential adversaries.

The concern I have about a new regime of any sort is the time it takes to reach a consensus among the nations that would participate in it, and if nations take their eye off the prize, which now is reform, to bring the MTCR up to the capacity to deal more effectively with cruise missiles and UAVs, then I think they take their eyes off that prize at the risk of allowing the continuing globalization of dual-use technologies to create the condition for cruise missile and UAV proliferation. So they ought to focus on the existing mechanism, reform it as best they can, and move out strongly to cope with the emergence of this threat.

Senator AKAKA. Thank you.

Mr. Bolkcom, in your testimony, you discuss the difficulty of identifying and distinguishing between cruise missiles and legitimate small aircraft. How effective would an advanced and universal combat identification system be for improving the rapid and accurate distinction between the two?

Mr. BOLKCOM. Sir, from a defense perspective, it is identifying what that blip on the radar screen is very important. We have very high standards in terms of trying to avoid friendly fire, trying not to shoot down our allies or non-combatants, and that sort of high standard can work against us in terms of cruise missile defense.

In terms of a specific answer to your question about improved or universal IFF systems, I have not thought about that specific solution much, but I would point out that there are some technologies that are coming online that will be very helpful, like Link-16, which is a secure, jam-resistant communications link that not only the United States but our NATO allies will also use, and that is not an IFF system in and of itself, but it will help provide an IFF function that should be very helpful in identifying friend from foe from neutral on the battlefield.

Senator AKAKA. Mr. Gormley, do you believe such a system would be acceptable to MTCR?

Mr. GORMLEY. I think we may be talking about two separate issues: Identification friend/foe in a military context, and some mechanism that would be used in an export control context.

The former that Mr. Bolkcom responded to is the requirement to have some way of distinguishing friendly from enemy assets on your air defense radars and that is an exceptionally difficult technical challenge. We have been trying to cope with that in a variety of different ways.

Ultimately, the best solution is to have high-quality radars that provide you not only with the ability to detect an incoming object at long range, but high-quality fire control quality data that gives you the confidence that you can fire on something because you understand it to be a non-friendly asset. That is a technology issue that I know the U.S. Department of Defense is working on, but a very difficult challenge, indeed.

If I understand your question to apply to an export control regime, that would almost suggest something along the lines of a safeguards regime that would essentially allow you to distinguish whether a transferred missile is being used in ways inconsistent with the end use assurances that you have negotiated with the recipient nation. And as I mentioned before, end use safeguards can be very technically sophisticated and that in and of itself makes them problematic because every member of the MTCR does not have an equal level of technology to build into their transfers that might occur.

So does that imply that the United States and the other lead industrial G–7 nations would provide safeguards technology to all the other non-G–7 members of the MTCR? I think that would raise an export control issue in and of itself. So I think it is very difficult to imagine a regime that would work in a robust way.

Senator AKAKA. I want to thank both of you and all witnesses for your testimony and the time that you took to be here. The United States will unilaterally withdraw from the Anti-Ballistic Missile Treaty in 2 days. In our race to field a missile defense system, we should heed the lessons of ballistic missiles. Short- and medium-range ballistic missiles are widespread and already pose a significant threat overseas to U.S. interests, military forces, and our allies. Cruise missiles are far fewer in number and our potential adversaries are said to own cruise missiles that are easy to track and have low accuracy. But this can change rapidly, especially with foreign assistance.

We must not lose this opportunity to stop the spread of cruise missiles. It will always be more effective to prevent a state from

acquiring cruise missiles than to build a system to defend against them.

It is clear that the administration recognizes the advantages that cruise missiles and UAVs give us in military operations. Since the beginning of Operation Enduring Freedom, I have seen one press report after another describing the new and improved uses for UAVs. In fact, the Air Force plans to spend about $1.5 billion to speed the initial operational capability of combat UAVs over the next 5 years.

However, as we broaden our uses of UAVs, we must assume that our adversaries are planning to do the same. The United States should set an example. We should not rush into easing restrictions on UAV sales to non-NATO members. We need to ensure that we have an end user verification system that can track where this technology goes and who has access to it once it leaves U.S. borders.

The administration should put pressure on our MTCR partners to abide by the guidelines on cruise missile exports. The administration needs to lead the debate on how the MTCR will address UAVs so that an agreement can be reached. We must not forget and we must not let our allies forget that once released, technological genies cannot be returned to their bottles.

Gentlemen, we have no further questions at this time. However, the record will remain open for questions for our witnesses and for further statements from our colleagues. We appreciate the timely response to any questions that are sent to you.

I would like to express my appreciation to all our witnesses for their time and for sharing their insights with us. Thank you again very much.

The hearing is adjourned.

[Whereupon, at 11:22 a.m., the Subcommittee was adjourned.]

APPENDIX

Testimony of Vann Van Diepen
Acting Deputy Assistant Secretary of State for Nonproliferation

Mr. Chairman, Senator Cochran, and Members of the Committee:

It is my privilege to testify before you on behalf of the State Department on the important subject of the proliferation implications of cruise missiles and unmanned air vehicles (UAVs). These systems provide important capabilities to the U.S. and its friends and allies, and in the hands of our adversaries can pose substantial threats. I will discuss briefly the threat potential from the proliferation of cruise missiles and UAVs, and then describe the steps that the U.S. and our nonproliferation partners have been taking to impede that threat.

What are UAVs? "Unmanned air vehicles" is the term used in the Missile Technology Control Regime (MTCR) to refer to unmanned systems that fly within the atmosphere and are not rocket-propelled. Different terms may be used other contexts, but for MTCR purposes this term includes cruise missiles, as well as target drones, reconnaissance drones, and other forms of UAVs, be they military or civilian, armed or unarmed. UAVs can be as large as a jetliner or as small as a model airplane, can be jet or propeller driven; there are even concepts for guided, unmanned blimps that would be UAVs.

Uses of UAVs. UAVs have been in military service since at least the use of the V-1 cruise missile and target drones in World War II. Since then, their use has grown dramatically in land-attack (in ground-, sea-, and air-launched modes), reconnaissance, as targets, and even in some civilian applications such as pipeline inspection and crop-dusting. The U.S. military is at the cutting edge, with nuclear-armed cruise missiles in the inventory for over 20 years, and extensive use of conventionally armed cruise missiles and of reconnaissance UAVs in the Gulf War and most of our subsequent military engagements. As UAVs become more capable (as in the recent use of armed UAVs in Afghanistan), they are taking on more missions that have been exclusively the province of manned aircraft; this is expected to grow in the future, with the further development of so called Unmanned Combat Air Vehicles (UCAVs).

The UAV proliferation threat. These same attributes of UAVs that are so useful for the U.S. military -- for example, the ability to strike targets with precision and substantial protection from interception and to collect real-time intelligence -- makes UAVs in the hands of our adversaries a threat to us and to our friends and allies. Moreover, UAV's are

potential delivery systems for weapons of mass destruction (WMD), and indeed are ideally suited for the delivery of chemical and biological weapons (CBW) given UAVs' ability to disseminate aerosols in the right places at the right altitudes. And while, thus far, the primary concern for adversary use of WMD-armed UAVs has been with nation-states -- such as Iraq, which has been converting L-29 trainer aircraft to UAVs for probable CBW use -- there is a potential for terrorist groups to produce or acquire small UAVs and use them for CBW delivery.

Dealing with the UAV proliferation threat. U.S. efforts to impede threats stemming from the proliferation of UAVs and their technology encompass a broad spectrum of measures. As in other nonproliferation areas, the U.S. attempts to use aggressively all of these tools to affect various aspects of the UAV proliferation threat.

-- Norms: The Nuclear Nonproliferation Treaty prohibits the acquisition of nuclear weapons by non-nuclear-weapon states, and the Biological Weapons Convention and Chemical Weapons Convention prohibit the acquisition of CBW. This helps dissuade new countries from getting into the WMD (and thus, WMD-delivery) business, impedes and de-legitimizes WMD proliferation, and supports the other measures the U.S. takes to fight proliferation. In addition, the MTCR Guidelines serve as a de facto norm against exports in support of WMD-delivery UAVs.

-- Export controls: U.S. and multilateral export controls help deny proliferators access to the Western technology (the best technology) that might be misused to develop WMD delivery systems, making adversary UAV programs slower, more costly, and less effective and reliable.

MTCR Category I. The MTCR from its inception in 1987 subjected exports of UAVs inherently capable of delivering a payload of at least 500 kg to a range of at least 300 km (so-called "Category I" or "MTCR-class" UAVs) and their directly associated technology to an unconditional "strong presumption of denial." Exports of complete guidance sets and warhead safing/arming/fuzing/firing subsystems useable in such UAVs, and their directly associated technology, also are subject to a "strong presumption of denial." Exports of the specially designed production facilities for Category I UAVs and their complete subsystems, and the technology directly associated with such facilities, are prohibited. (Of course, these strictures apply only to MTCR members and unilateral adherents.)

MTCR Category II. Key components and materials useable in producing MTCR-class UAVs -- such as small, fuel-efficient jet

engines; structural composites and their production equipment; various types of avionics, guidance, and flight control systems; telemetry and ground support equipment; various test equipment; and stealth technology -- are controlled as MTCR Category II items. MTCR countries review exports of such items on a case-by-case basis against specified nonproliferation criteria, and such exports are subject to a "strong presumption of denial" if judged to be intended for use in WMD delivery. In 1994, additional UAVs -- those not captured under Category I, but inherently capable of a 300 km range regardless of payload -- were added Category II MTCR controls.

Wassenaar. In addition to being controlled under the MTCR, military UAVs and their components are controlled under the Wassenaar Arrangement -- the nonproliferation regime for conventional arms and associated dual-use items. Wassenaar also requires controls on the export of a wide range of materials and equipment useful in the production of UAVs, beyond those controlled by the MTCR.

Catch-all controls. Moreover, there are a large number of UAV-relevant items that are not controlled under the MTCR or Wassenaar, mostly because of their broad civil uses (e.g., in manned aircraft). On a national basis, the U.S. and most other members of the nonproliferation regimes have enacted "catch-all" controls to cover exports of such items when an exporter knows or is informed by his government that they are intended for use in WMD programs (including WMD delivery).

Non-regime suppliers. The MTCR Guidelines encourage all countries to unilaterally abide by ("adhere to") the Guidelines. To the extent non-MTCR countries apply similar export controls, proliferators' efforts to obtain items for their UAV programs are further complicated. (Israel and several Central and Eastern European countries have adhered to the MTCR Guidelines.) The U.S. has a worldwide program of export control assistance -- focused on Central and Eastern Europe and the Newly Independent States, but also operating in East Asia, the Middle East, and South Asia -- to help countries enact regime-compatible export control laws and regulations, to erect effective interagency export licensing systems, and to improve enforcement.

-- Regimes: In addition to its role as a de facto norm -- and its export controls covering UAVs down to a range/payload capability of 300 km/0 kg, as well as key items of equipment and technology -- the MTCR also serves as a forum where Partner (member) countries can share information and concerns, and coordinate their national missile nonproliferation efforts. UAVs have taken on increasing prominence in the MTCR over the past

several years, including specific attention in the annual Information Exchanges during MTCR Plenary meetings.

-- Interdiction: The U.S. has a longstanding, day-to-day program of identifying potential exports of proliferation concern (including those related to UAVs) and working with other countries to investigate and, if warranted, stop such exports from proceeding. While the details of these activities are classified, they are an important contributor to achieving our nonproliferation objectives.

-- Sanctions: A variety of U.S. domestic laws require sanctions against foreign governments or (usually) entities involved in proliferation activities, including certain activities related to UAVs. The threat of sanctions can act as a deterrent to proliferation activity, and in some cases the diplomacy surround sanctions or waivers can result in positive nonproliferation progress.

The missile sanctions law (amendments to the Arms Export Control Act and Export Administration Act, codified in the National Defense Authorization Act for FY 1991) requires sanctions against foreign persons knowingly involved in the trade of MTCR-controlled items that contribute to MTCR-class missile programs (including UAV programs) in countries that are not "MTCR adherents" as defined in the law. As a result of one such sanctions case, China committed in October 1994 not to export ground-to-ground MTCR-class missiles (including UAVs of this type); as far as we are aware, China has abided by this pledge.

The Iran-Iraq Nonproliferation Act requires sanctions against foreign governments or persons that contribute knowingly and materially to efforts by Iran or Iraq to acquire destabilizing numbers and types of advanced conventional weapons (which include such cruise missiles as the President determines destabilize the military balance or enhance offensive capabilities in destabilizing ways).

Lethal Military Equipment (LME) sanctions (contained in annual Foreign Relations Authorization Acts and in the Foreign Assistance Act) require sanctions against governments that provide LME (which would include cruise missiles) to countries on the U.S. terrorist list (Cuba, Iran, Iraq, Libya, North Korea, Syria, Sudan).

The Iran Nonproliferation Act provides for possible sanctions against foreign persons that export to Iran items on multilateral export control lists (including the UAV-relevant items on the MTCR and Wassenaar lists).

-- Military capabilities: Our efforts and those of our friends and allies to defend against adversary UAVs and the WMD they might deliver, as well as to be able, if necessary, to destroy adversary UAV holdings and to retaliate against UAV and UAV-WMD use, help to deter use of UAVs against us and to make UAVs a less attractive option for our adversaries to pursue.

-- Intelligence capabilities: Good intelligence is central to all aspects of nonproliferation. The U.S. Intelligence Community has done a very good job in building awareness within the Policy Community of the UAV threat, and in supporting U.S. efforts to sensitize other countries. Intelligence liaison relationships also are important means of facilitating interdictions and of assisting other countries' export control enforcement.

-- Diplomacy: All of the above tools are enabled by active U.S. diplomacy. We are a leading member of the WMD treaties and the nonproliferation regimes and have worked actively to promote export controls and to obtain behavior changes in sanctions cases. Even military and intelligence capabilities require coalitions, access, overflights, etc., are made possible by diplomacy. In addition, we can sometimes use diplomacy directly as a nonproliferation tool, independent of the others, to promote good behavior and dissuade irresponsible behavior.

Energetic U.S. use of all of these tools, and intensive cooperation with our friends and allies, have had a positive impact in impeding the UAV proliferation threat. Adversaries' efforts to acquire UAVs have been complicated, and made more time-consuming and expensive. To the extent they have been able to acquire UAVs, our adversaries have had to settle for systems that are less effective and less reliable than if our nonproliferation efforts had not existed.

Conclusion. Just as they provide real opportunities for U.S. and allied militaries, UAVs also provide opportunities for our adversaries to threaten us. Dealing with that threat has been a part of U.S. nonproliferation efforts for over 15 years, and we have been strengthening our ability to impede and cope with it -- broadening MTCR export controls, adding "catch-all" controls, improving our military and intelligence capabilities. But we will need to keep working hard to keep pace with the threat, not only because our adversaries are determined, but because the increasing reliance on UAVs worldwide (including in civilian roles) and the dual-use nature of much UAV technology will make our job more difficult in the future.

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SENATE GOVERNMENTAL AFFAIRS COMMITTEE

STATEMENT OF

CHRISTOPHER BOLKCOM

ANALYST IN NATIONAL DEFENSE

CONGRESSIONAL RESEARCH SERVICE

BEFORE THE

SENATE GOVERNMENTAL AFFAIRS COMMITTEE

SUBCOMMITTEE ON INTERNATIONAL SECURITY, PROLIFERATION, AND

FEDERAL SERVICES.

HEARING ON CRUISE MISSILE PROLIFERATION

JUNE 11, 2002

NOT FOR PUBLICATION
UNTIL RELEASED BY
SENATE GOVERNMENTAL AFFAIRS COMMITTEE

Mr. Chairman, distinguished members of the subcommittee, thank you for the opportunity to appear before you to discuss cruise missile proliferation. As requested, I will address the following questions:

- What makes cruise missiles[1] attractive weapons to Nations of Concern or terrorist groups? What technical challenges make them an unlikely weapon for terrorist groups?
- What are the difficulties in assessing the spread of cruise missile technology?
- How aggressively are nations pursuing cruise missiles?
- What challenges does the link between cruise missiles and the aircraft industry pose to applying effective export controls?

Crosscutting Observations

Before I address these questions directly, I'd like to make three observations that cut across all four of your questions:

- First, almost all cruise missile technologies have legitimate commercial and civil applications.
- Second, because cruise missile technologies are widely found in the civil aviation industrial base, their proliferation is difficult to monitor, assess, predict, and control.
- And third, due to the previous two points, cruise missiles offer great potential for technological surprise. They can emerge quickly and unforeseen.

What features make cruise missiles and unmanned aerial vehicles an attractive weapon for nations of concern or terrorist groups?

Generally speaking, terrorists have demonstrated a preference for using cheap and easily accessible weapons and technologies. Common terrorist techniques include using truck bombs, letter bombs, suicide bombers, and hijacking commercial aircraft. If terrorists pursue cruise missiles, it will likely be because they find it easy and cost effective to do so, and because cruise missiles will offer perceived advantages over other proven terrorist weapons.

[1] There is no universally agreed upon definition of what constitutes a cruise missile. However, it is commonly recognized that cruise missiles are unmanned, self-propelled vehicles that sustain flight through the use of aerodynamic lift over most of their flight. Ballistic missiles (such as Scuds) are not cruise missiles. Manned aircraft are not cruise missiles. Unmanned aerial vehicles, autonomous targets and drones are not truly cruise missiles unless they carry a warhead or weapon. However, UAVs so closely resemble cruise missiles that they are often treated as such (e.g. Missile Technology Control Regime).

The main potential reason why nations of concern may pursue cruise missiles, is that they might view them as a cost effective means of "leveling the playing field" against more advanced militaries. Unable to compete against the air and naval forces of industrialized countries, nations of concern may pursue cruise missiles as the "poor man's air force" or "poor man's navy." Additionally, cruise missiles can give authoritarian regimes a higher degree of control over personnel. Disgruntled pilots can defect by flying their aircraft to neighboring countries. Cruise missiles, on the other hand, are incapable of desertion.

Cruise missiles possess many features that match observed terrorist patterns and the potential nation of concern motivations described above. These features are related to system acquisition, system employment, and logistics. Acquisition features include low acquisition cost, and multiple acquisition options. Employment features include high accuracy potential, operational flexibility, high probability of penetrating air defenses, and high pre-launch survivability. Logistical features relate to benign handling requirements and infrastructure burdens.

Low acquisition costs

Generally speaking, cruise missiles are no longer "rocket science" and are relatively inexpensive.[2] While today's most capable cruise missiles – such as the Tomahawk -- tend to cost more than $1 million per copy, many cruise missiles can be had for less than $400,000 (Otomat, AS-16, AS-17, SS-N-25, Hsiung Feng I). Some cruise missiles cost $250,000 or less (HY-2 series, AS-11). Many, if not most UAVs cost even less (e.g. Mastiff $100,000, and MQM-107 $175,000). As a point of comparison, in 1991, Russian ballistic missiles (e.g., Scud-B and SS-21) tended to sell for about $1 million each.[3] Chinese ballistic missiles have reportedly been offered for between $1 million and $2 million (the M-11 and M-9 respectively).[4]

Variety of acquisition paths

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[2] The U.S. built the first cruise missile in 1917, and the German's launched 20,000 V1s during World War II. Adjusting for inflation, estimates price the V1 at about $3,000 in 2002 dollars.
[3] *Assessing Ballistic Missile Proliferation and Its Control.* Center for International Security and Arms Control. Stanford University. November 1991. p.27.
[4] Steven Zaloga. *World Missiles Briefing.* Teal Group Inc. Fairfax, VA. May 2001

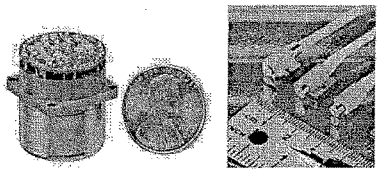
Cruise missiles can be acquired through a variety of acquisition paths. Export of relatively effective cruise missiles and UAVs (range <300km and payload <500kg) can be acquired without violating Missile Technology Control Regime (MTCR) guidelines. Once imported, access to a variety of civilian technologies and expertise could enable cruise missile upgrades or conversions.[5] Civilian and military aircraft can be converted into cruise missiles. Cruise missiles can be produced indigenously, frequently leveraging platforms and technologies found in the commercial sector. This variety of acquisition paths makes cruise missiles attractive to both terrorists and nations of concern, as it increases the likelihood of acquisition success. If one path proves fruitless, others can be pursued. (For a snapshot of the various, often overlapping cruise missile acquisition paths, see Appendix 2, a case study of Styx-class cruise missile proliferation.)

High accuracy potential

The advent of the Global Positioning System (GPS) has probably done more to draw attention to cruise missile proliferation than any other event. GPS -- and potentially other systems such as the Russian GLONASS -- offer cheap, effective, and passive means of correcting the drift errors inherent in the inertial navigation systems that guide cruise missiles. Today's standard GPS signals offer global accuracy of better than 10 meters.[6]

Inertial navigation systems themselves have also improved, in terms of accuracy reliability, and size. The typical inertial measurement unit (IMU), consisting of three gyroscopes, three accelerometers[7] and associated electronics weighed 25lbs in 1988. Currently, IMUs tend to weigh around 1 lb. Furthermore, fiber optic and ring laser gyros, which are more reliable and more accurate, are replacing traditional rotating mass gyroscopes. These more accurate inertial navigation systems require fewer GPS updates than less accurate systems over the same distance.

Figure 1: Modern Rotating Mass Gyro (L) and Accelerometers (R)



[5] Also, some MTCR members have proven willing to export cruise missiles that arguably violate MTCR guidelines. Steven Zaloga. "The Cruise Missile Threat: Exaggerated or Premature?" *Jane's Intelligence Review.* April 1, 2000.

[6] On May 1, 2000, "selective availability" mode of GPS, which degraded the accuracy of GPS signals available to non-military users, was turned off.

[7] Instruments for measuring, displaying, and analyzing acceleration and vibration

Precise navigation technology alone is not sufficient for accurate targeting. The target location, location of defenses, and major terrain features en route to the target must also be considered as part of the targeting solution.

The mission planning for some cruise missile applications may be easy. Delivering chemical or biological agents against cities, for example, might not require precise understanding of range, location, or terrain features. Because of their potential lethality, the effects from a very small amount of some biological agents might be felt over a very large area. Similarly, harassment, decoy, or attrition types of cruise missile attacks would not require complicated mission planning. Also, a number of UAVs are being outfitted today with communications and radar jammers. These unmanned electronic warfare (EW) platforms also would not require complicated mission planning, as U.S. communications and radar emissions would provide the required guidance. Yet, these UAVs have the potential to degrade the information dominance upon which many U.S. warfighting concepts depend.

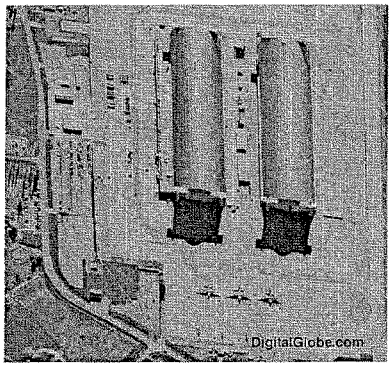
For more complicated missions such as accurately striking point targets, today's military planners have access to, and the ability to exploit a good deal more information than the general "lat/long" of a target. Three mission-planning resources of interest to cruise missile users include maps, satellite imagery, and Geographic Information Systems (GIS).

Accurate maps, from cartographic versions to accurate digital products are readily available to most consumers. The National Oceanic and Atmospheric Administration (NOAA) for instance, sells aeronautical charts at 1:500,000 with 152-meter vertical and 610-meter horizontal contour accuracy. The U.S. Geographical Survey (USGS) provides a variety of cartographic products, including 1:24,000-scale topographic quadrangle maps, Orthophotoquads (which are distortion-free aerial photographs that are formatted and printed as standard 7.5 minute, 1:24,000-scale quadrangles), and satellite imagery maps.[8] The National Imagery and Mapping Agency (NIMA) digital maps with <20 meter vertical and <990 horizontal contour accuracy are also made available commercially, though their distribution is controlled.

Satellite imagery promises accuracy compatible with advanced navigation. Satellite pictures are currently available commercially from several countries, including China, France, India (1-meter resolution), Israel (1.8-meter), Russia (2-meter), Japan, and the United States. The U.S. Government has approved commercial sale of satellite images of up to one half meter in resolution and at least two companies sell such images via the Internet.

[8] http://mapping.usgs.gov/www/products/1product.html

Figure 2: 1/2 meter Resolution Picture of Moffet Field, CA



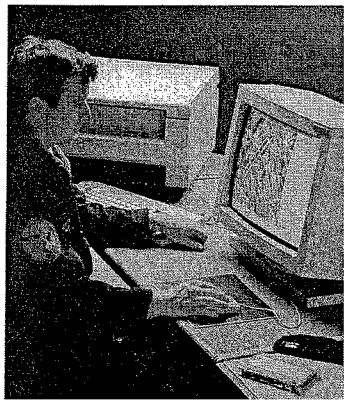
GIS, which create a computer environment for merging and exploiting different data sources, are also increasingly popular and commercially available products. For instance, *ER Mapper*, a product designed for Earth resource scientists, sells for less than $20,000. This product runs on a Sun computer workstation and can be used to integrate targeting coordinates with imagery compatible with advanced navigation systems.[9]

Cruise missile exporters include mission-planning resources as part of their sales. In their marketing literature, the French, for instance, advertise that the *Apache* cruise missile includes all required mission planning assets:

> All parameters, threats, ground relief and weather conditions are used by one workstation. Both data calculations and posting of flight plans are generated in real time on the screen. This ground equipment allows for the definition of the optimum trajectory for the missile and the carrier.[10]

[9] http://www.ermapper.com.cn
[10] Matra Defense. *Apache* marketing brochure. 37, avenue Louis-Breguet. 78140 Velizy-Villacoublay. France

Figure 3: Apache Cruise Missile Mission Planning Workstation



In terms of accuracy and mission planning, most modern land attack cruise missiles available to or being developed by nations of concern appear capable of attacking fixed area targets from theater ranges. These include population centers, ports, airfields, military headquarters, and logistics infrastructures.

Operational Flexibility

Cruise missiles offer noteworthy operational flexibility. This may be attractive to groups or countries with limited resources. One platform may serve many different purposes. Cruise missiles can be used against a variety of targets, both on the land and sea. They can be launched from aircraft, ships, and submarines. Thus, cruise missiles can augment existing air and naval platforms or they can be shot from ground-based launchers. Ground launchers tend to be mobile and compact.

Cruise missiles can be armed with a number of different warheads, such as high explosives, submunitions, chemical and biological agents, radiological material and nuclear warheads. They can fly variable flight paths, avoiding enemy air defenses, and attacking targets from multiple and unexpected vectors. Furthermore, the amount of fuel and payload in cruise missiles is relatively interchangeable. Either range or payload can be increased on most cruise missiles. However, this is not a built-in feature of the system, and typically requires some engineering work that may incur some overall penalty in terms of missile performance.

Finally, if as discussed above, cruise missiles are obtained cheaply, they may also be acquired in bulk. Large inventories can reduce the demand for high quality or make these weapons relatively expendable.

High probability of penetrating air defenses

A cruise missile's small size tends to lend it a smaller radar signature, which makes detection by air defenses difficult. This low radar cross section (RCS) coupled with electronic countermeasures and an increasing ability to fly at low altitude gives modern cruise missiles a high probability of penetrating air defenses. Also, because a cruise missile looks more or less like a manned aircraft on a radar screen, defenders must be very certain of combat identification (CID) to avoid shooting down friendly, neutral or civilian aircraft. Verifying the identity of a "blip" on a radar screen takes time, and that time is advantageous to the attacker.

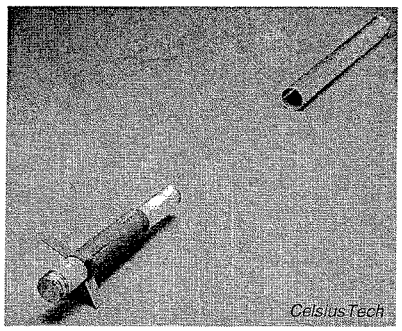
Today's low-altitude missile flight is most likely to take the form of terrain avoidance or "sea skimming." This requires some form of sensor and feedback control system to maintain the desired altitude. Some of the most readily available sensors that can be used are barometric altimeters and radar altimeters.

Barometric altimeters are simple devices that use a barometric capsule or a piezoelectric transducer to detect altitude based on the local atmospheric pressure. They are adequate to control missile flights down to about 100 meters for flights over a range of 20 to 30 km.

Radar altimeters are used to indicate the height above ground or sea. Radar altimeters can now be designed to operate down to a height of 1 to 10 meters. Such systems weigh about 2.5 kg. In practice, terrain roughness or Sea State limits the minimum safe operating altitude for low flying cruise missiles. In general, a missile would have to fly at least three times the mean crest-to-trough wave height to be reasonably certain of clearing the waves. Thus, five foot waves requires cruise missiles to fly at least 15 feet. A similar relationship would apply to overland flight.

Electronic countermeasures (ECM) such as self-protection jammers and towed radar decoys are available in size and cost commensurate with use in today's high-end cruise missiles (e.g., *Apache*). Employment of ECM could significantly increase the survivability of cruise missiles, once identified and targeted by air defenses.

Figure 4: Towed Radar Decoy Small Enough for Cruise Missile use



High pre-launch survivability

Cruise missiles, especially ground-launched cruise missiles, appear likely to enjoy greater pre-launch survivability than manned aircraft, and perhaps tactical ballistic missiles. Cruise missiles tend to project a much smaller operational footprint than manned aircraft, which require large airfields, hangars, maintenance facilities, and personnel billeting. Most modern ground launched cruise missiles are likely able to "shoot and scoot" on the same, or perhaps shorter timelines as ballistic missiles. Also, cruise missile's small size and relatively cool infra red launch signature may make them very amenable to camouflage, concealment, and deception (CCD) techniques. For example, from a distance, many cruise missile launchers are difficult to distinguish from busses, trucks, and some wheeled construction equipment. Small modifications to the cruise missile launcher – such as paint or canvas canopies, could make combat identification (CID) extremely difficult, especially if cruise missile launchers are interspersed with civilian traffic.

In Operation Enduring Freedom, the United States has demonstrated good capabilities against mobile targets compared to its "Scud hunting" track record of Operation Desert Storm 10 years ago. Yet, effectively attacking time-critical targets like ground launched cruise missiles remains a major challenge for DoD.[11] Furthermore, this class of targets appears to be much more challenging for other countries, even the relatively modern and robust militaries found among our NATO allies.

[11] e.g. "We've got to do a much better job with time-critical targeting," said Vice Adm. John B. Nathman, commander of Naval Air Forces. *Aviation Week & Space Technology*. April 29, 2002, p.55.

Relatively benign infrastructure and handling requirements

In addition to low acquisition costs, cruise missiles may offer a lower operations and maintenance (O&M) burden than other systems. Since there are no pilots, personnel costs for cruise missiles can be considerably less than that of manned aircraft.

The launch and mission control requirements of the average cruise missile system appear to be relatively easy to satisfy. Cruise missiles and UAVs use easily transportable "zero length" launchers (approximately the same length as the weapon), and mission control tends to be satisfied from a single small truck or van. Because weapon guidance is calculated and maintained over the course of the flight (e.g. GPS updates and terminal guidance) exact precision at launch is not critical to accurate targeting. This may facilitate fast set up and launch times. Scud missiles, on the other hand, tend to take on the order of one hour to set up and launch.

Also, because cruise missile ground launches can be achieved by relatively non-explosive means (e.g. mechanical catapult or strap-on rockets) launchers tend to require relatively little maintenance. It has been estimated that Scud TELs (transporter, erector, launcher) require overhaul after as few as three launches. Launch rails and other components need to be replaced due to metal fatigue caused by extreme temperatures.[12]

Cruise missiles powered by turbojet or reciprocating engines do not require an onerous "logistics train." These engines can be quite fuel-efficient. Ballistic missiles require both fuel and oxidant. The oxidant and fuel for a single Scud missile, by comparison, weighs 3.7 tons.

What technical challenges make them an unlikely weapon for nations of concern or terrorist groups?

There appear to be few technical challenges for most countries to acquire "medium-tech" cruise missiles. In a subsequent section, I will explore how many countries, even countries of modest economies, might have access to cruise missiles and many enabling technologies.

However, there are a number of more advanced cruise missile capabilities that currently appear outside the grasp of most, if not all countries of concern except through direct purchase. These capabilities include:

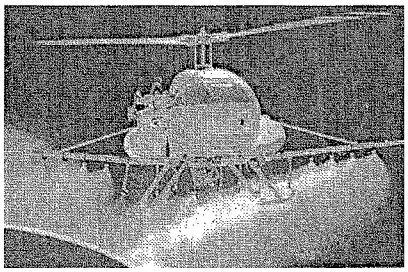
- Very low observable technology
- Terrain following navigation
- Ramjet propulsion

[12] Joseph Bermudez. "Ballistic Missiles in the Third World: Afghanistan 1979-1992. *Jane's Intelligence Review*. February 1992.

- Turbofan engines (which are very efficient and facilitate long ranges)
- High accuracy at very long ranges
- Real time targeting and battle damage assessment (BDA) required to effectively attack moving targets such as ground maneuver forces.

Also, experts debate the ease of disseminating chemical and biological agents (CBW) from cruise missiles. Some observers note that the typical cruise missile flight profile makes it a more effective delivery system than, for instance, a ballistic missile. Also, rotary-wing UAVs have become popular means of crop dusting in countries like Japan and South Korea.[13] Many claim that these unmanned helicopters could be used to spray CBW. Others disagree, saying that chemical, and especially biological agents have much more precise and delicate handling requirements than agricultural pesticides.

Figure 5: South Korean UAV. A Potential CBW Platform?



Technical challenges for terrorist organizations are less clear. The bottom line for terrorist group acquisition would likely be that cruise missiles would need to offer some capability or advantage over other delivery vehicles that are easier or cheaper to acquire. The intelligence community believes that this bottom line will remain elusive. According to a recent National Intelligence Estimate:

> "In fact, US territory is more likely to be attacked with these materials (chemical, biological, radiological, and nuclear) from non-missile delivery means – most likely from terrorists – than by missiles, primarily because non-missile delivery means are less costly, easier to acquire, and more reliable and accurate. They also can be used without attribution."[14]

[13] The Yamaha R-50 is an 11 foot long, UAV that has been used to spray hundreds of thousands of acres of Japanese farmland. It is GPS guided, and dispenses either dry or liquid chemicals. Unit Cost: $40,000. The Daewoo Arch 50 (S. Korea) has similar characteristics.
[14] Foreign Missile Developments and the Ballistic Missile Threat Through 2015. Unclassified Summary of a National Intelligence Estimate. National Intelligence Council. December 2001.

The Central Intelligence Agency (CIA) in recent testimony before this sub-committee echoed this opinion.[15]

What are the difficulties in assessing the spread of cruise missile technology?

In 1994, the Defense Science Board (DSB) -- DoD's premier group of scientific advisors -- made the following points regarding the proliferation of cruise missiles and their technologies:

- The cruise missile threat can be expected to evolve over time in both function and severity,
- The threat could evolve rapidly,
- It will be very difficult for the intelligence community to provide timely estimates of cruise missile and UAV threats.[16]

The DSB and others have identified several challenges to assessing the spread of cruise missiles and their technology. First, countries take great pains to keep missile design and production efforts secret. Often, countries hide missile development and production facilities, sometimes underground, to evade many U.S. surveillance techniques. The small size of cruise missiles relative to many other long-range weapons facilitates their covert development and manufacture. Aircraft manufacturing plants, as a point of comparison, tend to be very large facilities that are more difficult to hide or take underground. Iraq, Libya, North Korea, and Russia are some of the countries said to have built extensive underground military facilities.[17]

Second, countries often engage in active disinformation campaigns to intimidate neighbors and confuse those attempting to accurately assess their military intentions. A mock up of the Iraq's *Ababil* land-attack cruise missile was unveiled at an air show over a decade ago. This led many observers to conclude that Iraq was developing a long range, high payload cruise missile. Yet today, there is no open source evidence that this missile has been fielded. Was there anything more to the program than plywood models? It is doubtful that anyone outside (and perhaps even inside) the intelligence community really knows for certain.

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[15] Hearing of the International Security, Proliferation and Federal Services Subcommittee of the Senate Governmental Affairs Committee. March 11, 2002. Robert Walpole, Strategic and Nuclear Programs Officer, CIA.

[16] Report of the Defense Science Board Summer Study on Cruise Missile Defense. Office of the Undersecretary of Defense (A&T). January 1995. Washington, DC. p.14.

[17] See Jonathan Medalia, "Nuclear Weapons for Destroying Buried Targets." *CRS Report for Congress.* (RS20834) March 2, 2001. And Robert Burns. "Pentagon: U.S. Seeking Anti-Tunnel Nuclear Arms. *South Florida Sun-Sentinel.* March 15, 2002. P.12A.

Third, assessing the spread of cruise missiles and technology is complicated by disagreements over terms and definitions. Some defense experts call the Indian *Lakshya* air vehicle a UAV, while others say it has been tested with a warhead and is therefore a cruise missile. Some consider the Argentine *Martin Pescador* a cruise missile, while others call it an air-to-surface missile due to its rocket motor and short range. Iraq is reportedly building a solid rocket-powered tactical ballistic missile known as the *Ababil-100*. Is this the same system as the previously reported long range, turbojet-powered cruise missile? Or do two different programs merely have similar names?[18]

Fourth, the extent of today's cruise missile proliferation is difficult to assess because the technology "hides in plain sight." It is difficult to differentiate between military and civil application of many technologies that contribute to cruise missiles, such as engines, airframe materials, information technology, and GIS. There are few "tell tale" technologies that can alert export monitors of covert programs. Another complicating factor is the huge size of the commercial market for many cruise missile relevant technologies.

The commercial use of GPS, for example, is a multi-billion dollar industry that has spawned complementing and competing systems such as the Russian GLONASS, and European *Galileo* programs, as well as adjunct differential GPS systems being developed by and for the U.S. Coast Guard and Federal Aviation Administration.[19]

Accelerometers, a key navigational device, are found in the airbag deployment mechanism of almost every modern automobile. As several analysts have noted, the scope and form of information technologies that adversaries can exploit for cruise missile guidance is very broad: Iraq's import of children's video games, for instance, has become a cause for concern.[20] Similarly, it appears that many of the composite materials and structures that make surfboards both strong and lightweight could do the same for cruise missiles, as well as potentially reduce their radar signatures.

Finally, and in part due to the previous point, countries have developed, manufactured, and fielded cruise missiles in very short time spans, which makes assessment difficult and increases the likelihood of surprise. Often, they have done this by exploiting existing, and well understood aviation platforms, such as manned aircraft, UAVs, and anti-ship cruise missiles.

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[18] It turns out that they are, in fact, two different programs with similar names.

[19] The FAA is developing the Wide Area Augmentation System, for precise airline navigation. The Coast Guard is developing a Nationwide Differential GPS system for maritime navigation. Both concepts will use ground based radio beacons to transmit precise navigation information.

[20] The Sony Playstation 2 has 300 MHz, 128-bit processor, and a powerful graphics package. (Dennis Gormley, *Dealing with the Threat of Cruise Missiles* International Institute for Strategic Studies. Adelphi Paper 339. Oxford University Press. New York. June 2001. P.17.)

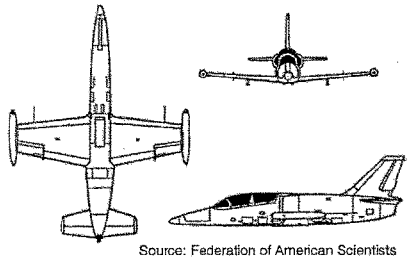
Leveraging manned aircraft

Historically, cruise missile builders have borrowed most heavily from aircraft technologies and techniques.[21] The Soviets borrowed heavily from existing aircraft resources in developing their first cruise missiles. The 1950s era SS-C-2b *Samlet* coastal defense missile, for example, was derived from the MiG-15 aircraft. The SS-C-2b used the MiG's fuselage with minor modifications, was powered by turbojet engines stripped from retired aircraft and shared some of the fighter's flight characteristics such as speed, range, stability, and maneuverability.

For the most part, the U.S. cruise missile development effort of the 1940s and 1950s emulated its early, WWI cruise missile R&D efforts. Engineers from both eras relied on contemporary aircraft propulsion. They adapted aircraft airframes of their time and made cruise missile-specific technological advances only in the areas of guidance and navigation. The first several U.S. post-WWII cruise missiles, for example, were built around widely used fighter aircraft jet engines and were not dissimilar to those aircraft in terms of size and performance. [22]

In more contemporary times, Iraq is believed to have converted manned aircraft into long-range (600km), high payload (200kg) cruise missiles. U.N. weapons inspectors reportedly suspect that Iraq is converting a Czech military training aircraft (the L-29 *Delfin*) into a long-range UAV from which it plans to disseminate biological weapons against its neighbors.[23] Norway has modified a manned aircraft, the Saab MFI-17 trainer, into a UAV.

Figure 6: L-29 *Delfin* Trainer Aircraft/Cruise Missile



Source: Federation of American Scientists

[21] In the early 1900s, experimental cruise missiles were literally unmanned aircraft. During WWI, the United States experimented with unmanned Curtiss N-9 seaplanes automatically controlled by cash register counters, and gyroscopes. British R&D focused on radio remote control of their aircraft, the *Bristol* fighter, *Sperry Avio*, *D.H.9A* and the *Wolf*.

[22] Matador, Mace, Regulus I, Regulus II, Hound Dog.

[23] Biannual report to Congress by the CIA. As reported by Andrew Koch. "US, UK Intensify Air Strikes on Iraqi SAM Forces." *Jane's Defense Weekly*. September 19, 2001.

Weaponizing Unmanned Aerial Vehicles (UAVs)

Countries have converted unmanned aerial vehicles into cruise missiles. Historically, the U.S. BQM-34A *Firebee*, and *Quail* drone had a profound impact on U.S. cruise missile programs. While contemporary cruise missiles were nearly as large as fighter aircraft of that time, the 1960s era *Firebee* and *Quail* UAVs employed turbojet engines of less than one foot in diameter which allowed the design and manufacture of much smaller weapons.

Sweden converted the French CT.20 target drone into the Rb08A cruise missile, a coastal defense and anti-ship system with a 250km range. The Italian-built *Mirach* series of turbojet powered UAVs is believed to be the precursor of two Argentine cruise missile programs and the aforementioned Iraqi *Ababil* cruise missile, a system with a purported range of 500km. Many open source defense publications claim that both Iran and India have weaponized UAVs in their inventories. There also appears to be a strong connection between Israel's UAV and cruise missile programs.

Figure 7: *Mirach* UAV/Cruise Missile on "Zero Length" Launcher

The U.S. *Predator* is the latest weaponized UAV. Designed originally to carry a variety of battlefield sensors, some *Predators* now carry *Hellfire* missiles as well. Because the *Predator* is a missile delivery platform rather than a missile itself, it is actually a more advanced class of cruise missile, the first operational uninhabited combat vehicle, or UCAV.

Building upon, or converting anti-ship cruise missiles

Anti-ship cruise missiles can serve as both evolutionary stepping-stones to a more advanced cruise missile capability and as systems that can be quickly converted directly into land attack weapons. The first generation Soviet ALCMs, GLCMs, and SLCMs, (AS-2, SS-N-1, SSC-1b) all had anti-ship capabilities, while the follow-on missiles (AS-3, SS-N-3) had both anti ship and land attack capabilities. In general, the basic design features of Soviet-era anti-ship cruise missiles suggest that these weapons are relatively easy to adapt to land attack roles. According to former Navy Secretary John Lehman, seven different Soviet anti-ship cruise missiles (SS-N-2, -3, -7, -9, -12, -19, and –22) could be converted to land-attack versions capable of striking the United States.[24]

The U.S. experience provides a more contemporary example of the conversion approach. Standoff Land Attack Missile (SLAM) was derived from off-the -shelf components, primarily from the Harpoon anti-ship cruise missile. SLAM and Harpoon share the same warhead, and sustainer and control sections. The primary difference between the two missiles is in guidance. While SLAM has the Harpoon's radar altimeter and midcourse guidance unit, it also employs technologies from other weapons systems, such as the *Walleye* video data link, and the *Maverick* imaging IR seeker. These components were coupled with a GPS receiver/processor.

The transformation of the Harpoon into the SLAM highlights some of the tradeoffs associated with the conversion approach. On the one hand, Navy engineers created a land attack cruise missile in only 18 months and at low cost. Yet, some compromises were made in missile performance. Use of existing hardware added more weight to the SLAM than more fully integrated and optimized components may have. This increased weight decreased weapon range. Off-the-shelf components required more space than custom-built components because they could not be integrated as efficiently. Thus, the SLAM is .64 meters longer than the Harpoon. In conjunction with the missile's increased weight, this increased length degrades the SLAM's aerodynamics since the control surfaces are optimized for the Harpoon's shorter airframe.[25]

The Harpoon to SLAM conversion began in 1988. Recent advances in the technology for precision guidance and "smart bombs," may provide cruise missile manufactures with more "off-the-shelf" conversion options today -- options that might not incur the performance penalties of past conversion strategies. The Harpoon missile again provides a case in point. Boeing is now working on a new land attack version of the Harpoon called the Harpoon Block II

[24] Arkin, Cochran et al. Nuclear Weapons Databook: Soviet Nuclear Weapons. Natural Resources Defense Council. Harper & Row Publishers. 1989. New York. P.156.
[25] Author's conversations with industry (SAIC) and government (DARPA) aeronautical engineers. June 1995.

that incorporates an integrated INS/GPS guidance system developed for the Joint Direct Attack Munition (JDAM).

The Harpoon Block II will also use the software, mission computer and GPS antenna developed for the SLAM. Harpoon Block II is expected to perform both anti-ship and land-attack missions, and should have aerodynamic performance similar to the original Harpoon. It is not clear which countries are capable of this type of conversion today, but those that can't convert the Harpoon into "the poor man's Tomahawk," as some have called the Harpoon Block II, may be able to import the weapon. Boeing officials foresee an international market for the Harpoon Blk II of 1,100 new-build missiles, and 1,500 retrofits. [26] In May 2002 it was reported that Denmark was the first Harpoon II customer, upgrading 50 of its 100 Harpoon missiles to the land-attack capable variant.[27]

Table 1: Comparison of Harpoon and SLAM

	Harpoon	**SLAM**	**Harpoon Blk II**
Mission	Anti-ship	Land-Attack	Anti-ship/Land-attack
Range (km)	124	93	124
Payload (kg)	227	227	227
Length (m)	3.8	4.5	3.8
Diameter (m)	.34	.34	.34
Wing Span (m)	.9	.9	.9
Weight (kg)	555	620	555
Propulsion	Turbojet	Turbojet	Turbojet
Guidance			
• Midcourse	• INS, radar altimeter	• INS/GPS , radar altimeter	• Precision INS/GPS
• Terminal	• Active radar seeker	• Imaging infrared	• Anti-ship: Active Radar. Land attack: INS/GPS
• End game	• Autonomous	• Man-in-the-loop	• Autonomous

It appears that other countries have mimicked the Harpoon-to-SLAM conversion. The Israeli Gabriel II anti-ship cruise missile and the South African and Taiwanese spin-offs (Skorpioen and Hsiung Feng II respectively), appear to have land-attack capabilities. All three systems have TV terminal guidance like the SLAM and share similar airframe geometries. Many cruise missile analysts contend that all three anti-ship cruise missiles are land-attack capable.

[26] Mark Hewish. "Anti-ship Missiles Intent on Littoral and Land Attack Roles", quoting Boeing officials in *Jane's International Defense Review*. August 1998. P.45. Thomas Duffy. "Navy Says Harpoon Block II Missile Successful in First Flight." *Inside the Navy*. June 11, 2001.
[27] Thomas Dodd. "Denmark to Upgrade Harpoons." *Jane's Defense Weekly*. May 8, 2002. p. 13.

How aggressively are nations pursuing cruise missile purchases as complete systems and developing indigenous capabilities?

Despite the ambiguity and assessment challenges noted above, a survey of unclassified literature does provide some insight into today's state of cruise missile capabilities[28]:

- 81 countries today appear to have cruise missiles of some kind (See Map 1 below). In 1992, 63 countries had cruise missiles.
- Approximately 70,000 cruise missiles are operational worldwide.
- Seventy-five different types of systems are currently in service.[29]
- Over 40 additional cruise missiles are reportedly under development.

Today, the most advanced cruise missiles (e.g., long-range, reduced radar signature, high accuracy, employing terrain hugging navigation, and end-game countermeasures) tend to be in the hands of allies and like-minded countries. Our adversaries and potential adversaries tend to own cruise missiles that appear to be shorter range, have higher radar signatures, and lower accuracy.

[28] Primary sources for the map, Tables 2-4 , Appendix 2, and estimates on cruise missile inventories and programs include publications: *Assessing Ballistic Missile Proliferation and Its Control.* Center for International Security and Arms Control. Stanford University, November 1991. Seth Carus. *Ballistic Missiles in the Third World.* CSIS. Washington, DC. Richard Betts. *Cruise Missiles: Technology, Strategy, Politics.* Brookings. Washington, DC. *Jane's Battlefield Surveillance Systems* (various years). Hooton, & Munson. Eds. Jane's Publishing Co. London. *Jane's Weapon Systems 1986-1987.* Jane's Publishing Co. London. *Jane's Air Launched Weapons.* (various years). Jane's Publishing Co. London. *Nuclear Weapons Databook.* Vol. IV Soviet Nuclear Weapons. National Resources Defense Council. Harper & Row Publishers. New York. Seth Carus. *The Prospects for Cruise Missile Proliferation in the 1990s.* CSIS. Washington, DC, 1992. Thomas Lydon. *RPV/Drones/Targets: Worldwide Market Study and Forecast.* DMS. *The Military Balance.* (various years) International Institute for Strategic Studies. London. *World Aviation Directory* (various years). McGraw Hill Publishers. New York. Michael Armitage. *Unmanned Aircraft.* Brassey's Defense Publishers. London. *Unmanned Air Vehicles After Desert Storm: Expanding World Markets for Flying Robots.* Market Intelligence Research Company. 1991. Steven Zaloga. *World Missile Briefing.* Teal Group Inc. Fairfax, VA. *Ballistic Missile Proliferation: An Emerging Threat.* System Planning Corp. Arlington, VA. 1992, *The World's Missile Dystems* (various years) General Dynamics. Pomona Division. *Aerospace Source Book* (various years) Aviation Week & Space Technology, McGraw Hill Publishers. New York.; Marketing and technical brochures on cruise missiles and technology: Aerospatiale, Alenia, Avionance S.A. Craiova, BAI Aerosystems, Boeing, Developmental Sciences Inc., E-Systems, General Atomics, Israeli Aircraft Industries, Korean Air, Aerospace Division, Lockheed Martin, Matra Bae, McDonnell, Douglas, Northrop Grumman, PT. Industry Pesawat Terbang Nusantara, Sener Ingenieria Y. Sistemas, S.A.m, Swiss Federal. Aircraft Factory, Teledyne Ryan; Databases and Web sites: http://www.cdiss.org (Master Tables), www.fas.org (Military analysis, CpFor Missiles), http://cns.miis.edu/research/missile.htm (Nuclear and missile database). Missile.Index: http://www.index.ne.jp/missile_e/

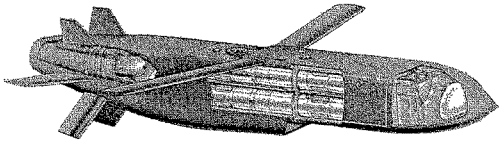
[29] The DIA reportedly estimates 130 different cruise missile types exist. Duncan Lennox. "Cruise Missiles." *Jane's Defense Weekly.* May 1, 1996.

As discussed earlier, however, cruise missile capabilities can change and emerge rapidly. Partly for this reason, it is difficult to find consensus in the defense planning community regarding the future scope and pace of cruise missile proliferation.

The most rapid way a country can acquire cruise missiles is through purchase of foreign-made missiles. A review of the last 50 years indicates that cruise missile exports have not been uncommon (See Appendix 1).

Furthermore, despite fairly well established patterns of cruise missile export, observers can still be caught off guard. In 1998 for instance, many people were surprised when France -- an MTCR member – reported the sale of an accurate, long-range, potentially stealthy variant of their *Apache* cruise missile, the *Black Shahine*, to the United Arab Emirates (UAE).[30]

Figure 8: Apache Cruise Missile



For those concerned about cruise missile proliferation, the spread of indigenous manufacturing capabilities is arguably greater cause for concern than the sale of turnkey cruise missile systems. A country with an indigenous cruise missile manufacturing capability can be of greater concern than a country that merely has cruise missiles in its inventory for three reasons:

- Countries that make cruise missiles tend to be most able to advance the technological state of the art, making cheaper, stealthier, and more accurate cruise missiles in the future.
- Manufacturers usually can quickly and significantly increase their cruise missile inventories. They can simply run a second or third shift at the factory. They don't have to find exporters, negotiate deals, finance sales or make deliveries.
- Manufacturers are potential, if not likely, proliferants. The UAE, for instance, is unlikely to export cruise missiles anytime soon, but France, China, Russia, Sweden, South Africa, Israel, and other current manufacturers may well do so.

[30] Michael Gething. "Upgrades and New Buys Boost UAE Mirage Fleet." *Jane's Defense Upgrades*. January 5, 1998

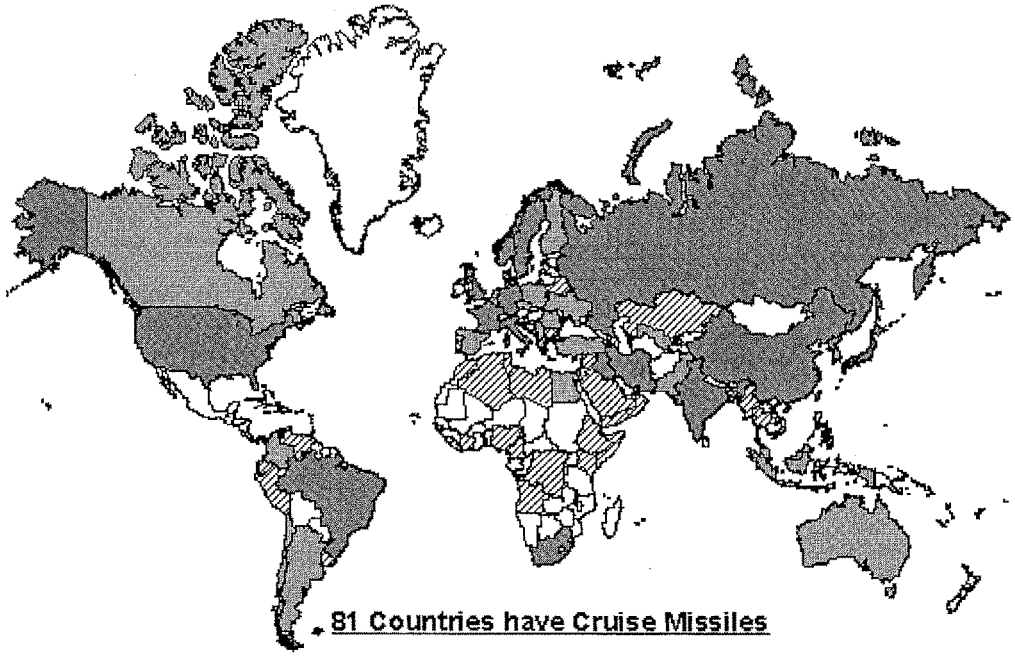
A survey of the 81 countries that have cruise missiles in their military inventories reveals that 18 countries manufacture cruise missiles domestically, and 13 of these countries also export them. These 18 countries and a simplified depiction of their supporting industrial base are summarized in Table 2 below.

Sixty-three of today's 81 cruise missile countries do not currently manufacture cruise missiles. However, 22 of these countries appear to have many capabilities that could be leveraged to create a cruise missile manufacturing capability sooner rather than later. These "threshold manufacturers" are depicted in Table 3 below.

These threshold manufacturers include a wide variety of countries and capabilities. Some, such as Argentina, have dedicated cruise missile programs, and are considered by some observers to already have a manufacturing capability today. Others, such as Canada, Australia, and the Netherlands, are industrially advanced countries that don't appear to have an indigenous cruise missile program, but clearly have the capacity to manufacture them. The exact capabilities of the remaining countries are more difficult to assess, but evidence of access to the design, engineering, and manufacturing capabilities required for cruise missiles is clear.

Using these same criteria for assessing a country's potential cruise missile manufacturing capabilities (production, cooperation and ownership), it appears that there are also at least four countries that currently do not own cruise missiles but could likely manufacture them if they desired -- Switzerland, New Zealand, Austria, and Slovakia. However, because these countries have not yet acquired cruise missiles, it is not clear that they are motivated to do so, and predicting a change in their intent is more difficult than making observations on their capabilities.

Map 1: Estimated Global Cruise Missile Capabilities



- 18 *Indigenous Manufacture* (make cruise missiles today)
- 22 *Threshold Manufacturers* (don't make cruise missiles today, but have or may soon have capability)
- 41 *Operate only* (unlikely to domestically manufacture in near future)

Table 2: Cruise Missile Manufacturers and Exporters
(listed alphabetically)

	Produce Domestically				Cooperatively Produce[31]				Own/Maintain			
18 countries	Cruise Missiles	UAVs	Combat Aircraft	Aircraft	Cruise Missiles	UAVs	Combat Aircraft	Aircraft	Cruise Missiles	UAVs	Combat Aircraft	Aircraft
Brazil	X	X	D	X	X	X	X	X	X	X	X	X
China ***E***	X	X	X	X	X	X	X	X	X	X	X	X
France ***E***	X	X	X	X	X	X	X	X	X	X	X	X
Germany ***E***	X	X		X	X	X	X	X	X	X	X	X
India	X	X	D	X	X		X	X	X	X	X	X
Iran	X	X	D	X	X				X	X	X	X
Iraq	X	X			?	X			X	X	X	X
Israel ***E***	X	X	X	X	X	X	X	X	X	X	X	X
Italy ***E***	X	X		X			X	X	X	X	X	X
Japan	X	X	X	X			X	X	X	X	X	X
N. Korea ***E***	X					X			X		X	X
Norway ***E***	X	D					X		X	X	X	X
Russia ***E***	X	X	X	X	X			X	X	X	X	X
S. Africa ***E***	X	X	X	X	X	X	X	X	X	X	X	X
Sweden ***E***	X	D	X	X	X		X	X	X	X	X	X
Taiwan ***E***	X		X	X			X	X	X	X	X	X
U. K. ***E***	X	X	X	X	X	X	X	X	X	X	X	X
U.S. ***E***	X	X	X	X		X	X	X	X	X	X	X

Key: X = Produces, cooperates, or owns, D = Under development, ? = Unclear, ***E*** = Cruise missile exporter

[31] This category includes a wide range of industrial relationships. In some instances, two countries may cooperate symbiotically in weapon system design and manufacture, where expertise and technology is shared on an equal footing, In other instances, one country may provide design expertise, while the second country manufactures the weapon under license, but gains engineering expertise in the process. A final cooperative case would be where one country simply assembles another's weapon system and little if any design or engineering expertise is transferred in the process.

Table 3: Countries that Import Cruise Missiles and are "Threshold Manufacturers" (Grouped roughly by capability)

	Produce Domestically				Cooperatively Produce				Own/Maintain			
22 Countries	Cruise Missiles	UAVs	Combat Aircraft	Aircraft	Cruise Missiles	UAVs	Combat Aircraft	Aircraft	Cruise Missiles	UAVs	Combat Aircraft	Aircraft
Argentina	D	X		X	D	X	X	X	X	X	X	X
Australia		X				X	X	X	X	X	X	X
Canada		X		X		X	X	X	X	X	X	X
Egypt		X				X	X	X	X	X	X	X
Indonesia		X		X			X	X	X	X	X	X
Netherlands		X		X			X	X	X	X	X	X
S. Korea		X	D	X		X	X	X	X	X	X	X
Czech. Rep.		D	X	X		X		X	X	X	X	X
Spain		D		X			X	X	X		X	X
Pakistan		X		X			X	X	X	X	X	X
Malaysia		X		X				X	X	X	X	X
Belgium		X		X		X	X	X	X	X	X	X
Turkey		X		X		X	X	X	X	X	X	X
Serbia			X	X			X	X	X		X	X
Poland			X	X			X	X	X		X	X
Finland				X			X	X	X	X	X	X
Colombia				X				X	X		X	X
Ukraine				X				X	X	X	X	X
Chile				X			X	X	X	X	X	X
Romania				X			X	X	X	X	X	X
Uzbekistan				X			X	X	X		X	X
Greece				X					X		X	X

Key: X = Produces, cooperates or owns, D = Under development.

The remaining 41 countries that operate cruise missiles today appear unlikely to become cruise missile manufacturers in the near future. These countries and a

simplified portrait of their cruise missile industrial and technology bases are depicted in Table 4 below. All of the countries in this category own cruise missiles and many also own UAVs. Yet, a review of the industry in these countries indicates that not only is the ability to manufacture cruise missiles apparently lacking, but these countries don't produce UAVs, combat aircraft or civilian aircraft, which as discussed earlier, can serve as "pathways" to cruise missile manufacturing. Furthermore, with the exception of eight countries, there also does not appear to be any cooperative programs through which these countries are currently gaining cruise missile design or manufacturing expertise. Owning aircraft and combat aircraft may drive some countries to develop some technical skills, however simple. These platforms require regular maintenance and repair, which in turn require expertise, tools, and specialized equipment. A country that is able to keep its aircraft in good order with little outside help, has more potential to develop future cruise missile expertise and infrastructure, than a country that cannot.

Table 4: Countries that Import Cruise Missiles

	Produce Domestically				Cooperatively Produce				Own/Maintain			
41 Countries	Cruise Missiles	UAVs	Combat Aircraft	Aircraft	Cruise Missiles	UAVs	Combat Aircraft	Aircraft	Cruise Missiles	UAVs	Combat Aircraft	Aircraft
Singapore							X	X	X	X	X	X
Denmark							X		X		X	X
Portugal								X	X		X	X
S. Arabia								X	X	X	X	X
Morocco								D	X	X	X	X
Libya								X	X	X	X	X
Philippines								X	X		X	X
Nigeria								X	X		X	X
Algeria									X	X	X	X
Syria									X	X	X	X
Thailand									X	X	X	X
UAE									X	X	X	X
Oman									X		X	X
Peru									X		X	X
Venezuela									X		X	X
Albania									X		X	X

Angola			X	X	X
Azerbaijan			X	X	X
Bahrain			X	X	X
Bangladesh			X	X	X
Belarus			X	X	X
Bulgaria			X	X	X
Cote D'Ivoire			X	X	X
Croatia			X	X	X
Cuba			X	X	X
Ecuador			X	X	X
Eritrea			X	X	X
Kazakhstan			X	X	X
Kenya			X	X	X
Kuwait			X	X	X
Qatar			X	X	X
Somalia			X	X	X
Tunisia			X	X	X
Vietnam			X	X	X
Yemen			X	X	X
Cameroon			X	X	X
Myanmar			X	X	X
Dem. Congo			X	?	X
Brunei			X		X
Cyprus			X		X
Uruguay			X		X
Key: X = Produces, cooperates owns, D = Under development, ? = Unclear.					

What challenges does the link between cruise missiles, unmanned aerial vehicles, and the aircraft industry pose to applying effective export controls?

The ability to effectively apply export controls to cruise missiles and their technologies appears to be challenged by their link to the civil aircraft industry in three ways.

First, as discussed earlier in this testimony, differentiating between civilian and military applications of aviation technology is often difficult. Most if not all cruise missile technologies are found in the civil and commercial sector. And, apparently non-threatening civil aircraft can be converted into cruise missiles. The inherent flexibility of cruise missiles, especially in the areas of range and payload, makes agreement on system capabilities, and control of these systems difficult. The French argue, for example, that the *Apache*-class cruise missile they sold to the UAE does not fall within MTCR constraints. The U.S. Government and some independent observers disagree with the French perspective.[32]

Second, because the aircraft industry is a major segment of the U.S. economy, and exports are important to the aerospace industry, any perceived reduction in export competitiveness due to export controls would likely cause concern among both aerospace industry leaders and policy makers.

Data provided by the Aerospace Industries Association show that over the past 35 years, for instance, the export of aerospace technology has totaled over $600 billion in sales and averaged almost 10% of all U.S. merchandise exported annually.

U.S. aerospace industry proponents point out that domestic orders for many aerospace products such as military aircraft have steadily decreased in the post Cold War timeframe. U.S. aerospace advocates argue that a reduction in domestic orders makes export success for U.S. aerospace industries more important, and impediments caused by restrictive export controls unwelcome.

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[32] Paul Beaver. "USA Angry Over French Decision to Export Apache." *Jane's Defense Weekly*. April 8, 1998.

As the importance of aerospace exports for U.S. companies has increased, competition for exports appears to have become more intense. European aviation and defense consolidation has matured significantly over the last 10 years, industry analysts point out, and many European aerospace products now rival U.S. products for market share. In commercial jetliner sales, for example Airbus's backlog of orders is currently larger than Boeing's, with a 51.6% share by value. Some analysts predict that Airbus's share of the overall market will continue to grow, averaging over 42% of the global market through the year 2010.[33]

Similarly, U.S. industry proponents say that in the defense aviation sector, the recently formed European Aerospace Defense and Space Company (EADS) appears to have the resources and expertise to compete with the largest U.S. defense firms. Also, due to their own decline in domestic orders, Russian aerospace companies are aggressively marketing their products abroad. Because the Warsaw Pact no longer exists, Russian aerospace exporters no longer have a "captive audience" for their products. Therefore, many argue, they are aggressively marketing their products to many countries where the United States may have previously enjoyed little competition. Also, some Russian aerospace products, like the Su-35 fighter, compare favorably to current U.S. combat aircraft, many argue, and many Russian aviation products cost less than U.S. products.[34]

Many believe that in light of the circumstances outlined above, export controls that pertain to aerospace products and technologies need to be overhauled and streamlined. In its second Interim Report, the Commission on the Future of the United States Aerospace Industry writes:

> Export controls have been and should be an important component of America's national security. The Commission believes, however, that export controls are increasingly counterproductive to our national security interests in their current form and method of implementation.[35]

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[33] "Commercial Jet Transports: Market Overview." *World Military and Civil Aircraft Briefing.* Teal Group, Inc. Fairfax, VA. October 2001. Note: The argument over share of the commercial jetliner market is complicated. There are competing measures of market share (e.g. backlog, aircraft deliveries) and arguments can be made in favor of either company's current dominance. Airbus's competitive presence in the market, however, appears clear.

[34] For example, the Su-35 is currently competing with the F-16 for a 24 aircraft deal with Brazil. Many observers believe that the Su-35 has the upper hand in the competition. Axel Bugge. "Sukhoi said 'Sure Thing' in $700M Brazil Tender." *Moscow Times.* June 6, 2002.

[35] Commission on the Future of the United States Aerospace Industry. (Interim Report #2. March 20, 2002. Section IV "Dual Use Exports," p. 10.

The third challenge to applying effective export controls is posed by the potentially large growth in demand for unmanned systems as the technology matures and becomes applicable to an increasing number of civil and military roles. Some estimate that the market for UAVs and cruise missiles over the next eight years will exceed $25 billion.[36] Some analysts suggest unmanned systems will in the near future take on many new military roles. Companies such as Boeing and Northrop Grumman, for instance, are actively engaged today in researching and designing tomorrow's unmanned combat aerial vehicles.

The cruise missile and UAV proliferation witnessed to date has been generated by what can be described as a "niche" demand. The production and export of manned aircraft has traditionally dwarfed that of unmanned systems. How quickly and to what extent will unmanned systems proliferate in the future, as their military applications become more widespread?

Finding a balance between national security and economic competitiveness in the area of cruise missile proliferation appears to be a complicated public policy challenge. The recently proposed export of the *Predator* UAV to Italy is an example of this challenge. On the one hand, this system (if deemed exportable under MTCR guidelines) would go to a close NATO ally, with which the United States has a long track record. It would improve Italy's surveillance capabilities, and promote interoperability with U.S. forces. The sale could help U.S. industry. On the other hand, the *Predator* is a very capable system that can be easily weaponized. Exporting this system to any country, some argue, sends the wrong message regarding cruise missile proliferation, and reduces the U.S.' leverage when attempting to deter others from exporting unmanned systems.

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[36] *World Missile Briefing.* Teal Group Inc. Fairfax VA. Figure was derived by adding forecasts for UAVs, stand-off air-to-surface, and anti-shipping missiles.

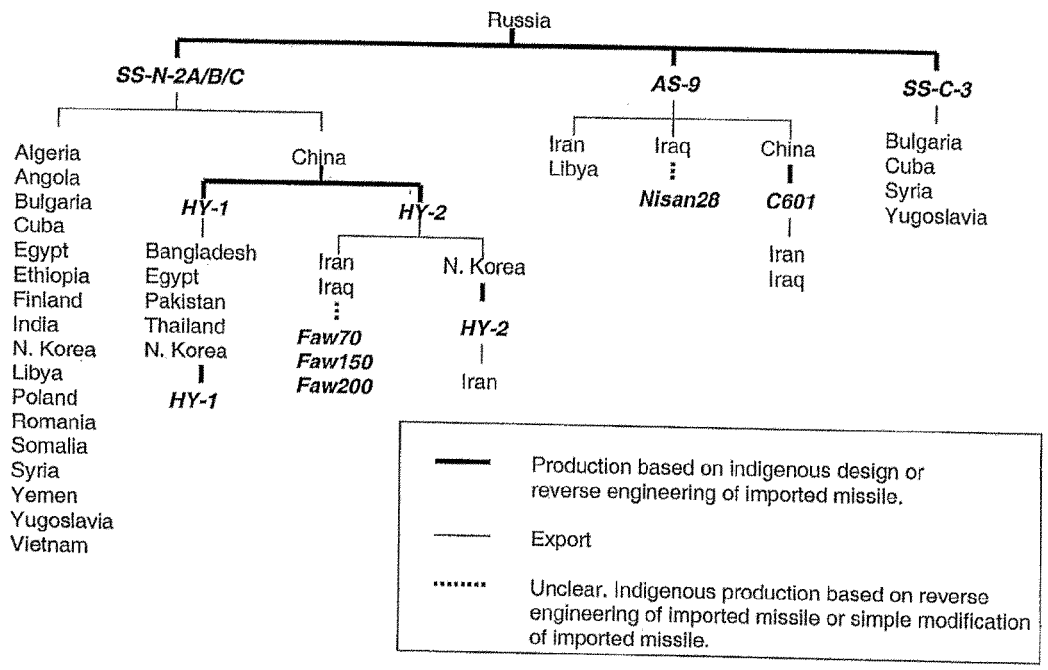
Appendix 1: Illustrative Cruise Missile Sales[37]

Exporter	Missile	Importer
China	FL-1/HY-1	Bangladesh, Egypt, N. Korea, Pakistan, Thailand
	HY-2	Iran, Iraq, N. Korea, Zaire
	HY-4	Iran
	C601	Iran, Iraq
	C801	Iran, Thailand
	C802	Iran
France	Apache	UAE
	Armat	Egypt, Iraq, Kuwait
	Exocet	Argentina, Bahrain, Belgium, Brazil, Brunei, Cameroon, Chile, Colombia, Ecuador, Ethiopia, Germany, Greece, India, Indonesia, Iraq, S. Korea, Kuwait, Libya, Malaysia, Morocco, Nigeria, Oman, Pakistan, Peru, Philippines, Qatar, S. Africa, Spain, Thailand, Tunisia, UAE, UK.
	SCALP	Greece
Germany	Kormoran	Italy
Israel	Gabriel I/II	Chile, Ecuador, Kenya, Singapore, S. Africa, Taiwan, Thailand
Italy	Otomat	Egypt, Iraq, Kenya, Libya, Nigeria, Peru, S. Arabia, Venezuela,
N. Korea	HY-2	Albania, Egypt, Iran, Pakistan
Norway	Penguin	Greece, Sweden, Turkey
Russia	AS-4	Iraq
	AS-5	Egypt, Iraq
	AS-9	China, Iran, Libya, Yemen
	AS-11	Iran, Iraq
	AS-12	Iraq
	Kh-41	China
	SSN-3	Syria, Yugoslavia
	SSN-2A/B	Bulgaria, Finland, India, Libya, Poland, Romania, Yugoslavia, Yemen
	SSN-2C	Algeria, Angola, Bulgaria, Cuba, Egypt, Ethiopia, Finland, India, N. Korea, Libya, Poland, Romania, Somalia, Syria, Vietnam, Yemen, Yugoslavia
	SSN-22	China, India, Iran
	SSN-25	Algeria, India, Vietnam
	SSC-2B	Bulgaria, China, Cuba, E. Germany, Egypt, N. Korea, Poland, Romania, Syria
	SSC-1B	Bulgaria, Syria
	SSC-3	Bulgaria, Cuba, Syria, Yugoslavia
Sweden	RBS15	Finland, Poland, Yugoslavia
UK	Sea Eagle	Germany, India, Oman
	Sea Skua	Germany, S. Korea, Kuwait, Turkey
US	Harpoon	Australia, Canada, Denmark, Egypt, Germany, Greece, Indonesia, Iran, Israel, Japan, S. Korea, Kuwait, Netherlands, Norway, Pakistan, Portugal, S. Arabia, Singapore, Spain, Taiwan, Thailand, Turkey, UK, Venezuela.
	Tomahawk	UK

[37] The Military Balance (Various years). International Institute for Strategic Studies. Oxford University Press. London

Appendix 2: Illustrative Export, Reverse Engineering, and Production of Russian Cruise Missiles

Proliferation Case Study: Evolution of Styx-Class Cruise Missiles



Source: See footnote #27

Appendix 3: Acronyms and Abbreviations

ALCM	Air launched cruise missile
ASCM	Anti-ship cruise missile
BDA	Battle damage assessment
CBW	Chemical and biological weapons
CCD	Camouflage, concealment, and deception
CEP	Circular error probable
CIA	Central Intelligence Agency
CID	Combat identification
DoD	Department of Defense
DSB	Defense Science Board
EADS	European Aerospace Defense and Space Co.
ECM	Electronic countermeasures
EW	Electronic warfare
GIS	Geographic information systems
GLCM	Ground launched cruise missile
GPS	Global positioning system
IMU	Inertial measurement unit
INS	Inertial Navigation System
JDAM	Joint Direct Attack Munition
LACM	Land attack cruise missile
NIMA	National Imagery and Mapping Agency
MTCR	Missile Technology Control Regime
O&M	Operations and Maintenance
RCS	Radar cross-section
R&D	Research and development
RLG	Ring laser gyro
SLAM	Stand off land attack missile.
SLCM	Sea launched cruise missile
TEL	Transporter, erector, launcher
TERCOM	Terrain contour matching
UAV	Unmanned aerial vehicle
UCAV	Uninhabited combat aerial vehicle
UN	United Nations

STATEMENT BY
DENNIS M. GORMLEY
Before the
Subcommittee on International Security, Proliferation and Federal Services
Of the
U.S. Senate Committee on Governmental Affairs
June 11, 2002

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

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

What accounts for the growing concern that cruise missiles and UAVs may fall into the hands of nations of concern or terrorist groups? As I argued in my testimony before this committee on February 12, cruise-missile proliferation is fueled by two primary realities: first, the quantum leap in unregulated dual-use technologies supporting cruise-missile development; and second, the fact that the 33-nation Missile Technology Control Regime (MTCR) is much less effective at controlling the spread of cruise missiles and UAVs than ballistic missiles. This means that states have a multitude of

possible paths to acquire cruise missiles and UAVs, including direct purchase from industrial suppliers; conversion of anti-ship cruise missiles into land-attack systems; conversion of unarmed UAVs and drones into weapons-carrying cruise missiles; conversion of small manned airplanes (including so-called kit planes) into autonomous cruise missiles; and by far the most arduous and US-preferred path, indigenous cruise-missile production.

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

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

Regional states facing any US-led coalition cannot expect to see their aircraft survive much beyond the first blow of any campaign. Yet cruise missiles launched from a variety of survivable platforms would enable such a state to mount a strategic air campaign with cruise (and ballistic) missiles—all without achieving air superiority. In this connection, military effectiveness interacts closely with the growing vulnerability of American-style force projection, especially its dependence on short-legged aircraft, ground forces, and related logistical support operating out of a few forward bases.

Besides being more effective than ballistic missiles (conservatively) by at least a factor of ten in delivering biological payloads, cruise missiles have several other operational advantages compared with ballistic missiles. Cruise missiles can be placed in canisters, which make them especially easy to operate for extended periods in harsh environments. In contrast to large cumbersome ballistic missiles, more modern and compact cruise missiles offer more flexible launch options (air, sea, and ground), greater mobility for ground-launched versions, and a smaller logistics tail, which improve their pre-launch survivability. Moreover, cruise missiles need no special preparations to ensure launch-pad stability, which means that their operators can practice shoot-and-scoot tactics.

But these strong motivations must be tempered by several possible constraints. However much the prestige value of cruise missiles may have risen since the Persian Gulf War, and no matter how much more effective cruise missiles may be compared to ballistic missiles, acquisition of ballistic missiles starts a proliferating state down the path toward possessing an intercontinental-range missile. Possession of an ICBM carries with it enormous coercive value. Although a regional adversary of the US probably could, without detection, use cruise missiles earmarked for regional warfighting to attack US territory from an offshore vessel, the deterrent coercive value of such an option pales in comparison to possession of an ICBM. Another possible constraining factor is the doctrinal and bureaucratic difficulty of fully integrating cruise missiles into third-world force structures dominated by aircraft, tanks, and ships. Moreover, the underlying dual-use technologies supporting either indigenous or conversion programs are relatively new: cheap and widely available GPS/INS systems are less than a decade old; the commercial market for high-resolution satellite imagery is just beginning to mature; and subsidiary aerospace industries specializing in autonomous flight management systems to convert manned aircraft into UAVs are a recent phenomenon. Simply put, it takes time for such technologies to be fully absorbed and incorporated into third-world development programs. But perhaps the most important reason why cruise missiles have yet to spread widely is the absence of effective layered defences, including counterforce capabilities, against ballistic missiles. Not until after 2007 will such defences begin to be effectively deployed by US forces.

Yet, to the extent that America successfully pursues effective theater and national missile defenses against ballistic missiles, nations and terrorist group will be even more strongly motivated than otherwise might be the case to pursue land-attack cruise missiles and weapons-carrying UAVs. For example, the low cost of cruise missiles, small airplanes modified to become autonomous vehicles, and other propeller-driven and armed UAVs makes the cost-per-kill arithmetic of theater missile defense stark. Whether a *Patriot* PAC-3 missile costs $5,000,000 or the desired $2,000,000 per copy, the figure compares unfavorably with either a $200,000-per-copy cruise missile or large saturation attacks of $50,000-per-copy modified airplanes. Quite simply, because ballistic and cruise missile defenses depend largely on the same high-cost air-defense interceptors, complementary cruise and ballistic missile attacks, especially saturation ones and those delivering WMD payloads, will present enormous challenges for the defense.

On it own, the emergence of the cruise-missile threat confronts American military forces with enormous challenges. The effectiveness of both airborne and ground-based surveillance radars is being undermined by missile designs that are increasingly sleek and aerodynamic, and have lower radar cross-sections. Reduced radar observability means that the defense has less time to react. Also, many missiles have very low flight profiles and employ terrain features to avoid detection. Low flight impedes airborne surveillance, owing to radar "clutter" from ground objects other than the target, which makes a land-attack cruise missile difficult to detect.

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

The emergence of large numbers of weapons-carrying unmanned aerial vehicles (UAVs) or converted kit airplanes flying at very slow speeds also threatens the utility of legacy air-defense systems. Today's expensive air-defense systems were designed to

detect high-performance Soviet air threats flying at high speeds. Sophisticated look-down radars eliminate slow-moving targets on or near the ground in order to prevent their data processing and display systems from being overly taxed. Thus, large numbers of propeller-driven UAVs flying at speeds under 80 knots would be ignored as potential targets. Although ground-based SAM radars could detect such slow-flying threats, the limited radar horizon of ground-based radars combined with large raid size means that SAMs could be quickly overwhelmed and their missile inventories rapidly depleted.

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

Indeed, the latest NIE—no doubt influenced by the events of September 11—argues that this among several other attack options is more likely to occur compared to a long-range ballistic missile attack on the US homeland. This is because such alternatives are less costly, easier to acquire, and more reliable than using an ICBM. While this scenario and other non-ICBM threats deserve close scrutiny, the conversion of small manned airplanes into weapons-carrying, fully autonomous cruise missiles concerns me the most. Terrorist use of large commercial airliners on 11 September came as a complete shock to American planners. To be sure, 11 September engendered a whole rash of reforms to cope with a repeat of just such an attack. But these reforms deal

largely with commercial aircraft security rather than private aviation. Even though small converted aircraft cannot begin to approach the carrying capacity of a jumbo jet's 60 tons of fuel, the mere fact that gasoline, when mixed with air, releases 15 times as much energy as an equal weight of TNT, means that even relatively small aircraft can do significant damage to civilian and industrial targets. Such platforms, too, stand as effective means of delivering biological weapons.

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

How might the kinds of cruise missile threats I've outlined change or evolve over the next 5 to 10 years? Conventional wisdom would suggest that the cruise-missile threat will evolve over time, from relatively few highly observable missiles in the near-term (1-5 years), via higher numbers of lower observable, terrain-hugging missiles in the mid-term (5-15 years), to larger numbers of stealthy missiles with end-game countermeasures in the long-term (>15 years). But major features of the long-term threat could materialize much sooner if the MTCR's handling of cruise-missile transfers does not improve, or if US-Russian and US-Chinese relations worsen. In either case, it is

conceivable that modest numbers of stealthy cruise missiles with countermeasures, accompanied by large numbers of cheap, slow-flying UAVs or converted kit planes, could emerge in 5-10 years. Progress in US cruise-missile defenses seems unlikely to keep pace with even the slowly evolving threat, much less the accelerated version.

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

Decisions could be taken to erect some level of modest defenses against off-shore cruise missile launches. The North American Aerospace Defense Command is currently studying the idea of an unmanned airship operating at 70,000 feet altitude and carrying sensors to monitor low-flying cruise missiles and aircraft. Several airships would be needed together with quick-reacting interceptors to react to perceived threats. Alternatively, perhaps on the order of 100 aerostats flying at an altitude of 10-15,000 feet could act as a system of surveillance and fire control system for quick-reacting interceptors. Still, numerous challenges exist, not least the problem of furnishing warning information on potentially hostile ships embarking from ports of concern (to make the Coast Guard's monitoring function feasible), as well as developing very high quality combat identification information needed to justify shooting down an air vehicle. It is safe to say that even a limited defense of the entire US homeland against off-shore cruise missiles would cost at least $30-40bn—an unspoken fact when the cost of national

missile defense is discussed publicly. Moreover, any effort to construct a homeland defense against cruise missiles hinges on progress in service programs. But such programs lack the necessary funding and have enormous service interoperability, doctrinal, and organizational issues standing in the way of truly joint cruise-missile defenses. In sum, missile-defense options alone are likely to be financially taxing, operationally challenging, and too late in coming to cope with the emerging threat.

What should one make of the complementary effect of nonproliferation policy in stopping or slowing the evolution of the cruise missile threat? The appropriate mechanism is the MTCR. However, as I testified on February 12 before you, the MTCR is more effective in controlling ballistic than cruise missiles and UAVs for several reasons. First, there is a reasonably solid consensus among members for restricting ballistic missiles, while the same does not yet hold for cruise missiles and other UAVs. Second, loopholes in systematic exemptions for all civilian and military aircraft can be used to circumvent many of the regime's restrictions on UAVs. Third, the inherent modularity of cruise missiles makes determining their true range and payload, and trade-offs between the two, difficult, though by no means impossible. In particular, variations in cruise-missile flight profiles—especially those taking advantage of more fuel-efficient flight at higher altitudes—can lead to substantially longer ranges than manufacturers and exporting countries advertise. Finally, and perhaps more important, the provisions of the MTCR's equipment and technology annex—particularly as it applies to cruise missiles and UAVs—simply have not kept pace with the extraordinarily rapid expansion in commercially available technology facilitated by today's globalized economy. The matter of small aerospace companies being formed specifically to provide fully integrated flight management systems to enable the transformation of manned aircraft into entirely autonomous UAVs is only the most egregious illustration.

Yet, however imperfect its critics argue it has been, the MTCR has achieved notable success in controlling the spread of ballistic missiles. It has blocked the export of hundreds of components, technologies, and production capabilities, and succeeded in dismantling the *Condor* missile program sought by Argentina, Iraq, and Egypt—a missile that reportedly included sophisticated *Pershing* II-level technology. The major consequence of this success is that the ballistic missile technology that has spread thus

far is largely derived from 50-year-old *Scud* technology, a derivative itself of the World War II German V-2 missile program. Missile defenses can exploit many of the weaknesses of this technology. Yet, perhaps because they fear weakening their advocacy, few strong supporters of ballistic missile defense are willing to admit that missile proliferation can be effectively controlled. This tendency to view the MTCR glass as half empty has fostered a reluctance to adapt the regime to cope with several major shortcomings in addressing cruise missile proliferation.

Of course, adapting the 33-nation MTCR to grapple more effectively with cruise missile proliferation would require serious US commitment to a decidedly multilateral mechanism. I outlined five specific reforms in my prepared statement for my February 12 appearance before you, including improved language for determining the true range and payload of cruise missiles and UAVs, controls on stealthy cruise missiles, and more exacting coverage of flight control systems, countermeasures equipment, and jet engines. None of these reforms is conceivable without a determined US effort to work closely with the founding G-7 partners of the MTCR. This core group must convince the broad partnership of the benefits of enhanced controls, not just to hinder the widespread proliferation of increasingly sophisticated cruise missiles, but to complicate the currently easy transformation of manned kit airplanes into unmanned terror weapons. Thus far, I have seen no apparent appreciation of the long-term implications of a failure to address these critical reforms. This would suggest either a failure to appreciate the implications of the spread of cruise missiles and UAVs or possibly an unwillingness to adversely affect the industrial benefits that flow from the explosive growth expected for both unarmed and armed UAVs over the next two decades. Such growth potential will inevitably lead to ever-increasing pressure from the UAV industry to create ever more flexible MTCR rules governing the export of these systems.

The firmest evidence of a continuing failure by the MTCR membership, including the United States, to address the cruise-missile threat lies in time and effort spent on developing an international code of conduct against ballistic missile proliferation. The code is the latest manifestation of the longstanding quest by various states to establish a universal, legally binding treaty covering missile proliferation. Attempts in the later regard have inevitably failed, not least because those states who have come to depend

upon longer-range ballistic and cruise missiles are unwilling to forgo their benefits in exchange for whatever marginal gains might flow from improved norms. Nonetheless, beginning in 1999, the MTCR membership took up the writing of a politically binding code that calls upon signatories to declare their ballistic missile programs once annually and alert all signatories before the conduct of all ballistic missile tests. After the MTCR membership approved a draft text in September 2001, more than 80 nations, including the 33 MTCR member states, met in Paris in early February 2002 to review and approve a draft document outlining the code's provisions. Putting aside concerns about the nature of the technology carrots needed to lure states like Iran and North Korea into code membership, the most egregious shortcoming in the code's formulation is the absence of any mention of cruise missiles and UAVs, this in spite of the fact that the MTCR covers both classes of missiles.

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

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

UNCLASSIFIED

Questions for the Record Submitted to
Mr. Vann H. Van Diepen
By Chairman Daniel K. Akaka
Committee on Governmental Affairs
June 11, 2002

Question 1:

In 1998, the French and British announced their intent to sell the Black Shaheen cruise missile to the United Arab Emirates. The Black Shaheen is a Category I system under the MTCR with stealth capabilities. The French and British claim that they can provide adequate safeguards on the end-use of the missiles. The United States opposed this sale and has pressured the French and British to cancel the transfer. Is the United States sill actively opposing this sale? Does the Administration's proposal to enable exports of American made UAVs to non-NAO allies endanger or undercut U.S. efforts to halt the transfer of the Black Shaheen to the United Arab Emirates? If British and French assurances on safeguards were not adequate for the U.S. to approve the sale, why should MTCR members be satisfied with our assurances?

Answer:

This issue is classified. At the unclassified level, I can say that the U.S. position is to insist that MTCR members fully abide by and act in accordance with their commitments under the MTCR Guidelines. U.S. export policy is fully consistent with the U.S.'s own commitments under the MTCR Guidelines, and therefore would not endanger or undercut U.S. efforts to ensure that other MTCR countries act in accordance with the MTCR commitments. There is no issue of being satisfied with U.S. assurances; U.S. behavior will demonstrate the consistency of our policy with our MTCR commitments.

UNCLASSIFIED

Questions for the Record Submitted to
Mr. Vann H. Van Diepen
By Chairman Daniel K. Akaka
Committee on Governmental Affairs
June 11, 2002

Question 2:

Could you please provide more information on the Administration's proposal to enable exports of Category I UAVs to non-NATO members on a case-by-case basis. Under the MTCR, Category I items have a "strong presumption of denial" of export while Category II are decided on a case-by-case basis. Would the Administration's proposal weaken Category I items to Category II levels? If the United States decides to define how, on a "rare occasion," we can override the strong presumption of denial, will other nations, such as Russia and China, do the same?

Answer:

The details of U.S. policy on potential exports of Category I UAVs are classified. Congressional staff have been fully briefed on these details. U.S. policy is consistent with our MTCR commitments, including the application to all exports of Category I items (including Category I UAVs) of the "strong presumption of denial" concerning such transfers. There is no issue of weakening Category I MTCR controls. All MTCR members and adherents may authorize exports of Category I items only on "rare occasions" and where its government has (a) obtained appropriate and binding assurances from the government of the recipient state called for in the Guidelines and (b) assumes responsibility for taking all steps necessary to ensure that the item is put only to its stated end-use.

UNCLASSIFIED

Questions for the Record Submitted to
Mr. Vann H. Van Diepen
By Chairman Daniel K. Akaka
Committee on Governmental Affairs
June 11, 2002

Question 3:

The Iran Nonproliferation Act of 2000 prohibits the sale or transfer to Iran of materials on control lists maintained by the Nuclear Supplier Group, the MTCR, the Australia Group, and Chemical Weapons Convention, and the Wassenaar Arrangement. On May 9, 2002, the U.S. imposed economic sanctions on several Chinese entities for selling cruise missiles and chemical weapons to Iran. Were the cruise missiles in violation of the MTCR technology control list?

Answer:

The Iran Nonproliferation Act of 2000 (INPA) authorizes sanctions against a foreign person if there is "credible information indicating that" the person transferred to Iran an item listed by the multilateral export control regimes. All such persons must be reported to Congress every six months, along with a detailed explanation of any decision not to sanction a reported transfer (unless a statutory exemption is invoked). On May 9, 2002, the U.S. imposed sanctions against two Armenian, eight Chinese, and two Moldovan entities pursuant to the provisions of the INPA, for the transfer to Iran of equipment and technology controlled under multilateral export control regimes. The activities of the entities sanctioned on May 9 are classified; these activities, and the multilateral export control lists on which the items in question are included, are noted in the classified INPA report submitted to Congress on May 9, 2002.

UNCLASSIFIED

Questions for the Record Submitted to
Mr. Vann H. Van Diepen
By Chairman Daniel K. Akaka
Committee on Governmental Affairs
June 11, 2002

Question 4:

The MTCR offers useful guidelines and a forum for cooperation. However, adherence to export restrictions are voluntary. Are there discussions among member states to impose some monitoring or penalty mechanism to the MTCR?

Answer:

The Missile Technology Control Regime (MTCR) is an informal political mechanism among like-minded states. Monitoring or penalty mechanisms would not be appropriate for such a forum, and in any case would be unlikely to command the necessary consensus of all 33 members to be enacted.

GOVERNMENTAL AFFAIRS SUBCOMMITTEE
ON INTERNATIONAL SECURITY, PROLIFERATION
AND FEDERAL SERVICES HEARING ON
CRUISE MISSILE AND UAV THREATS
TO THE UNITED STATES
JUNE 11, 2002

QUESTIONS FOR MR. CHRISTOPHER BOLKCOM
FROM CHAIRMAN DANIEL K. AKAKA

1. The MTCR offers useful guidelines and a forum for cooperation. However, adherence to export restrictions are voluntary. Do you believe that a monitoring or penalty mechanism would improve compliance to the MTCR? What features should be included in such a monitoring system?

The process of negotiating penalties and implementing monitoring schemes could have a strengthening effect on the MTCR. Such schemes would likely require both technical standards and political "codes of conduct." On the technical side, agreeing upon penalties and monitoring schemes would likely force member countries to synchronize their national export laws regarding technology and platforms. Consistent export laws among MTCR members would reduce country-specific interpretations of MTCR guidelines and help eliminate the cracks through with questionable missile transfers pass. Also, penalties and monitoring would require a uniform method of determining and measuring missile and technology performance, such as stealth, range, payload, and flight profile. This uniformity would increase confidence between MTCR members that other members weren't trying to "bend the rules."

While negotiating MTCR technical standards may be challenging, implementing a political "code of conduct" for cruise missile export would likely be even more difficult. For instance, the French and British view selling the *Black Shahine* as legitimate support for a key ally (The UAE). To the United States, however, this sale appears dangerous and destabilizing. Many argue that the *Black Shahine's* performance far outstrips that of any other cruise missile found in the Persian Gulf region, and its export will likely encourage the UAE's neighbors to improve their defenses or seek their own more capable cruise missiles. France and Great Britain disagree.

Criteria need to be developed to determine when cruise missile exports provide a positive influence on a given region's military balance, and conversely when such an export would negatively influence the military situation. A conventionally armed cruise missile that could enable Country X to "decapitate" Country Y's military command and control system -- due to a combination of the missile's performance and the adversary's weaknesses-- is an illustrative example of what could be agreed upon as a destabilizing capability.

Whether penalties and monitoring improve MTCR guideline compliance depends on how well designed and implemented these mechanisms are. A key question is whether MTCR countries have the political will to negotiate penalties with sufficient weight to deter members from incurring them. Monitoring schemes must be intrusive and reliable, yet palatable to a variety of public policy, and business stakeholders. For example, cruise missile manufacturers may resist technical data exchanges that they believe could help rival companies conduct industrial espionage.

GOVERNMENTAL AFFAIRS SUBCOMMITTEE
ON INTERNATIONAL SECURITY, PROLIFERATION
AND FEDERAL SERVICES HEARING ON
CRUISE MISSILE AND UAV THREATS
TO THE UNITED STATES
JUNE 11, 2002

QUESTIONS FOR MR. DENNIS GORMLEY
FROM CHAIRMAN DANIEL K. AKAKA

1. Upon examination of the MTCR Technology annex, it appears that most of the items covered pertain only to ballistic missiles (e.g. heat shields, rocket motors, environmental chambers that simulate exo-atmospheric conditions). What technologies that enable cruise missiles, if any, should get greater treatment?

The two primary barriers to the development of land-attack cruise missiles are suitable flight management and adequate propulsion to reach strategically significant ranges. Once a country has obtained rudimentary land-attack cruise missiles, they are likely to consider improving them by way of adding stealth features or specially tuned countermeasures equipment, such as towed decoys or terrain bounce jammers. In all four areas, the current MTCR technology annex comes up short. To fix such shortcomings, the following reforms are essential:

1. **Controls on UAV Flight Management Systems.** As I indicated in my prepared statement, an area of major proliferation concern is the transformation of small manned airplanes into unmanned and armed "cruise missiles." A number of small aerospace companies have been formed to sell so-called autonomous flight control systems that enable the recipient to turn a recreational aircraft, requiring a pilot to fly it, into a completely autonomous flight vehicle. The MTCR's coverage of flight-control systems and technology is provided under Item 10 of its equipment and technology annex, but it constrains only those systems "designed or modified for the systems in Item 1" (meaning complete rockets and UAVs capable of delivering at least a 500kg payload to a range of at least 300km). The original 1987 version of Item 10 applied the more liberal language—"usable in the systems in Item"—that would subject such flight management systems to case-by-case review before they are exported.

2. **Broadened Parameters Covering Jet Engines.** The capability of a jet engine is the most critical variable in determining the range of a cruise missile. Commercial and military engines with slightly above 2,000 pounds of thrust are fully usable in cruise-missile development or conversion programs. Yet the MTCR currently does not subject them even to minimal control. Broadening the MTCR's current parameters covering jet-engine thrust under Category II would impose only a slight administrative burden on export-control organizations to review licensing applications that are commonly used in manned aircraft. Such case-by-case review would greatly enhance the MTCR membership's capacity to monitor the diversion of jet engines to cruise-missile applications with Category I capabilities (capable of delivering a 500-kg payload to at least 300 km).

3. **Tighter Controls on Stealthy Cruise Missiles.** The application of stealth technology to cruise missiles gives them the same characteristics of ballistic missiles that inspired the MTCR: difficulty of defense, short-warning time and shock effect. Calls for tighter controls on stealthy cruise missiles are longstanding, but the membership has struggled to reach consensus on precisely what level of control to impose. Because of their inherent risk, Category I systems are automatically subject to a strong presumption of denial. The best approach to controlling stealthy cruise missiles would be to subject those missiles with greater than 300km range, which are presently covered by Category II controls, to the same presumption of denial as Category I missiles. Cruise missiles capable of such ranges need not carry 500kg payloads to represent an extremely dangerous proliferation threat. Indeed, they are significantly more effective in delivering small biological and chemical payloads than even Category I ballistic missiles. Coverage should be tightened on such stealthy cruise missiles.

4. **Controls on Specially Designed Countermeasure Equipment.** The addition of end-game countermeasure equipment, such as towed decoys or terrain bounce jammers, can greatly complicate cruise-missile defenses, increasing their costs and greatly reducing their effectiveness. Since countermeasures' effectiveness is higher as a missile's radar signature diminishes, incentives for using them will rise as radar cross-section values for cruise missiles fall lower and lower. Because such countermeasure equipment is used to enhance manned aircraft survivability, at first glance it would appear that such items might be exportable under existing MTCR Category II controls as parts of manned aircraft. But to achieve their intended synergistic effect with stealthy cruise missiles, countermeasure devices must be specially designed or modified to fit their companion vehicle. This suggests that such devices could be captured under the existing framework and subjected to case-by-case review before they are exported.