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MISSILE PROLIFERATION IN THE INFORMATION AGE

HEARING

BEFORE THE

SUBCOMMITTEE ON INTERNATIONAL SECURITY, PROLIFERATION, AND FEDERAL SERVICES

OF THE

COMMITTEE ON GOVERNMENTAL AFFAIRS
UNITED STATES SENATE

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WITNESSES

Monday, September 22, 1997

MISSILE PROLIFERATION IN THE INFORMATION AGE

MONDAY, SEPTEMBER 22, 1997

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

The Committee met, pursuant to notice, at 10:06 a.m., in room SD–342, Dirksen Senate Office Building, Hon. Thad Cochran, Chairman of the Subcommittee, presiding.

Present: Senators Cochran and Levin.

OPENING STATEMENT OF SENATOR COCHRAN

Senator COCHRAN. If we could please come to order. I want to welcome everybody to today's hearing of the Governmental Affairs Subcommittee on International Security, Proliferation, and Federal Services.

The topic of our hearing this morning is missile proliferation in the information age. We live in a time of rapid technological change. The computers on our desktops have computational and storage capabilities that were not just unheard of, but undreamed of, only a generation ago. The Internet has magnified those advances by linking hundreds of thousands of computers and putting those resources at our fingertips.

New constellations of satellites are being constructed which will put us all in instantaneous and constant communication with each other. Already, Global Positioning System navigation satellites have enabled humans, for the first time in history, to know precisely where they are at all times, anywhere in the world, using a device that now costs about $100.

We must acknowledge, however, that there are negative consequences from the coupling of rapid technological advances with the information age. These advances make it easier for adversaries of the United States to obtain the means to threaten our interests, and perhaps our homeland as well. The same personal computer technology that enhances our lives also makes it easier for less technologically advanced adversaries to design and build weapons that put the United States at risk.

The Internet puts the technical resources of the United States, and those of other countries, at the disposal of anyone with a telephone line.

NASA, for example, maintains a database of over 2 million technical documents, including detailed reports on the construction of long-range ballistic missiles, available to anyone with access to the World Wide Web. The U.S. Global Positioning System may help ensure that a hiker is never lost in the woods, but it also can aid adversaries in solving one of the most critical challenges in building a long-range missile, the problem of missile guidance.

Sophisticated hardware, too, is increasingly available and affordable to those who are seeking it. Much of what was once available only for military applications is now openly sold on the commercial market. For example, in an innovative countermeasures program, a small team of junior engineers at the Air Force Phillips Laboratory has successfully procured radar-absorbing material, inertial measurement units, rocket motors, heat shield materials, and a multitude of other components critical for building ballistic missiles, all without identifying their government affiliation. They have even managed to design and build a fully capable cruise missile, using only publicly available information and materials.

And some critical components are being sold on the black market. Within the last 10 days, news reports have once again detailed how guidance components from ICBMs dismantled under the START treaty were shipped to Iraq to aid in that country's development of long-range ballistic missiles. The ready availability of components from some of the most threatening weapons in the Russian arsenal underscores the seriousness of this proliferation problem.

And the problem appears to be getting worse. The Central Intelligence Agency reported in June of this year, and I am going to quote, ". . . countries determined to maintain [weapons of mass destruction] programs over the long term have been placing significant emphasis on securing their programs against interdiction and disruption. In response to broader, more effective export controls, these countries have been trying to reduce their dependence by developing an indigenous production capability. Many third world countries—with Iran being the most prominent example—are responding to Western counter-proliferation efforts by relying more on legitimate commercial firms as procurement fronts and by developing more convoluted procurement networks."

The United States has good reason to be proud of both its technical accomplishments and its willingness to share these accomplishments with the rest of the world. America cannot, however, ignore the potential consequences for American security that are inherent in this openness. Much of the sophisticated technology that is the cornerstone of our security had to be invented by the United States. That same technology is increasingly available to the rest of the world, both allies and adversaries alike. And the record of America's intelligence agencies in predicting how quickly our adversaries will acquire advanced technology has been mixed. In the last 2 weeks, there have been very disturbing news reports based on Israeli intelligence, that the Russian and Chinese scientific establishments have been helping Iran develop long-range ballistic missiles that could reach Central Europe within 3 years.

The fact is that the United States can be threatened by technology other than the most advanced. Older technology, in some cases 40 to 50 years old, is capable of presenting a severe threat to the United States. It was 40 years ago that the Atlas ICBM, America's first long-range missile, was built. Relatively old technology, now more easily available, should not be overlooked in its potential to threaten America and American interests.

This hearing, then, will examine the extent to which technological information, materials, and other resources that make possible the proliferation of ballistic missiles are available, both on the open and the black markets.

We are fortunate to have with us today Dr. William Graham, who served as science advisor to President Reagan and as Deputy Administrator of NASA, and Dr. W. Seth Carus, who is a visiting fellow at the National Defense University. He is also a well-known expert on proliferation.

Because the hearing had to be postponed from our scheduled date last week, our third witness, retired Air Force General Bernard Schriever, who built America's first Intercontinental Ballistic Missile, is unable to be with us today, but he has asked Dr. Graham to present his statement for the record.

Before we begin, let me note that while we intend to examine the problem of proliferation in the information age, we do not intend to make the problem easier to solve for proliferators. We will not say specifically where some of this information can be found, and we have asked the witnesses to be sensitive to this challenge, also. If necessary, we will compile these sources, though all are unclassified, in a classified addendum in the hearing record.

Senator COCHRAN. Before we begin, I'll turn to my distinguished colleague and Senator from Michigan, the Ranking Member, Senator Levin is recognized.

OPENING STATEMENT OF SENATOR LEVIN

Senator LEVIN. Thank you, Mr. Chairman, and I will be brief.

First, as you have noted, this hearing concerns an issue that is highly significant to America's security, the proliferation of missiles and missile technology and information that could lead to the acquisition or the creation of that technology. Both the Congress and the executive branch in the last two administrations have devoted a great deal of energy to this issue because of the threat to ourselves and our allies in the world of the proliferation of missiles, missile technology, and information.

It is rightfully one of the highest, if not the highest national security priorities, and we have focussed significant resources and intelligence efforts to address this problem.

We have done it in many ways, including trying to convince other nations that missile proliferation is a threat to international stability and security, and we have encouraged other countries to join the missile technology control regime. We have had some success in reducing the potential threat from weapons of mass destruction in the states of the former Soviet Union, through the Nunn-Lugar Cooperative Threat Reduction Program, which is administered by the Department of Defense, as well as companion programs that are administered by the Department of Energy and the State Department.

For instance, this Cooperative Threat Reduction Program has helped to make Ukraine, Belarus, and Kazakhstan nuclear-free states, after they first inherited thousands of nuclear weapons from the collapse of the Soviet Union. We have recently reached about the $4-billion-per-year level in spending on the development and the deployment of defenses against ballistic missiles, and we are working hard to prepare counter-proliferation options that will be available if necessary before missiles are launched against the United States or our allies.

As hard as we try, there are going to be determined governments which are going to challenge our efforts, and we will devote sufficient resources and patience in order to achieve some level of missile capability. That is the challenge ahead of us. It is to try to stop those nations, particularly nations which could threaten neighbors or other countries in the world with missiles and who might actually use such missiles.

We are facing a problem, a particular problem in the information age. The proliferation of missiles is made more difficult by the proliferation of information, and that is one of the focusses of this morning's hearing. It is the proliferation of information which is directly connected, short term and even more so in the long term, to the proliferation of missiles, and the question is to what extent do we focus on the information explosion to try to somehow contain that and keep that from getting into the hands of people who would misuse it, and to what extent do we put our efforts into trying to prevent the technologies from falling into their hands. It is that balance of efforts.

We have got to do both, but the question is, like everything else, when you have to put your focus in one place and your secondary focus somewhere else, what should be our focus, what specific actions should this government take that we are now not taking, what actions should the rest of the world take that maybe we can encourage and indeed help achieve through one means or another which will reduce the threat of the proliferation of weapons of mass destruction which I think is the major threat, the new threat that we face in this Nation.

So this is a very important subject, and I am glad that you are having a hearing such as this, this morning, Mr. Chairman.

Senator COCHRAN. Thank you very much, Senator Levin, for your comments and your participation in these hearings.

Dr. Graham, welcome. You may proceed.

TESTIMONY OF WILLIAM R. GRAHAM, FORMER SCIENCE ADVISOR TO PRESIDENT REAGAN AND FORMER DEPUTY ADMINISTRATOR OF NASA

Mr. GRAHAM. Thank you very much, Chairman Cochran and Senator Levin. I am pleased to be able to testify here this morning on the availability of long-range missile technology throughout the world today, and as the Chairman said, when I finish this testimony, I will be glad to present General Schriever's testimony as well. He sends his apology and regret that he had an unfortunate conflict in his schedule and was not able to be here today.

It was 50 years ago that long-range ballistic missile technology was an arcane and largely unexplored field. However, in the last 50 years, we have seen enormous investments of manpower and resources in this area, and today, several generations of ballistic missile technology have been developed and deployed.

During and immediately after World War II, ballistic missile technology was treated by governments as a secret field of research. Since that time, however, the need to educate, train, and maintain a large cadre of ballistic missile and space launch specialists, together with the relaxation of government restrictions on the dissemination of ballistic missile technology, hardware, software, and trained personnel, have made useful knowledge of the subject widely available.

Today, opportunities for developing countries to acquire long-range ballistic missile technology are at an all-time high. The current situation is the result of the confluence of at least five sources of opportunity; I will mention each one of these and then give an example or two of each in my testimony.

Long-range ballistic missile technology is available from widely disseminated sources, as Senator Cochran mentioned.

Education in long-range ballistic missile technology is openly available to students from throughout the world.

Long-range ballistic missile hardware and software are openly available in the United States and throughout the world.

Scientists, engineers, and technicians experienced in long-range ballistic missile technology are available to assist developing countries.

Most important, and sometimes overlooked, it has been known for over 40 years that it is possible to build ballistic missiles of intercontinental range that can carry hundreds to thousands of pounds of payload and deliver it with a high degree of accuracy.

I will address each of these opportunities in turn and show how they are used to overcome barriers in ballistic missile development in key areas that include rocket propulsion, lightweight structures, guidance and navigation, missile staging, reentry vehicles, and systems integration.

First, let me mention briefly the availability of long-range ballistic missile technical information. In surveying the availability of such information on a worldwide basis, it is important to note that there is a technological continuum between short-range, intermediate-range, and long-range systems, and technical information that applies to one range usually applies to the other ranges as well.

I will give you one example of the type of information available on the Internet and the great depth and breadth of technical documentation that can be found there. I will just read part of something that I downloaded from the Internet. The full download is in my testimony transcript.

I will not give the reference of this. However, as you have suggested, Mr. Chairman, I can provide that for an annex, if you wish. "The Aerospace Database is the electronic version of the International Aerospace Abstracts," and I continue to quote, "It also contains abstracts of reports issued by NASA, other U.S. Government agencies, international institutions, universities, and private firms."

"Dating back to 1962, the online Aerospace Database contains more than 2 million references that you can search and retrieve easily and cost effectively. And you can quickly access them on a modem-equipped computer terminal. Once you have located the reference you want, you can obtain a photocopy or microfiche of the full text from . . .,” the agency that put up this page.

However, some places do not have good telecommunications, and they have made provision for that. They say, “The CD–ROM version of our database is the cost-effective solution for frequent database users. An especially good bargain for international subscribers, it lets you avoid the telecommunications requirements and costly connection charges of online service.”

They go on to mention what is on the CD–ROM, which includes an in-depth coverage of aeronautics, astronautics, space sciences, chemistry and materials, engineering, mathematics, and computer sciences, as well as others. They then give instructions on how to subscribe to this service.

U.S. Government agencies are also a rich source of unclassified technical information in missile technology. For example, a small sample of online NASA document listings—and this is a very small sample compared to what is available—includes guidance of ballistic flight vehicles, experimental development and testing of missiles, solid propellant ballistic missiles, ballistic missile design, computation of reentry trajectories for a single ballistic missile, and design of missile flight tests in terms of estimation of errors derived, or how accurately you can hit targets.

The U.S. Patent Office is another substantial source of information on missile technology, and of course, it is not only the United States, but all patent offices of the developed countries have this same property. An online search of patents was conducted for the key words “missile” and “ballistic.” A search time of 1.15 seconds was required to produce the following hits, and this is the summary of what was found. Under “missile,” we found 4,400 occurrences in 1,651 patents; “guidance,” 5,021 occurrences in 3,160 patents; “missiles and guidance,” 255 patents.

Of those 255, I have abstracted about 10 on the list here, which include: ballistic missile structure simulator; method for guiding the final phase of ballistic missiles; methods and apparatus for reducing ballistic missile range errors due to viscosity uncertainties, air drag in particular; Polaris—you will recall our first sublaunch ballistic missile—Polaris guidance system; ballistic missile remote targeting system and method; missile warheads; propellant grain design; a method for compensating for atmospheric perturbations; thrust vector controls for steering missiles; and method and an apparatus for spreading warheads, spreading out multiple warheads from a missile. Those are all open patents available through the online facilities of the U.S. Patent Office.

There is a patent classification security process, by the way, that is available in the United States, and patents can be filed under that. However, the patents shown in my submission have been released from that security system.

Let me go on to address the second point which is educational opportunities that support long-range ballistic missile acquisition.

Since 1954, there has been a steady increase in the number of foreign students studying at American universities. In 1954, there were about 40,000 foreign students in the United States. By 1994, 40 years later, the number was 450,000, more than a ten-fold increase. Recent studies by the National Science Foundation and the

Institute of International Education show trends in several areas: the subject matter being studied, the level of study, and changes in the national origin of the foreign student body.

According to the Institute of International Education, for the 1993 academic year, 45 percent of all foreign students in the United States were studying at the graduate level. This is an increase of about 10 percent over the level in 1990. These students were studying at the highest levels of our educational institutions.

The figures show that foreign graduate students are more likely than Americans to study science and engineering. In 1995, the foreign student population earned 43 percent of U.S. doctoral degrees in the physical sciences and 58 percent of the degrees in engineering. Similarly, foreign students received half of the mathematics doctorates and nearly half of all computer science doctorates. By comparison, in the same period only 23 percent of the social and behavioral sciences doctorates were awarded to foreign-born students.

Mainland China continues to contribute the highest number of foreign students, a number that has stood consistently at about 10 percent of all students.

The National Science Foundation estimates that as many as half of all science and engineering graduates return to their country of origin.

When I was last in the government, Mr. Chairman, which was a decade ago, there was, in fact, some imperative from U.S. Government agencies to have these graduate students return to their country of origin after they had been educated in advanced technologies here.

According to the annual report of the Visa Office of the State Department's Immigration and Naturalization Service, the following number of non-immigrant visas have been issued in Category F, which is students and their dependents, since 1984 for the countries indicated. To give you a sample of the countries we are educating in technologies: North Korea, 98 visas; Iran, 16,854; Iraq, 2,007; Libya, 408; Syria, 9,308 visas; and China, 121,952. As far as I have been able to tell, Mr. Chairman, neither the State Department nor the Immigration and Naturalization Service nor anyone else tracks the actual course of study of any of these students once they are given student visas to come into the United States.

Postgraduate education in aerospace science and engineering in the United States includes a wide range of subjects relevant to long-range ballistic missiles, and I have just looked in the online Internet catalog of one of our leading State universities and listed various courses that they give at the graduate level: astrodynamics, spacecraft attitude dynamics and control, atmospheric flight methods, and so on.

I pulled up the prospectus for the course listed under atmospheric flight control, which you might think relates just to aircraft, and it says "exposure to flight guidance and control, draws heavily from vehicle dynamics as well as feedback theory, careful treatment of the nonlinear aspects of the problem is critical. Conventional synthesis techniques are stressed, although modern methods are not ignored. Multivariate systems analysis is included, along with flight-control design objectives and hardware limitations. Emphasis on aircraft and missiles," not just in aircraft study. I list another 10 or 12 courses, all relevant to missiles as well as aircraft design.

Professional societies are now largely worldwide organizations and provide not only for the exchange of state-of-the-art information, but for the continuing education of their members.

I pulled up from the Internet one of the leading society's web page, and they discuss their international outreach there. In the international outreach, they say, the organization ". . . is the premier professional society for aerospace engineers, scientists, designers, and other professionals, serving more than 30,000 members worldwide. Our global range encompasses seminars and conferences held at sites throughout the world; technical papers, books, and journals published by international authors, and the Aerospace Database," which was referenced before, "with over 2 million aerospace citations accessible via the World Wide Web."

This organization ". . . is dedicated to forging meaningful information exchange between crucial players on the world's aerospace stage."

They say, "We strive to make our events, publications, and services relevant to aerospace professionals everywhere," and under conferences and seminars, they go on to say that the society's international work centers are organized, sponsored, or cosponsored for international conferences or seminars, including a list of events that they give for 1996, which include the Third International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows—subject is useful in the design of jet engines and also rocket engines. That conference was at Beijing, China. The professional organization also sponsored the Seventh International Spaceplanes and Hypersonic Systems and Technologies Conference at Norfolk, Virginia.

They also provide continuing education for aerospace professionals, and they note that they have over 25 professional development courses taught by internationally renowned experts and attended by aerospace professionals from around the world. "Home courses of study are an excellent way to enhance your career without expensive travel costs."

In addition to that, they publish books which are excellent reference textbooks on ballistic missile design. Some of them, a few, are here with me.

Senator COCHRAN. I suggested to Senator Levin a minute ago that that might be our assigned reading that you brought to us, and we will invite all of the Members of our Subcommittee to check out those books.

Mr. GRAHAM. Very good.

Senator LEVIN. I wonder if we could make those books a part of the record, Mr. Chairman. I am just kidding.

Senator COCHRAN. Well, we appreciate you bringing that to our attention.

Mr. GRAHAM. We can provide for a closed-book test at the end of the hearing, if you wish, Senator. I think it should be given to the witnesses as well as the Members.

This is typical of the extent to which ballistic missile technology has diffused and is moving around the world today. There is literally no reason that anyone interested in the technology cannot educate himself in the field, either here in the United States or at home in another country.

Ballistic missile hardware is also available widely. Each year, the Defense Department must dispose of used, obsolete, and surplus military equipment that when new cost tens of billions of dollars. Some of the equipment is sold as-is, and some is sold only after it has been made nonfunctional or reduced to scrap. With such a high volume of surplus and the emphasis that has been established on profits from its sale, not all key technologies and equipment are demilitarized and rendered useless before sold, not even the ones that in retrospect should have been demilitarized or rendered useless.

The government provides a guide for purchasing surplus military equipment entitled "How to Buy Surplus Personal Property from the United States Department of Defense," put out by the Defense Reutilization and Marketing Service. The November 1994 edition, for example, which was the most current one I was able to get on short notice, lists two categories of particular interest to this hearing. One is Category 1440 which includes guided missile, launchers, components, and remote control systems; and the other is category 1450, guided missile handling and service equipment.

One of the entries in these categories is shown here: a console used in the service equipment category to test assemblies from the LGM–30 missile. The LGM–30 missile is more commonly known as the Minuteman missile, and this is a piece of test equipment that was being sold for that purpose.

That item's listing had left the Internet by the time I went to the site, but I found another one there that I show in my testimony, which is a recorder-reproducer electronic data processing unit, made by the Boeing company for the LGM–30 Minuteman missile, and it looks to me like a device used for transferring data in and out of the LGM–30 Minuteman missile system.

When surplus dealers purchase such equipment, it often enters the commercial market. Here is a receipt for two missile steering motors purchased for $100 each from a surplus dealer that happened to be in Southern California. These are, indeed, rocket motors designed for the control function of missiles and space-launch vehicles.

For several years, China has been one of the major buyers of——

Senator COCHRAN. And they were purchased for $100 each?

Mr. GRAHAM. It was $100 each, yes. I have no idea what they cost to build, but I would say if it were only a thousand times that much, it would be surprising.

For several years, China has been one of the major buyers of U.S. surplus military equipment, and ships scrap and not scrap material directly to China in large storage containers.

Sales of military equipment, of course, are not limited to the U.S. Government by any means. As a result of the difficult economic conditions prevailing in Russia and other states of the former Soviet Union today, more than surplus military equipment, that is, military equipment which is fully functional and with the operational forces, is for sale and often at very low prices.

In addition, the atmosphere of pervasive criminality in Russia today, coupled with the uncertain future of the Russian economy and government, has created an environment in which military hardware and technology flow into the developing world through both official and unofficial channels. Examples include: the official sale of cryogenic fuel rocket engines and technology to India; unofficially, presumably, the Russian long-range missile guidance components discovered in the Middle East in the last few years, particularly precision gyroscopes for missile navigation; several reports of a very large transfer of SS–18 missile technology to China; and recent reports of active assistance to the Iranian missile development program by both Russian and Chinese technologists. This list could continue, but the point is clear. Despite Russian official participation in missile-related arms control regimes, like the MTCR, access to Russian technology and know-how is available for proliferant states.

This transfer of missile-related hardware does not end, however, just at subassemblies or components. Government-to-government sales of complete ballistic missile systems have taken place and include the sale of the 3,000-kilometer class CSS–2 intermediate-range ballistic missile system by China to Saudi Arabia, the apparent sale of ground-mobile M–11 ballistic missiles by China to Pakistan, and the sale of SCUD missiles to Iran by North Korea. Note that particularly with these latter two sales, the ballistic missile trade is now taking place between countries of the developing world and does not require the direct cooperation of countries of the developed world to go forward.

I am going to just mention briefly that ballistic missile software—computer programs—is also widely available, and available through the Internet as well as elsewhere.

This graphic, also downloaded from the Internet, accompanies the following description of a product that is commercially available. The provider states: ". . . (this) is our flagship product and is unique in the world of launch simulation programs. It combines a graphical user interface with accurate trajectory modeling, targeting and optimization. The analytical power of this package establishes a remarkably higher level of productivity for the user . . . (it) can model any rocket, missile, or launch vehicle from any planet," (presumably including the earth), "to any set of burnout conditions. Comprehensive function allows the user to directly model the vehicle, optimize the trajectory, and cut and paste the resulting maps, charts, and summary statements into presentation charts or documents. The product is currently available for Windows 95 and Windows NT."

Another category of technical assistance for missile proliferators that I mentioned in the introduction was the availability of experienced scientists, engineers, and technicians. There is today a glut on the world market of both advanced hardware, including the components we mentioned, and skilled personnel to assist other nations in using that hardware and software. Many of these individuals were among the elite of the Soviet Union and now face deprivation and hardship if they do not take their skills abroad.

Recent newspaper reports that I mentioned show the Chinese and Russian expertise helping Iran, and Dr. Carus, I believe, will address that point further.

Let me give you just a sample biography of someone who was my counterpart when I was President Reagan's science advisor. This gentleman was the Secretary of the Department of Science and Technology in India at the time. I will just read you a little bit of his biography. Before he was the Secretary of Science and Technology, he was a visiting scholar at Stanford University, and before that, director of the Vicram Sarabati Space Center, the prime R&D center and the largest establishment of the Indian Space Research Organization. He obtained his M.S.C. and Ph.D. in chemical engineering from Birmingham University. Before going to the Space Center, he was with the United Kingdom Atomic Energy Authority, and with the Summerfield Research Station, an agency established by the British Ministry of Aviation, serving as a senior technical officer, and he was for many years on the Solid Rocket Technical Committee of the American Institute of Aeronautics and Astronautics.

It goes on to show his other credits, but he is obviously a very competent individual, and very knowledgeable. He presented me with this book on polymer science when I was visiting India, and even though he was the Minister of Science and Technology, his principal interest was in the state of development of large solid rocket engines that we were building for ballistic missiles at the time.

How to get started? The big picture of missile system development and integration is also available worldwide. The United States has published several documents that can be used as starter kits for long-range ballistic missile development. One such document, "Short-Range Ballistic Missile Technology Infrastructure Requirement for Third-World Countries," put out by the Arnold Engineering Center, is a very complete and thorough analysis of the subject and I think an excellent introduction for U.S. intelligence; unfortunately, it is an excellent introduction for third-world proliferators as well.

It shows, among other things, how to use commercial industries in a country as infrastructure to support ballistic missile system development. It lists its objectives, "The primary objective of this report is to define the infrastructure required for an indigenous third-world country's short-range missile capability. These requirements are described in terms of the technology and hardware that compromise the design, manufacturing process, assembly, testing, and deployment of" tactical short-range ballistic missiles. "A secondary objective is to provide a training aide for ballistic missile fundamentals." NASA has published similar documents, Mr. Chairman.

In view of the availability today of technical literature, education for students throughout the world, the world market in ballistic missile hardware and software, the availability of experienced scientists, engineers, and technicians, and the certain knowledge that long-range ballistic missiles can and have been built, there are no insurmountable barriers to any nation developing such a capability.

As Germany demonstrated with its V–2 program and the United States and the U.S.S.R. with their intercontinental ballistic missile programs in the 1950's and 1960's, political will and national priority are the major determinants of the rapidity with which national ballistic missile programs are brought to operational status. Even North Korea, which is one of the poorest and most isolated of nations, unable to provide subsistence for many of its inhabitants, not only has been able to develop a series of increasingly longer-range ballistic missiles, but has become a major supplier of ballistic missiles and technology to some of the world's most irresponsible and hostile regimes.

Other nations have demonstrated that it is possible to purchase complete, operational missile systems. Today, no missile development program will be obstructed by lack of capability or of opportunity, and several countries hostile to the United States are supporting their ballistic missile acquisition programs with national will and determination.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Graham follows:]

PREPARED STATEMENT OF MR. GRAHAM

THE WORLDWIDE AVAILABILITY OF LONG RANGE BALLISTIC MISSILE TECHNOLOGY

Mr. Chairman and distinguished Members of the Committee, thank you for the opportunity to testify on the availability of long range ballistic missile technology throughout the world today.

Fifty years ago, long range ballistic missile technology was an arcane and largely unexplored field. However, the last fifty years have seen an enormous investment of manpower and monetary resources in that area, so that today several generations of ballistic missile technology have been developed and deployed.

During and immediately after WWII, ballistic missile technology was treated by governments as a secret field of research. Since that time, the need to educate, train, and maintain a large cadre of ballistic missile and space launch vehicle specialists, together with the relaxation of government restrictions on the dissemination of ballistic missile technology, hardware, software, and trained personnel, have made useful knowledge of the subject widely available.

Today, opportunities for developing countries to acquire long range ballistic missiles are at an all-time high. The current situation is the result of the confluence of at least five sources of opportunity:

- Long range ballistic missile technology is available from widely disseminated sources.
- Education in long range ballistic missile technology is openly available to students from throughout the world.
- Long range ballistic missile hardware and software are openly available in the United States and throughout the world.
- Scientists, engineers, and technicians experienced in long range ballistic missile technology are available to assist developing countries.
- Most important, it has been known for over forty years that it is possible to build ballistic missiles of intercontinental range that can carry hundreds to thousands of pounds of payload with a high degree of accuracy.

I will address each of these in turn, and discuss how these opportunities can be used to overcome the barriers to ballistic missile development in the key technological areas of rocket propulsion, lightweight structures, guidance and navigation, missile staging, reentry vehicles, and systems integration.

Availability of Long Range Ballistic Missile Technical Information

In surveying the availability of long range ballistic missile technology worldwide, it is important to note that there is a technological continuum between short range and long range systems, and technical information that applies to one range usually applies to other ranges as well.

The following is an example of the great depth and breadth of technical documentation available through the Internet for purchase and shipment worldwide:

> *"The Aerospace Database is the electronic version of International Aerospace Abstracts. It also contains abstracts of reports issued by NASA, other U.S. government agencies, international institutions, universities, and private firms.*

"Dating back to 1962, the online Aerospace Database contains more than 2 million references that you can search and retrieve easily and cost effectively. And you can quickly access them on a modem-equipped computer terminal. Once you've located the reference you want, you can obtain a photocopy or microfiche of the full text from . . .

"The CD–ROM version of our database is the cost-effective solution for frequent database users. An especially good bargain for international subscribers, it lets you avoid the telecommunications requirements and costly connection charges of online service.

"The world's foremost source of scientific and technical aerospace information available online or on CD–ROM anywhere in the world. Access is available on a paid subscription basis through . . .

"Updated monthly, the Aerospace Database online is perfect for monitoring aerospace markets in other countries, gaining access to the work of international aerospace leaders, staying abreast of new products and trends, keeping up with emerging technologies. In just seconds the Aerospace Database lets you search more than 30 years of accumulated knowledge in aerospace and related sciences. You'll find in-depth coverage of aeronautics, astronautics, space sciences, chemistry and materials, geosciences, life sciences, mathematics, and computer sciences.

"You'll have the convenience of using the CD–ROM at your desktop. No costly connection charges. Just an easy to use CD–ROM for your own personal use. . . . Aerospace scientists and engineers will find in-depth coverage of:

- aeronautics
- astronautics
- space sciences
- chemistry and materials
- engineering
- geosciences
- life sciences
- mathematics
- computer sciences

"Key Features:

"Sort your search results by title, journal name, author, year of publication, or conference title. Use the Journal Name index for fast selection of articles. Track articles by original language of publication. Limit your search with Conference Papers Only, Conference Title, Conference Sponsor, or Conference Year.

"To subscribe, contact . . ."

U.S. government agencies are also a rich source of unclassified technical information. For example, a small sample of on-line NASA document listings include:

Guidance of Ballistic Flight Vehicles

Experimental Development and Testing of Missiles

Solid Propellant Ballistic Missiles

Ballistic Missile Design

Computation of the Reentry Trajectory of a Single Ballistic Missile

Design of the Missile Flight Tests in terms of Estimation of Errors Derived

The U.S. Patent Office is another substantial source of information on missile technology. An on-line search of patents was conducted for the key words *missile* and *ballistic.* A search time of 1.15 seconds was required to produce the following hits:

Search Summary:

Missile: 4400 occurrences in 1,651 patents.

Guidance: 5021 occurrences in 3,160 patents.

(Missile AND Guidance): 255 patents.

Ten of the 255 patents identified are listed below:

Patent No. and Title:

4,465,464	Ballistic missile structure simulator
4,220,296	Method for guiding the final phase of ballistic missiles
3,990,657	Method and apparatus for reducing ballistic missile range errors due to Viscosity Uncertainties
4,476,562	Polaris guidance system
5,544,843	Ballistic missile remote targeting system and method
4,664,035	Missile warheads
4,936,092	Propellant grain design
4,111,382	Apparatus for compensating a ballistic missile for atmospheric perturbations
5,662,290	Mechanism for thrust vector control using multiple nozzles
5,619,010	Method and an apparatus for spreading warheads

Educational Opportunities Supporting Long Range Ballistic Missile Acquisition

Since 1954 there has been a steady increase in the number of foreign students studying at American universities. In 1954, there were about 40,000 foreign students in the United States. By 1994, the number was 450,000, more than a ten-fold increase. Recent studies by the National Science Foundation (NSF)[1] and the Institute of International Education (IIE)[2] show trends in several areas: the subject matter being studied, the level of study, and changes in the national origin of the foreign student body.

- According to the IIE study, for the 1993 academic year, 45 percent of all foreign students in the United States were studying at the graduate level, an increase of 10 percent over the level recorded in 1990.
- The figures show that foreign graduate students are more likely than Americans to study science and engineering. In 1995, the foreign student population earned 43 percent of the doctoral degrees in the physical sciences, and 58 percent of the doctoral degrees in engineering.[3] Similarly, foreign students received 50 percent of the mathematics doctorates and 49 percent of all computer science doctoral degrees. By comparison, in the same period only 23 percent of the social and behavioral doctorates were awarded to foreign-born students.
- Mainland China continues to contribute the highest number of foreign students, a number that has stood consistently at about 10 percent of all foreign students.
- The NSF estimates that as many as half of all Science and Engineering graduates return to their country of origin.

According to the annual report of the Visa Office of the State Department's Immigration and Naturalization Service, the following number of non-immigrant visas have been issued in Category F (Students and Dependents) since 1984 for the countries indicated:

- North Korea: 98
- Iran: 16,854
- Iraq: 2,007
- Libya: 408
- Syria: 9,308
- China: 121,952

Post-Graduate Education in Aerospace Science and Engineering in the United States

The U.S. Government does not track what foreign students are actually studying at our universities; however, a visit to the classrooms of leading technical graduate schools suggests that courses in the most advanced aerospace and other related fields are very popular. Typical of the courses available is the following list from the graduate school of a leading state university, with one, *Atmospheric Flight Control,* shown with its description emphasizing its application to both aircraft and missiles:

601—Astrodynamics
602—Spacecraft Attitude Dynamics and Control

[1] U.S. National Science Foundation, *Immigrant Scientists, Engineers, and Technician: 1993.* Division of Science Resource Studies, NSF96–322 (Washington, DC: 1996)
[2] Institute of International Education, *Open Doors 1993–1994.* (New York: 1994)
[3] U.S. National Science Foundation, *Selected Data on Science and Engineering Awards, 1995.* NSF96–303 (Washington, DC: 1996) P. 46–49.

640—Atmospheric Flight Mechanics
641—Linear Systems Dynamics
642—Atmospheric Flight Control

Exposure to flight guidance and control. Draws heavily from vehicle dynamics as well as feedback theory, and careful treatment of the non-linear aspects of the problems is critical. Conventional synthesis techniques are stressed, although modern methods are not ignored. Multivariable system analysis is included along with fight-control design objectives and hardware limitations. Emphasis on aircraft and missiles.

643—Digital Control
644—Optimal Control of Aerospace Systems
650—Variational Methods in Structural Mechanics
651—Smart Structures
652—Finite Element Method in Engineering
653—Nonlinear Finite Element Analysis of Continua
654—Composite Structures
655—Structural Dynamics
656—Aeroelasticity
657—Theory of Structural Stability
661—Advanced Propulsion
662—Advanced Propulsion II

All of these courses provide education in key missile-related areas.

Professional Societies

Professional societies in aeronautics and astronautics have become international organizations in their membership and technical activities. They provide a rich source of technical information and post-university training worldwide. The following information, taken from the Internet, describes a few of the programs of one of the leading professional societies:

"International Outreach

". . . is the premier professional society for aerospace engineers, scientists, designers, and other professionals, serving more than 30,000 members worldwide. Our global range encompasses seminars and conferences held at sites throughout the world; technical papers books and journals published by international authors, and the Aerospace Database with over two million aerospace citations accessible via the World Wide Web.

". . . is dedicated to forging meaningful information exchange between crucial players on the world's aerospace stage. At our conferences, we bring together representatives from governments, industry, and academia to debate and collaborate on the new world of possibilities for the international aviation, defense, and space communities. We strive to make our events, publications, and services relevant to aerospace professionals everywhere.

"Conferences and Seminars

Much of (the Society's) international work centers around (the Society's) organized, sponsored, or cosponsored international conferences or seminars, including these events in 1996:

- Global Air & Space International Conference and Exhibition (Arlington, Virginia);
- . . . Aeroacoustics Conference (State College, Pennsylvania);
- . . . Atmospheric Flight Mechanics Conference (Xian, China);
- 2nd Test and Evaluation International Aerospace Forum (London, England);
- 3rd International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows (Beijing, China);
- 20th Congress of the International Council of the Aeronautical Sciences (Sorrento, Italy);
- 7th International Conference on Adaptive Structures Technologies;
- 47th International Astronautical Federation Congress (Beijing, China);
- 1st World Aviation Congress and Exposition (Los Angeles, California);
- 9th Conference on Astronautics (Ottawa, Canada); and
- 7th International Spaceplanes and Hypersonic Systems and Technologies Conference (Norfolk, Virginia).

". . . has over 25 professional development courses taught by internationally renowned experts and attended by aerospace professionals from around the world. Home study courses are an excellent way to enhance your career without expensive travel costs!

"The . . . Calendar of Events is the best way for International members to keep up-to-date on the latest . . . conferences, seminars, and home study courses.

"International Member Activities

"The 47th IAF Congress in Beijing included a special meeting of . . . members from China, hosted by the members of the International Activities Committee present at the Congress. This followed a similar gathering the year before in Oslo with . . . members from Norway, Sweden, and Denmark. It was an occasion to meet old friends again and to recall that . . . organized the first exchange of delegations between China and the United States as early as 1979. A productive exchange of views regarding . . . its activities, and benefits for international members also took place."

Ballistic Missile-Related Hardware Availability

Each year, the Department of Defense disposes of used, obsolete, surplus military equipment that when new cost tens of billions of dollars. Some of the equipment is sold as is, and some is sold only after it has been made non-functional or reduced to scrap. With such a high volume of surplus and the emphasis that has been established on profits from its sale, not all key technologies and equipment are demilitarized and rendered useless before sold.

The government provides a guide for purchasing surplus military equipment: *How to buy Surplus Personal Property from the United States Department of Defense,* Defense Reutilization and Marketing Service. The November 1994 edition lists:

Guided Missile Equipment

1440: Guided Missile, Launchers, Components and Remote Control Systems
1450: Guided Missile Handling and Servicing Equipment

The following is a current listing from the Internet Site the Department of Defense uses for surplus equipment sales:

"Welcome to Sales Assets

Text Descriptions & Photographs

(Photo Provided)

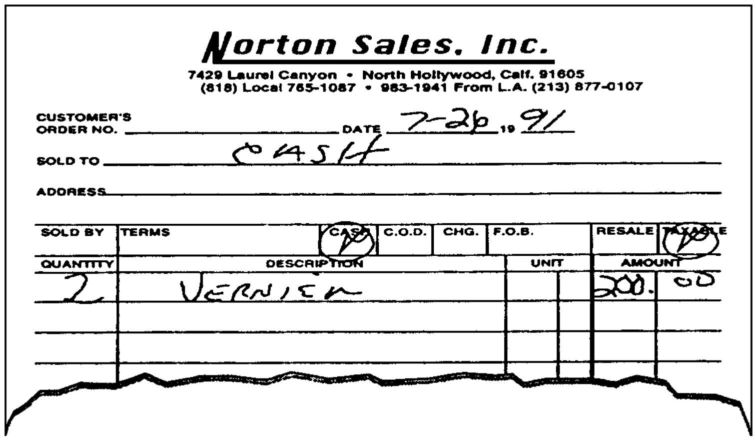
FSG49—Maintenance or Service Equipment

DTID: FE452870550197

Item Name: Recorder-Reproducer, Electronic Data Processing
Location: DRMO MINOT
Date: 3-Jun-97
Commodity Group: IIELEC
Federal Supply Class: 4935
NIIN or LSN: 00–004–3826
Unit of Issue: EA
Manufacturer Name: BOEING CO
Model/Part/Serial Number: P/N 25–66564–14
Rated Capacity: N/A
Purpose and/or End Item: LGM–30 MINUTEMAN
ID/Registration Number: N/A
Size/Dimensions/Weight: EST WT 240 LBS
Parts Missing/Detached: N/A
Condition: USED—FAIR CONDITION
Description: Tape RD–368/G, CI 10793AA, 110 VAC, In Hard-Sided Metal Transit Case.

Last updated Thu Sep 11 07:26:20 EDT 1997"

When surplus dealers purchase such equipment, it often enters the commercial market. Here is the receipt for two missile steering motors purchased for $100 each from a surplus dealer in Southern California:



Norton Sales, Inc.

7429 Laurel Canyon • North Hollywood, Calif. 91605
(818) Local 765-1087 • 983-1941 From L.A. (213) 877-0107

CUSTOMER'S ORDER NO. ____ DATE 7-26 19 91

SOLD TO CASH

ADDRESS ____

SOLD BY	TERMS	CASH	C.O.D.	CHG.	F.O.B.	RESALE	TAXABLE

QUANTITY	DESCRIPTION	UNIT	AMOUNT
2	VERNIER		200.00

For several years, China has been one of the major buyers of U.S. military surplus.

Sale of military equipment is not limited to the U.S. Government. As a result of the difficult economic conditions prevailing in Russia and other states of the former Soviet Union today, more than surplus military equipment is for sale, often at very low prices.

In addition, the atmosphere of pervasive criminality in Russia, coupled with the uncertain future of the Russian economy and government, has created an environment in which military hardware and technology flows into the developing world through both official and "unofficial" channels. Examples include: the sale of cryogenic fuel rocket engines to India; Russian long-range missile guidance components discovered in the Middle East; several reports of SS–18 technology transfers to China; and recent reports of active assistance to the Iranian missile development program. This list could continue, but the point has already been made clear: despite Russian official participation in missile-related arms control regimes like the MTCR, access to Russian technology and know-how is available for proliferant states.

Government-to-government sales of complete ballistic missile systems include the sale of the 3,000 km. range CSS–2 system by China, the apparent sale of the ground-mobile M–11 by China to Pakistan, and the sale of SCUD missiles to Iran by North Korea. Note that ballistic missile trade is now taking place between countries of the developing world.

Ballistic Missile-Related Software Availability

There is a large body of commercial and educational ballistic missile-related software available through textbooks, program libraries, and directly through the Internet. The following is an example of a commercial software-missile flight trajectory and targeting program on the Internet:

> *". . . is our flagship product and is unique in the world of launch simulation programs. It combines a graphical user interface with accurate trajectory modeling, targeting and optimization. The analytical power of . . . establishes a remarkably higher level of productivity for the user . . . can model any rocket, missile, or launch vehicle from any planet to any set of burnout conditions. Comprehensive function allows the user to directly model the vehicle, optimize the trajectory, and cut and paste the resulting maps, charts, and summary statements into presentation charts or documents. The product is currently available for Windows 95 and Windows NT."*

Experienced Scientists, Engineers, and Technicians

There is a glut on the world market of both advanced military hardware, including ballistic missile components, and skilled personnel to assist other nations with such hardware. Many of these individuals were among the elite of the Soviet Union, and now face deprivation and hardship if they do not take their skills abroad. Recent newspaper reports state that several hundred Russian and Chinese experts are currently in Iran helping the Iranians develop new ballistic missiles. My fellow witness, Dr. Carus, will describe the transfer of ballistic missile technology further.

How to Get Started:

The big picture view of missile system development and integration is also available worldwide. The United States has published several documents that can be used as "starter kits" for long range ballistic system development. One such document is:

> *Short Range Ballistic Missile (SRBM) Technology Infrastructure Requirements for Third World Countries,* AEDC 10405–04–91, September 1991, Arnold Engineering Development Center, Air Force Systems Command. The Executive Summary of the report contains the following:
>
> *"1.2 Objectives*
>
> *"The primary objective of this report is to define the infrastructure required for an indigenous Third World country's short-range missile capability. These requirements are described in terms of the technology and hardware that comprise the design, manufacturing processes, assembly, testing, and deployment of a tactical SRBM. A secondary objective is to provide a training aid for ballistic missile fundamentals."*

NASA has published similar unclassified documents.

Conclusion

In view of the availability today of technical literature, education for students throughout the world, the world market in ballistic missile hardware and software, the availability of experienced scientists, engineers, and technicians, and the certain knowledge that long range ballistic missiles can and have been built, there are no insurmountable barriers to any nation developing such a capability.

As Germany demonstrated with its V–2 program and the United States and U.S.S.R. with their intercontinental ballistic missile programs in the 1950s and 60s, political will and national priority are the major determinants of the rapidity with which national ballistic missile programs are brought to operational status. Even North Korea, which is one of the poorest and most isolated of nations, unable to provide subsistence for many of its inhabitants, not only has been able to develop a series of increasingly longer range ballistic missiles, but has become a major supplier of ballistic missiles and technology to some of the world's most irresponsible and hostile regimes. Other nations have demonstrated that it is possible to purchase complete, operational missile systems. Today, no missile development program will be obstructed by lack of capability or opportunity, and several countries hostile to the United States are supporting their ballistic missile acquisition programs with national will and determination.

Senator COCHRAN. Thank you, Dr. Graham, for your interesting and complete review of the situation. We appreciate that very much.

Dr. Carus, you may proceed with your statement.

We do have a statement from General Schriever, which we can present.

Mr. GRAHAM. Yes.

Senator COCHRAN. I will tell you what, why don't we go ahead and have Dr. Carus' statement now. Then you can summarize Dr. Schriever's statement and we will print it in the record.

Dr. Carus, you may proceed.

TESTIMONY OF W. SETH CARUS, VISITING FELLOW, NATIONAL DEFENSE UNIVERSITY

Mr. CARUS. Thank you, Mr. Chairman.

It is an honor to be asked to testify before this Committee. There are few issues of greater national security interest to the United States than the proliferation of ballistic missiles, and for that reason, I am grateful for this opportunity to present my views in today's hearings.

Before continuing, let me note that my testimony does not necessarily reflect the views of the National Defense University, where I am a visiting fellow, or the Center for Naval Analyses, my home organization, or the Department of Defense.

I would like to focus on one main issue today: our ability to predict emerging missile threats. Sometimes we grow overly confident of our ability to monitor and predict developments in other countries. Despite the sometimes impressive achievements of those following foreign ballistic missile programs, there is considerable reason to worry that the United States could be surprised by the activities of other countries as they seek to acquire missile capabilities.

In the next few minutes, I will review three cases in which the United States failed to accurately assess foreign ballistic missile activities. Using these cases, I would like to draw some general insights about potential limitations in our future ability as a Nation to predict foreign missile development activities.

The first case I would like to look at involves the Iraqi Al Husayn missile. This was an extended-range version of the Soviet-designed SCUD. The program has surprised the United States in three distinct ways. First, the development of the missile itself was unexpected. Second, the United States underestimated the strategic importance of the missile during the period leading up to the Gulf War in 1991. Finally, the United States never detected the existence of Iraq's chemical and biological missile warheads.

First, let me say a few words about the development of the Al Husayn. Iraq purchased 819 of the SCUD–B missiles from the Soviet Union. A large number of these missiles were fired at Iran during the course of the 1980–1988 Iran-Iraq War. What was not known, however, was that the Iraqis had launched an extensive effort to develop an extended-range version of this missile.

In August 1987, the Iraqis reported that they had successfully tested a missile with a range of 650 kilometers. At the time, this claim was generally discounted. Some people believed that Iraq might be referring to a new Soviet-supplied system. Others simply believed that the Iraqis were lying. Only on February 29, 1988, when Iraq began firing Al Husayn missiles at Iranian cities, deep inside Iran, did it become clear that the Iraqis, in fact, did possess an extended-range missile. This initiated the final round of the so-called War of the Cities fought during the Iran-Iraq War. During the next 6 weeks, Iraq fired approximately 189 of the Al Husayn missiles at Iranian cities, killing, according to Iranian estimates, perhaps around 2,500 people.

It was the Iranians who analyzed the wreckage of the Al Husayns and determined that the missiles were, in fact, extensively modified SCUD–B's. The Al Husayn missile had a range of 650 kilometers, as the Iraqis had claimed, compared with only 300 kilometers for the standard Soviet-build SCUD–B's. The Iraqis manufactured the Al Husayns by cannibalizing their existing SCUD missiles. Reportedly, they took three SCUD–B's, cut them up and used the components to construct two of the extended-range missiles. Other modifications also were needed, including a reduction in warhead weight. The missiles were inaccurate and clearly had limited tactical military utility. Yet in the context of the Iran-Iraq War, these Al Husayns were a key strategic factor in forcing the Iranians to sue for peace.

Unfortunately, the failure to identify the appearance of the Al Husayn missiles was followed by another failure of even greater significance when the United States failed to assess the potential importance of these missiles in the period leading up to the Gulf War in 1991. Because the Al Husayn missiles were inaccurate and had only a small warhead, the U.S. military and intelligence communities argued that the missiles had no or limited military significance. What these communities failed to understand was that the missile had considerable political importance, especially in Israel, and that this might have an impact on the ability of the United States to prosecute the war against Iraq.

When Iraq began firing missiles at Israel, the government of Israel came under considerable pressure to intervene in the conflict to eliminate Iraq's missile launch capability. The United States, however, believed that it was essential to keep Israel out of the conflict in order to preserve the coalition against Iraq. As a result, the United States was forced to send Patriot missile batteries to Israel and to divert a significant number of combat aircraft to operations against the SCUD launchers. According to the U.S. Air Force, about 1,500 air strikes during Desert Storm were directed against SCUD targets, or about 3.5 percent of all the air strikes during the war. These missions involved many of the most capable aircraft available to the coalition forces. Yet, no missile launchers are known to have been destroyed in the attacks.

Finally, after the end of the Gulf War, we learned that Iraq had produced a significant number of chemical and biological warheads for its SCUD missiles. While the intelligence community assessed that Iraq was capable of producing such warheads, it was never able to develop convincing supporting evidence. After the end of the conflict, the United Nations Special Commission, UNSCOM, began investigations of Iraq's nuclear, biological, and chemical weapons programs. In the course of their investigations, they were told that Iraq had set aside 75 SCUD warheads for use with nerve agents. It was only in late 1996, more than 5 years after the end of the war, as a result of information obtained after the defection of Husayn Kamal, that evidence emerged about Iraq's biological warheads.

At that time, it was learned that Iraq had filled 25 missile warheads with biological agents. Now, the effectiveness of these chemical and biological warheads is uncertain, but their strategic significance is self-evident.

Moreover, we only have Saddam's word that most of the warheads were destroyed, since UNSCOM itself only eliminated 29 of the 100 chemical and biological warheads. The result, the Iraqis claim to have destroyed on their own.

The history of the Al Husayn program illustrates three issues that complicate efforts to follow foreign missile development programs. First, it is possible for missile development programs to go completely undetected. Quite simply, it is impossible to guarantee timely intelligence when a country pursues programs that do not fit our preconceived expectations.

Second, even when information is available on missile capabilities, it is possible to misinterpret the significance of the detected capabilities. It is not enough to understand the technical capabilities of a missile. Even more important are assessments of potential military and strategic impact.

Finally, existing missiles can be modified in ways difficult to detect. Possession of missiles armed with chemical and biological warheads clearly has extraordinary strategic importance, and the failure to detect the existence of such delivery systems demonstrate a serious limitation in intelligence-gathering capabilities.

The second case I wanted to look at was the delivery of the Chinese missiles to Saudi Arabia. In some ways, the Saudi acquisition of Chinese DF–3 intermediate-range ballistic missiles, which is sometimes called the CSS–2, was even a greater surprise to the United States than the Iraqi Al Husayn program.

As it happens, we now know a great deal about the Saudi efforts to acquire these ballistic missiles, in part due to some memoirs that were written by Saudi participants. It appears that the Saudis believed that their country needed ballistic missiles simply because so many other countries in the Middle East possessed them. At that time, at least eight other countries in the region had ballistic missiles. The Saudis tried to purchase ballistic missiles from the United States, and asked for permission to purchase the short-range Lance missile. This request was rejected.

As a result, the Saudis looked for an alternative supplier. They soon found that the Chinese were willing to supply the DF–3 intermediate-range ballistic missiles with a range of at least 2,500 kilometers. They conducted secret negotiations with the Chinese and arranged to purchase a complete missile force for an estimated $3 billion.

According to press reports, the United States discovered the Chinese missiles by accident, and only as the missiles were being deployed. Apparently, a photographic interpreter identified some newly built bunkers in Saudi Arabia that looked suspiciously like those that he knew were associated with China's DF–3 ballistic missiles. At that point, the intelligence community initiated an intensive effort to identify the presence of the Chinese missiles.

The Saudi missile purchase case illustrates two important points. First, it is difficult to anticipate developments when countries can acquire missile capabilities through purchase of complete, off-the-shelf systems.

Second, making predictions when a country intends to rely on imported missiles requires an appreciation of the motivations of both potential purchasers and suppliers. Unfortunately, understanding motivations is difficult under the best of circumstances. Consider that the Saudi requirement for a ballistic missile was primarily motivated by political concerns, and thus could be met equally well by a missile of 120-kilometer range, like the Lance, or with range of more than 2,500 kilometers, like the Chinese DF–3.

Finally, I would like to make a few comments about the discovery of SS–23 missiles in Eastern Europe. In the wake of the breakup of the Warsaw Pact, NATO countries discovered that several

Eastern European countries possessed SS–23 medium-range ballistic missiles. The SS–23, which has a range of about 500 kilometers, was banned by the terms of the Intermediate Range Nuclear Forces Treaty, the INF Treaty. Because of the military and political significance of these missiles, they were a priority target for intelligence organizations of the NATO countries. Indeed, there were few areas of the world subject to more intensive intelligence surveillance than Eastern Europe in the 1980's. Yet, the Western countries were totally unaware that the Soviet Union had given SS–23 missiles to East Germany, Czechoslovakia, and Bulgaria.

The Western countries only learned about these missiles after the fall of the Communist regime in East Germany. In March 1990, the successor leadership in East Germany reported that the Soviet Union had provided 24 SS–23 missiles, 4 missile launchers, 4 missile transporters, and other supporting equipment to the East Germans. It is unclear when the SS–23's were given to the East Germans, but it appears they were deployed in Eastern Europe by the Soviet military in the 1984–1985 time frame. The missiles were banned under the 1987 INF Treaty. However, the INF Treaty only covered missiles in the possession of the Soviet Union and the United States. So the Soviets claimed that they had not violated the INF Treaty, since the missiles were delivered before the INF Treaty was signed.

This episode highlights one key issue about ballistic missiles. As long as missiles are not fired, they are easy to hide. Ballistic missiles do not necessarily require the extensive operational training that other weapon systems require. As a result, the country can acquire ballistic missiles and keep them hidden away in secret storage facilities.

These cases illustrate the fundamental difficulties that are faced by those who follow trends in missile proliferations. Before concluding my remarks, I would like to make some additional points about two specific issues that affect assessments of missile programs, the impact of foreign assistance on indigenous missile development programs and some significant limitations of the missile technology control regime.

Technology provided by foreign individuals, organizations, or governments can enable a proliferant country to develop unexpected new capabilities. This is particularly important when proliferating countries want to enhance sophistication or range. External support can permit a country to overcome technical challenges that otherwise would prevent it from developing more capable systems. Foreign assistance also can reduce costs and shorten the amount of time required to develop complete systems.

The importance of foreign suppliers for missile development programs has been demonstrated time after time. Iran apparently depends on North Korea, Russia, and China for its missile technology. Recent press reports suggest that the Russian assistance to Iran has been growing, despite Russia's adherence to the MTCR. Syria and Egypt also rely on North Korea. The Indian Agni missile is based on a U.S. space-launch vehicle, while the Indian Prithvi is an adaptation of the Soviet SA–2 surface-to-air missile. Similarly, the South Korean NHK–1 is an adaptation of the U.S. Nike Hercules surface-to-air missile.

Most missile proliferation has resulted from transfers of complete systems from one country to another. Thus, Israel acquired its first ballistic missiles from France through the MD–620 missile development program. This also accounts for the widespread adoption of the SCUD missile produced either by the former Soviet Union or North Korea. Many of the countries with SCUD missiles, such as Vietnam, Yemen, and the United Arab Emirates, lack the indigenous capabilities to develop their own missiles, but by purchasing missiles from a foreign supplier, they have been able to acquire significant military capabilities.

This type of activity has been the focus of the missile technology control regime, the MCTR. Thus, it is important to understand the extent to which the MTCR poses an obstacle to future missile developments and how its limitations might impede efforts to assess missile programs.

Under the MTCR, adherents to the regime agree not to transfer complete ballistic missile and cruise missile systems that exceed certain capabilities and to control the export of certain technologies needed to produce ballistic or cruise missiles. The regime is supposed to treat equivalent systems, such as space-launch vehicles, as restrictively as ballistic missiles. It places equally strict restrictions on production technology and major components as well.

The MTCR was negotiated among the G–7 countries in 1987, but since then, an additional 22 countries have joined the regime. In addition, some other countries have agreed to adhere to the provisions of the regime.

The MTCR has had an important role in slowing the spread of ballistic missile technology. It provided the framework for the attack on the Condor missile program, a medium-range ballistic missile system developed in Europe by West German, Italian, and French companies, in cooperation with the governments of Argentina, Egypt, and Iraq. Similarly, the MTCR provided the context for negotiating an end to Soviet transfers of SCUD missiles, even before Russia agreed to adhere to the regime.

Unfortunately, the regime has not ended all transfers of missiles or missile technology. At present, it appears that the MTCR has three main limitations which could have a significant impact on the ability of the United States to monitor missile development programs. First, there is no universal adherence. Second, enforcement of its limitations are unevenly applied. Third, as currently interpreted, it does not apply to space-launch vehicles.

There are a few countries that refuse to accept the technology transfer restraints of the MTCR. North Korea continues to offer its SCUD–B and SCUD–C missiles, and there are concerns that it intends to export its No Dong missile, which could have a range of as much as 1,200 kilometers with high-explosive warheads. Egypt, Iran, and Syria all depend on North Korean assistance for their missile programs. While the United States has attempted to convince the North Koreans to halt their missile exports, these efforts have shown scanty results. The latest rounds of talks was postponed recently due to the defection of the North Korean diplomats based in Egypt.

The most serious problems, however, have resulted from the continued refusal of China to abide by its commitments to adhere to the MTCR. China has considerable expertise in the missile arena, and has demonstrated capability to produce missiles with great range and higher accuracies than those produced by North Korea. The United States began talks with the Chinese about missile transfers after the 1988 sale of the DF–3 intermediate-range ballistic missiles to Saudi Arabia.

On several occasions, the United States believed that it had received assurance from China that it would end its missile exports. Repeatedly, however, we have found China providing equipment that violated these assurances.

In 1994, the Chinese told us once again of their commitment to the MTCR. According to Winston Lord, "As a result of the sanctions we had imposed following China's sale of missile equipment to Pakistan, China agreed not to export ground-to-ground, MTCR-class missiles, and reaffirmed its commitments to abide by the MTCR Guidelines and Annex."

Unfortunately, recent Pakistani claims to have tested a Hatf–3 missile with an 800-kilometer range casts doubts on these Chinese assurances. It is generally agreed that if Pakistan has such a missile, it either was provided a complete Chinese missile, such as the M–9, or if the missile was indigenously developed, the Pakistanis relied heavily on Chinese technical assistance.

In the long run, however, the most serious potential problem for the United States is the possibility that space-launch vehicles will be used to create ballistic missiles. The text of the MTCR requires that SLVs be treated as restrictively as ballistic missiles. However, the current administration, while requiring new MTCR members that are not nuclear weapon states to eliminate MTCR-proscribed missiles, allows such new members to continue SLV programs and to receive assistance on those programs from other MTCR members.

Unfortunately, there is no real difference between a ballistic missile and a space-launch vehicle. Thus, many ballistic missiles have been adapted for use as space-launch vehicles. There are also examples of the reverse, as with the Indian Agni missile, which is based on the design of a space-launch vehicle. These developments suggest that it will be possible to use a space program to mask efforts to develop ballistic missiles.

Of particular concern is the extent to which new generation space-launch vehicles are beginning to look like ballistic missiles. New space-launch vehicles now under development generally require fewer people to operate, often are designed to be fired from mobile launchers, and are designed to be operated with minimal preparation. These characteristics are needed to support the new constellation of communication satellites that are now planned, which rely on large number of satellites operating in low earth orbit. Unfortunately, these same characteristics are useful for ballistic missiles as well as space-launch vehicles.

This increases the possibility that countries might be able to hide ballistic missile programs under the guise of permitted SLV projects. Unfortunately, this will complicate the task of those responsible for assessing missile developments, since assessments will depend on difficult-to-make estimates of the motivations for pursuing SLVs.

In conclusion, there is a great deal of reason for caution in attempting to make firm predictions about missile developments. We have been surprised in the past. It is likely that we will be surprised again in the future. Ultimately, we need to adopt policies that take into account the uncertainties that are inherent in this prediction process.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Carus follows:]

PREPARED STATEMENT OF MR. CARUS

Note: *The views expressed in this testimony are those of the author and do not necessarily reflect the official policy or position of the Department of Defense or the U.S. Government.*

It is an honor to testify before this subcommittee. There are few issues of greater national security interest to the United States than the proliferation of ballistic missiles, and for that reason I am grateful for this opportunity to present my views to the subcommittee.

Before continuing, let me note that my testimony does not necessarily reflect the views of the National Defense University, where I am a visiting fellow, or the Center for Naval Analyses, my home organization, or the Department of Defense.

I would like to focus on one main issue in my presentation today: Our ability to predict emerging missile threats. Sometimes we grow overly confident of our ability to monitor and predict developments in other countries. Despite the sometimes impressive achievements of those following foreign ballistic missile programs, there is considerable reason to worry that the United States could be surprised by the activities of other countries as they seek to acquire missile capabilities.

In the next few minutes, I will review three cases in which the United States failed to accurately assess foreign ballistic missile activities. Using these cases, I would then like to draw some general insights about potential limitations in our future ability as a nation to predict foreign missile development activities.

Iraqi Al Husayn missiles

The Iraqi military developed an extended range version of the Soviet-designed Scud missile, which they called the Al Husayn. This has surprised the United States in three distinct ways. First, the development of the missile itself was unexpected. Second, the United States underestimated the strategic significance of the missile during the period leading up to the start of the Gulf War in 1991. Finally, the United States never detected Iraq's chemical and biological missile warheads.

First, let me say a few words about the development of the Al Husayn missile. Iraq purchased 819 of the Scud B missiles from the Soviet Union. A large number of these missiles were fired at Iran during the course of the 1980–1988 Iran-Iraq War. What was not known, however, was that the Iraqis had launched an extensive effort to develop an extended range version of the Scud B.

In August 1987, the Iraqis reported that they had successfully tested a missile with a range of 650 kilometers. At the time, this claim was generally discounted. Some people believed that Iraq might be referring to a new, longer-range Soviet-supplied missile. Others simply believed that the Iraqis were lying about possessing such a system. Only on February 29, 1988, when Iraq began firing Al Husayn missiles at Iranian cities did it become clear that the Iraqis possessed an extended range missile. This initiated the final round of the so-called "The War of the Cities." During the next six weeks, Iraq fired approximately 189 of the Al Husayn missiles at Iranian cities, killing an estimated 2,500 people.

It was the Iranians who analyzed the wreckage of the Al Husayn's and determined that the missiles were extensively modified Scud B missiles. The Al Husayn missile had a range of 650 kilometers, compared with only 300 kilometers for the standard Soviet-built Scud B. The Iraqis manufactured the Al Husayns by cannibalizing existing Scud missiles. Reportedly, they took three Scud Bs, cut them up, and used the components to construct two of the extended-range missiles. Other modifications also were needed, including a reduction in the warhead's weight. The missiles were inaccurate and had limited tactical military utility. Yet, in the context of the war with Iran, the missiles were a key strategic factor in compelling the Iranians to sue for peace.

Unfortunately, the failure to identify the appearance of the Al Husayn missiles was followed by another failure of even greater strategic significance when the United States failed to assess the potential importance of the missiles in the period leading up to the Gulf War in 1991. Because the Al Husayn missiles were inaccurate and had only a small warhead, the U.S. military and intelligence communities argued that the missiles had no military significance. What these communities failed to understand was that the missile had considerable political importance, especially in Israel, and that this might have an impact on the ability of the United States to prosecute the war against Iraq. When Iraq began firing missiles at Israel, the government of Israel came under considerable pressure to intervene in the conflict to eliminate Iraq's missile launch capability. The United States, however, believed that it was essential to keep Israel out of the conflict in order to preserve the coalition against Iraq. As a result, the United States was forced to send Patriot missile batteries to Israel and to divert a significant number of combat aircraft to operations against the Scud launchers. According to the U.S. Air Force, 1,459 air strikes during Desert Storm were directed against Scud targets, or about 3.5 percent of all the air strikes during the war. These missions involved many of the most capable aircraft available to the Coalition forces, yet no missile launchers are known to have been destroyed in the attacks.

Finally, after the end of the Gulf War, we learned that Iraq had produced a significant number of chemical and biological warheads for its Scud missiles. While the intelligence community assessed that Iraq was capable of producing such warheads, it was never able to develop convincing supporting evidence. After the end of the conflict, the United Nations Special Commission (UNSCOM) began investigations of Iraq's nuclear, biological, and chemical weapons programs. In the course of their investigations, they discovered that Iraq had set aside 75 Scud warheads to use with nerve agents. It was only in late 1996, as a result of information obtained after the defection of Husayn Kamal, that evidence emerged about Iraq's biological warheads. At that time, it was learned that Iraq had filled 25 missile warheads with biological agents: 13 with botulinum toxin, 10 with aflatoxin, and 2 with anthrax. The effectiveness of these chemical and biological warheads is uncertain, but the strategic significance is self-evident. Moreover, we have only Saddam's word that most of the warheads were destroyed, since UNSCOM itself only eliminated 29 of these warheads. The rest the Iraqis claim to have destroyed on their own.

The history of the Al Husayn missile program illuminates three issues that complicate efforts to follow foreign missile development programs. First, missile development programs can go completely undetected. Quite simply, it is impossible to guarantee timely intelligence when a country pursues programs that do not fit preconceived expectations. Second, even when information is available on missile capabilities, it is possible to misinterpret the significance of the detected capabilities. It is not enough to understand the technical capabilities of a missile. Even more important are assessments of potential military and strategic impact. Finally, existing missiles can be modified in ways difficult to detect. Possession of missiles armed with chemical and biological warheads has extraordinary strategic importance, and the failure to detect the existence of such delivery systems demonstrates a serious limitation in intelligence gathering capabilities.

Saudi DF–3 (CSS–2) missiles

In some ways, the Saudi acquisition of Chinese DF–3 intermediate range ballistic missiles (which is sometimes called the CSS–2), was an even greater surprise to the United States than the Iraqi Al Husayn program.

We now know a great deal about the Saudi efforts to acquire ballistic missiles, partly due to memoirs written by Saudi participants in the process. It appears that the Saudis believed that their country needed ballistic missiles simply because so many other countries in the Middle East possessed them. At that time, at least eight other countries in the region had ballistic missiles. The Saudis tried to purchase ballistic missiles from the United States, and asked for permission to purchase short-range Lance missiles. This request was rejected. As a result, the Saudis looked for an alternative supplier. They soon found that the Chinese were willing to supply the DF–3 intermediate range ballistic missile with a range of 2,500 kilometers. They conducted secret negotiations with the Chinese, and arranged to purchase a complete missile force for an estimated $3 billion.

According to press reports, the United States discovered the Chinese missiles by accident, and only as the missiles were being deployed. Apparently, a photographic analyst identified some newly built bunkers that looked suspiciously like those that he knew were associated with China's DF–3 ballistic missiles. At that point, the intelligence community initiated an intensive effort to identify the Chinese missiles.

The Saudi missile purchase case illustrates two important points. First, it is difficult to anticipate developments when countries can acquire missile capabilities through purchase of complete, off-the-shelf systems. Second, making predictions when a country intends to rely on imported missiles requires an appreciation of the motivations of both potential purchasers and suppliers. Unfortunately, understanding motivations is difficult under the best of circumstances. Consider that the Saudi requirement for a ballistic missile was primarily motivated by political concerns, and thus could be met equally well by a missile of 120 kilometers (the Lance) or 2,500 kilometers (the DF–3).

East European SS–23 missiles

In the wake of the break up of the Warsaw Pact, the NATO countries discovered that several East European countries possessed SS–23 medium range ballistic missiles. The SS–23, which has a range of 500 kilometers, was banned by the terms of the Intermediate Range Nuclear Forces (INF) Treaty. Because of the military and political significance of these missiles, they were a priority target for intelligence organizations of the NATO countries. Indeed, there were few areas of the world subject to more intensive intelligence surveillance than eastern Europe in the 1980s. Yet, the Western countries were totally unaware that the Soviet Union had given SS–23 missiles to East Germany, Czechoslovakia, and Bulgaria.

The Western countries only learned about these weapons after the fall of the Communist regime in East Germany. In March 1990, the successor leadership in East Germany reported that the Soviet Union had provided 24 SS–23 missiles, 4 missile launchers, 4 missile transporters, and other supporting equipment to the East Germans. It is unclear when the SS–23s were given to the East Germans, but it appears that they were deployed in East Europe by the Soviet military in the 1984–1985 period. The missiles were banned under the 1987 INF treaty. However, the INF treaty only covered missiles in the possession of the Soviet Union and the United States, so the Soviets claimed that they had not violated the INF treaty.

This episode highlights one key issue about ballistic missiles: As long as missiles are not fired, it is easy to hide them. Ballistic missiles do not necessarily require the extensive operational training that many other weapons systems require. As a result, a country can acquire ballistic missiles and keep them hidden away in secret storage facilities.

Additional issues

These cases illustrate the fundamental difficulties that are faced by those who follow trends in missile proliferation. Before concluding my remarks, I would like to make some additional points about two specific issues that affect assessments of missile programs: The impact of foreign assistance on indigenous missile development programs and some significant limitations of the Missile Technology Control Regime (MTCR).

Foreign assistance

Technology provided by foreign individuals, organizations, and governments can enable a proliferant country to develop unexpected new capabilities. This is particularly important when proliferating countries want to enhance sophistication or range. External support can permit a country to overcome technical challenges that otherwise would prevent it from developing more capable systems. Foreign assistance also can reduce costs and shorten the amount of time required to complete development.

The importance of foreign suppliers for missile development programs has been demonstrated time after time. Iran apparently depends on North Korea, Russia, and China for its missile technology. Recent press reports suggest that the Russian assistance to Iran has been growing, despite Russia's adherence to the MTCR. Syria and Egypt also rely on North Korea. The Indian Agni missile is based on a U.S. space launch vehicle, while the Indian Prithvi is an adaptation of Soviet SA–2 surface to air missile technology. Similarly, the South Korean NHK–1 is an adaptation of the U.S. Nike Hercules surface to air missile.

Most missile proliferation has resulted from transfers of complete systems from one country to another. Thus, Israel acquired its first ballistic missiles from France through the MD–620 missile development program. This accounts for the widespread adoption of the Scud missile, produced either by the former Soviet Union or North Korea. Many of the countries with Scud missiles, such as Vietnam, Yemen, and the United Arab Emirates, lack the indigenous capabilities to develop their own missiles. But by purchasing missiles from a foreign supplier, they have been able to acquire significant military capabilities.

This type of activity has been the focus of the MTCR. Thus, it is important to understand the extent to which the MTCR poses an obstacle to future missile developments, and how its limitations might impede efforts to assess missile programs.

Impact of the MTCR

Under the MTCR adherents to the regime agree not to transfer complete ballistic and cruise missile systems that exceed certain capabilities and to control the export of certain technologies needed to produce ballistic or cruise missiles. The regime is supposed to treat equivalent systems, such as space launch vehicles, as restrictively as ballistic missiles; it places equally strict restrictions on production technology, and major components as well. The MTCR was negotiated among the G–7 countries in 1987, but since then an additional 22 countries have joined the regime. In addition, some other countries have agreed to adhere to the provisions of the regime.

The MTCR has had an important role in slowing the spread of ballistic missile technology. It provided the framework for the attack on the Condor missile program, a medium range ballistic missile system developed in Europe by West German, Italian, and French companies in cooperation with the governments of Argentina, Egypt, and Iraq. Similarly, the MTCR provided the context for negotiating an end to Soviet transfers of Scud missiles, even before Russia agreed to adhere to the regime.

Unfortunately, the regime has not ended all transfers of missiles or missile technology. At present, it appears that the MTCR has three main limitations, which could have a significant impact on the ability of the United States to monitor missile development programs. First, there is not universal adherence. Second, enforcement of its limitations is unevenly applied. Third, as currently interpreted, it does not apply to space launch vehicles. These limitations create problems for those seeking to assess the potential impact of foreign support on missile proliferation.

There are a few countries that refuse to accept the technology transfer restraints. North Korea continues to offer its Scud–B and –C missiles, and there are concerns that it intends to export its No Dong missile, which could have a range of as much as 1,200 kilometers with a conventional high explosives warhead. Egypt, Iran, and Syria all depend on North Korean assistance for their missile programs. While the United States has attempted to convince the North Koreans to halt their missile exports, these efforts have shown scanty results. The latest round of talks was postponed recently due to the defection of the North Korean diplomats based in Egypt.

The most serious problems, however, have resulted from the continued refusal of China to abide by its commitments to adhere to the MTCR. China has considerable expertise in the missile arena, and has a demonstrated capability to produce missiles with greater range and higher accuracy than those produced by North Korea. The United States began talks with the Chinese about missile transfers since the 1988 sale of the DF–3 intermediate range ballistic missile to Saudi Arabia.

On several occasions, the United States believed that it had received assurances from China that it would end its missile exports. Repeatedly, however, we have found China providing equipment that violated such assurances. In 1994, the Chinese told us once again of their commitment to the MTCR. According to Winston Lord, "as a result of the sanctions we had imposed following China's sales of missile equipment to Pakistan, China agreed not to export ground-to-ground MTCR-class missiles, and reaffirmed its commitments to abide by the MTCR Guidelines and Annex." Unfortunately, recent Pakistani claims to have tested a Hatf–3 missile with an 800-kilometer range casts doubt on these Chinese assurances. It is generally agreed that if Pakistan has such a missile, it either was provided a complete Chinese missile, such as the M–9, or if the missile was indigenously developed the Pakistanis relied heavily on Chinese technical assistance.

The most serious potential problem for the United States, however, is the possibility that space launch vehicles will be used to create ballistic missiles. The text of the MTCR requires that SLVs be treated as restrictively as ballistic missiles. However, the current administration, while requiring new MTCR members that are not nuclear weapon states to eliminate MTCR-proscribed ballistic missiles, allows such new members to continue SLV programs and to receive assistance on those programs from other MTCR members.

Unfortunately, there is no real difference between a ballistic missile and a space launch vehicle. Thus, many ballistic missiles have been adapted for use as space launch vehicles. There are also examples of the reverse, as with the Indian Agni missile, which is based on the design of a space launch vehicle. These developments suggest that it will be possible to use a space program to mask efforts to develop ballistic missiles.

Of particular concern is the extent to which new generation space launch vehicles are coming to look like ballistic missiles. New space launch vehicles now under development generally require fewer people to operate, often are designed to be fired from mobile launchers, and are designed to be operated with minimal preparation. These characteristics are needed to support the new constellations communication satellites that are now planned, which rely on large numbers of satellites operating in low earth orbit. Unfortunately, these same characteristics are useful for ballistic missiles as well as space launch vehicles.

This increases the possibility that countries might be able to hide ballistic missile programs under the guise of permitted SLV projects. Unfortunately, this will complicate the task of those responsible for assessing missile developments, since assessments will come to depend on difficult to make estimates of the motivations for pursuing SLVs.

Implications

There is reason for caution in attempting to make firm predictions about missile developments. We have been surprised in the past. It is likely that we will be surprised again in the future. Ultimately, we need to adopt policies that into account the uncertainties that are inherent in the prediction process.

Senator COCHRAN. Thank you, Dr. Carus.

Dr. Graham, could you summarize for us General Schriever's statement? General Schriever was the father of our Atlas ICBM program, program manager, in fact, 40 years ago. And then we will just print his statement in the record in full.

Mr. GRAHAM. Yes, Mr. Chairman, I will do that.

It is a pleasure to be representing him, as he is such a distinguished American who led us into the post-war era, matching and ultimately exceeding the Soviet ballistic missile program in the 1950's and the 1960's.

He said that he wishes to focus only on the missile delivery platforms in the hearing today and not on the warheads, in that he was responsible for the development of intercontinental ballistic missiles. Of course, he had the weapons packages as well under his purview. And he wanted to share his experiences in order to assist you in drawing your own conclusions concerning when and how nations with interests hostile to the United States might acquire ballistic missiles capable of reaching us.

Much speculation exists concerning the question of when and how nations can acquire ballistic missiles of intercontinental range. When it comes to the development of ballistic missiles, it is General Schriever's personal experience that increasing the range is actually quite simple to achieve. The more difficult problems he lists are accuracy and system integration.

Over four decades ago, General Schriever undertook as a matter of a highest national priority the development of the intercontinental ballistic missile in the Atlas program, which became America's first ICBM, as you noted, Mr. Chairman. This program was accorded one of the highest priorities in our national security of the day. Remember that in the technology of the mid-1950's, that was an era of slide rules and vacuum-tube computers. These were the analytical tools that he and his engineers used. He pioneered the use of solid-state computers for not only the program scheduling and control functions, but also for technical matters and for the guidance of the missile itself. Such use was not commonplace. However, today virtually anyone can purchase a computer with capabilities orders of magnitude greater than what he used at the time.

He then goes on to note the breathtaking amount of information that is available today through the Internet and elsewhere and describes, somewhat along the lines that I described earlier, what that information is.

He notes that this stands in stark contrast to the relatively rudimentary base of capabilities that we had available 40 years ago. In fact, he notes the biggest obstacles in building the Atlas ICBM are not obstacles today. How to address what were then the obstacles is now commonly taught in American graduate schools.

General Schriever noted that improving a missiles range is among the easiest and most straightforward things to do. One needs only to add additional boosters, either on top or on the sides of the missile, or both, and that is what he did four decades ago by taking the Thor intermediate-range ballistic missile and adding an upper stage to create the first U.S. ballistic launch vehicle having intercontinental range. This "kluged" or compiled upper stage demonstrated a 5,000-mile range, (about 8,300 kilometers), greater than the distance from North Korea to the West Coast. It achieved the required 3- to 5-mile accuracy at the time, and indeed, if you look at our current fleet of space-launch vehicles, we still stack the stages and add strap-on boosters. The Delta launch vehicles uses strap-ons; the Delta itself a derivative of a Thor. The Atlas uses the Centaur upper stage for space launch, and the Titan–3 and Titan–4 use both strap-ons and upper stages to deliver the largest payloads to orbit.

He wanted to remind you, too, that the United States imposed strict requirements on our ICBMs with respect to responsiveness and maintainability, as well as accuracy. The United States had originally sought an accuracy of 1,500 meters, about 5,000 feet. However, the prospects for lightweight nuclear weapons with high yields enabled the United States to relax the accuracy requirements to 3 to 5 miles. This significantly reduced the guidance problem. Yet, even the 3 to 5 miles of accuracy was aimed at war-fighting applications. If the only requirement for a ballistic missile were to hold population centers at risk, when using weapons of mass destruction, accuracy requirements could be further relaxed from even the 3- to 5-mile figure. Thereby, guidance becomes a relatively straightforward problem to solve, made even easier through the commercial availability of global positioning system signals, but in fact, commercially available inertial systems alone can also do this job.

General Schriever identified systems integration as a major task when he managed the ICBM programs. This was due to the fact that virtually all of the components and subsystems were first of a kind. He pioneered, but by no means had time to refine, the idea of black-box testing as a way of testing subsystems. Such testing is now well refined and procedures are systematic and well known, and I believe the piece of equipment we showed you earlier was one such black-box tester.

In addition, today, components of many key subsystems are available for purchase on the open market, leaving little question as to their operability.

General Schriever also did a great deal of integrated system testing—ballistic missile testing. He did so due to a lack of either understanding of the basic physics—in some cases, for example, reentry conditions—or analytical modeling capability, which as we mentioned was rather embryonic at that stage.

Today, both the physics and the analytical capabilities are readily available. As a result, much of the integrated testing General Schriever conducted to assess a vehicle's structural response to dynamics of flight could today be done with computer analysis. The mysteries he worked his way through 40 years ago are today taught as engineering problems in any good American graduate school.

In conclusion, experience taught General Schriever that necessity is the mother of invention. That was the case in developing the U.S. ICBM program. The government provided the priority necessary to get the job done. For example, from program start to operational status, it required just over 5 years in the case of the Atlas and the Titan programs which he led. The Minuteman, which he also led, which introduced solid propellants and launch from underground silos, became operational in just under 5 years.

Our experience should lead us to be prudent regarding what unfriendly nations might do in today's environment with respect to their ICBM range and schedule. Furthermore, as Dr. Carus mentioned, intelligence estimates are not infallible. In General Schriever's opinion, the will, rather than the know-how, is the key factor for nations to achieve an earlier ICBM capability than now projected.

Thank you, Mr. Chairman.

[The prepared statement of General Schriever follows:]

PRERPARED STATEMENT OF GENERAL SCHRIEVER

Mr. Chairman, Members of the Subcommittee, it is a pleasure to appear before you today to discuss the issue of missile proliferation in the information age. Concerns about the proliferation of weapons of mass destruction and the means to deliver such weapons are leading to serious debate—and in some cases action. While acquiring the weapons of mass destruction—the payload and the weapon's delivery platform—such as the missiles—have some common obstacles, today I will focus on the missile delivery platforms only. Having been responsible for the development of our intercontinental ballistic missiles, I wish to share some of my experiences in order to assist you in drawing your own conclusions concerning when and how nations with interests hostile to the United States might acquire ballistic missiles capable of reaching us.

Much speculation exists concerning the question of when and how nations with interests hostile to the United States could acquire ballistic missiles of intercontinental range. When it comes to the development of ballistic missiles, it is my personal experience that increased range is actually quite simple to achieve. The more difficult problems are accuracy and integration.

Over four decades ago, we undertook as a matter of the highest national priority the development of the intercontinental ballistic missile in the Atlas program, which became America's first ICBM. This program was treated as one of the highest priority national security issues of its day. Remember that the technology of the mid-1950's, was an era of slide rules and vacuum tube computers. These were the analytic tools we used. We pioneered the use of solid state computers for not only program scheduling and control but also for technical matters. Such use is now commonplace. Furthermore, today virtually anyone can purchase a computer with capabilities orders of magnitude greater than we used.

As Bill Graham has described, a breathtaking amount of information is also available through open sources—particularly the Internet. Today's availability of (1) design aiding software available on the Internet for free, (2) subsystem drawings available from patents and other sources, (3) state of the art technical papers in professional journals and (4) information from organizations whose primary mission is to promote the use of technologies that are relevant to long range ballistic missiles, stand in stark contrast to the relatively rudimentary base of capabilities we had available 40 years ago. In fact, our biggest obstacles to building America's first ICBM—the Atlas ICBM—are not obstacles today. How to address what then were obstacles is commonly now taught in America's graduate schools.

As I said, improving a missile's range is among the easiest and most straightforward things to do. One needs only to add additional boosters—either on top or on the sides of an existing missile. That's what we did four decades ago by taking the Thor intermediate range ballistic missile and adding a upper stage to create our first ballistic launch vehicle having intercontinental range. This "kluged" upper stage demonstrated a 5,000 mile range. In terms of kilometers, that's about 8,300 kilometers, which is greater than the distance from North Korea to the west coast of the United States. It did so, while also achieving the required 3-5 mile accuracy. Indeed, if you look at our current fleet of launch vehicles, we still stack and strap-on boosters. The Titan and Delta launch vehicles use strap-ons while the Atlas uses the Centaur upper stage.

Remember, we imposed strict requirements on our ICBMs with respect to responsiveness, maintainability as well as accuracy. We originally sought an accuracy of 1500 meters. However, the prospects for lightweight nuclear weapons with high yield enabled us to relax the accuracy requirements to 3-5 miles. This significantly reduced the guidance problem. Yet, even the requirement of 3-5 miles was aimed at war fighting applications. If the only requirement is to hold population centers at risk—when using weapons of mass destruction, accuracy requirements can even be further relaxed. Thereby guidance becomes a relatively straightforward problem to solve—made even easier through the commercial availability of global positioning system signals. In fact commercial available inertial systems can alone do this job.

System integration was a major task during the time I managed the ICBM programs. This was due to the fact that virtually all of the components and subsystems were first of a kind items. We pioneered, but by no means refined, the idea of black box testing as a way of testing subsystems. Such testing is now well refined and procedures are systematic and well known. In addition, today components and many of the key subsystems are available for purchase on the open market—leaving little question as to their operability. We also did a great deal of integrated testing. We did so due to a lack of either an understanding of the basic physics—for example, re-entry conditions—or analytical modeling capability. Today both the physics and the analytical capability are readily available. As a result, much of the integrated testing we conducted—to assess a vehicle's structural responses to the dynamics of flight—could today be done using computer analysis. The mysteries we worked our way through 40 years ago are today taught as engineering problems in any good American graduate school.

In conclusion, experience has taught me that necessity is the mother of invention. This was the case in developing the U.S. ICBM program. The government provided the priority necessary to get the job done. For example, from program start to operational status required just over 5 years in the case of both the Atlas and the Titan programs to reach operational status. The Minuteman, which introduced solid propellants, became operational in just under 5 years. Our experience should lead us to be prudent regarding what certain unfriendly nations might do in today's environment with respect to both ICBM range and schedule. Furthermore, intelligence estimates are not infallible. In my opinion, the "will" rather than the "know-how" is the key factor for these nations to achieve an earlier ICBM capability than now projected.

Senator COCHRAN. Thank you very much.

Let me ask a couple of questions about General Schriever's statement to both of you and get your reactions, and then I am going to yield to my good friend from Michigan for any questions he might have.

General Schriever stated that he built this first ICBM by adding an upper stage to the intermediate-range Thor missile. Does this mean, based on this experience, that other nation states, if they decide to build ICBMs, and first developed a shorter-range missile capability, is this indicative of the capacity to then take that next step? Is it logical to assume that they could do that without a great deal of difficulty? Is that your conclusion?

Mr. GRAHAM. Yes, it is, Mr. Chairman, and I believe that is General Schriever's conclusion as well.

He noted as a man of great precision that the Thor system was never made militarily operational as an ICBM. It was his backup to the Atlas Centaur program, but it was the first to achieve the long distance, and that capability of adding a second stage can certainly be used by countries today to extend missile range to intercontinental distances once they have achieved the shorter-range missiles.

Senator COCHRAN. Dr. Carus, General Schriever also talked about the fact that during this time frame of just over 5 years from the start of the program to operational status, they, I assume, had some flight testing before the missiles were ready to use. Are you aware of what kind of testing program or how long that took, and is a testing program necessary in order for a nation state to develop and maintain a lethal and capable missile system?

Mr. CARUS. I am not closely familiar with that system, but if one looks at the early history of our ballistic missile program, say through the 1960's, it was typical for us to have large numbers of launches to test various parameters of the missile.

I think we still tend to like to do a fair amount of testing, as did the Soviet Union. However, we know from experience that some of the proliferant countries are less concerned with reliability and performance issues than we are, and as a result, have not tested their systems as much as we would.

Senator COCHRAN. I think in the Iran-Iraq War, we saw missiles being used that had not been tested, or the first we knew even of the existence of the missiles was when they fired them. Is that accurate?

Mr. CARUS. The Iraqis had fired the Al Husayn missile in some test flights, but only a small number. They developed a variant that, as far as I know, they had not tested before using.

Senator COCHRAN. In terms of intelligence, too, we know about missiles when they are fired, but we do not necessarily know about them if they are not fired. Is this one of the challenges for the intelligence community? I think you touched on this in your prepared statement. What, if anything, can we do to improve our intelligence-gathering capability so we can have more reliable and accurate information about this kind of thing?

Mr. CARUS. Actually, there is a subset of the issue which I would like to address first, if I may, and that has to do with the problem of cruise missiles.

In the case of cruise missiles, we could detect a test and still not know what its range is if it is never tested to its maximum range.

In the case of ballistic missiles, I think we tend to believe that somebody would have to fire it at least once or twice before they would have any confidence that the system would work, which I think emphasizes the importance of us maintaining the resource investments and the various kinds of intelligence-gathering systems that we have deployed to monitor tests of this character in places like North Korea or Iran.

Senator COCHRAN. To follow up on that, is it possible that we would not know a country had a long-range ballistic missile until it was launched?

Mr. CARUS. It is possible, and in fact, it appears to have happened. I believe it was late 1989. The Iraqis launched what they claimed was a space-launch vehicle, which nobody had known anything about until it went up into space. In fact, there was a little bit of confusion at the time because for a period of time we thought that they might have actually orbited something. As it turns out, the rocket blew up before it reached that kind of altitude, but I think that shows that it is possible to develop some fairly substantial systems on the quiet without us necessarily being able to detect them.

Mr. GRAHAM. Mr. Chairman, might I also add an answer to your reliable and accurate information question from the intelligence community?

Senator COCHRAN. Sure.

Mr. GRAHAM. I believe they are addressing the wrong question, and have been addressing the wrong question for many years. The question they have been addressing is what do we know about developing countries' long-range ballistic missile capability. I believe the right question is what information do we know to persuade us that developing countries are not developing long-range ballistic missiles, and while that sounds like a nuance, another example of that would be the difference, say, between the intelligence reports in the early 1940's that they had no information the Japanese were developing shallow-water torpedoes, and the discovery we made on December 7, 1941, at Pearl Harbor—that, in fact, we just did not know that the Japanese had developed shallow-water torpedoes and, therefore felt safe to put our Pacific fleet in a shallow-water harbor.

The key information for military purposes is to what extent do you have confidence that a hostile capability is not being developed. That is a much harder question. Nonetheless, that seems to me to be the one of military relevance, and there are other things we can do in addition to just challenging the intelligence community with that question to get insight into what is going on in the developing world.

Senator COCHRAN. Thank you. Senator Levin.

Senator LEVIN. Thank you, Mr. Chairman. Thank you for yielding to me so I could get in a few questions before I have to leave, and I appreciate that.

First, Dr. Graham, you make reference to a number of documents which have been made public, which have technology information relative to short-range ballistic missiles on page—well, there is no page number, but in 1991—you are familiar with this—it says here that the Arnold Engineering Development Center of the Air Force Systems Command released a report. I think you testified that, in effect, I think you are saying, that that should not have been released. Is that your argument that that contained classified information in September of 1991?

Mr. GRAHAM. The classification is for government officials to decide.

Senator LEVIN. Well, should it have been classified as secret?

Mr. GRAHAM. In my view, that document should have been restricted for official use in the United States, at an absolute minimum, and not made generally available.

Senator LEVIN. Does that mean classified, or is that something less than classified?

Mr. GRAHAM. Well, "For Official Use Only" is one level of classification.

Senator LEVIN. Well, I think it would be useful to ask the Defense Department, even though this is some years ago, as to why a document like that was not restricted, and the same thing with other information which is referred to in Dr. Graham's testimony. There are some NASA references in here.

I think it would be helpful, Mr. Chairman, if the Subcommittee referred the documents to the Defense Department and to NASA and to request their comment on it since they are not here today. Would that be possible?

Senator COCHRAN. Well, let's talk about that. I do not know whether there is a statute of limitations.

Senator LEVIN. No, I am not talking about any action. I am just curious as to why a document like that, if they could help us out, would not have been restricted.

Senator COCHRAN. I would be glad to join you in writing them a letter to ask them that.

Senator LEVIN. Right, OK.

Mr. GRAHAM. I would add, Senator, that this type of information is widely available. I brought examples of it, but certainly nothing comprehensive you would find many places where this information would have to be classified if that were to be done.

The point of my testimony was that this information is so widely available that that restriction of it at this point is going to be ineffective.

Senator LEVIN. Well, I am not talking about restricting it at this point. I am talking about why wasn't material like this restricted, to try to get a philosophy from them, the same with the Patent Office. There is a reference in here to the Patent Office, Dr. Graham says, as another substantial source of information on missile technology and search time of 1.15 seconds produced the following hits, and then there is 1,651 patents on missiles and 3,160 patents on guidance systems. I mean, I think we ought to ask them to comment if this is a current program, a current policy. Why is it that that should be made public? Why is that not classified now, so we can get an idea as to what is the guidance that they have on this kind of an issue?

Presumably, it is your testimony that that should not be made public. I assume that is why you are here today.

Mr. GRAHAM. No. My testimony is that this information is widely available, Senator. It is a policy judgment as to whether it should be made available or not. I am just stating the facts that it is, indeed, available.

Senator LEVIN. Well, then I think it would be useful to ask the Patent Office as to what the basis of their policy judgment is. So, again, if the Chairman wants to——

Senator COCHRAN. I think that is an appropriate thing for us to ask the Patent Office, what is their policy, how do they decide what goes out on the Internet, or is available on their page, or in any other way to the general public. That is appropriate, I think, and I would be glad to join you in that inquiry.

Senator LEVIN. OK, thank you.

On the surplus property issue, there is some Minuteman engines and a few other things that you have made reference here to, and I think it would be useful to find out from the Defense Department as to what is there or what steps were taken to make sure that no sensitive equipment was disposed of as surplus. I am sure there are very strict rules as to what is declared surplus and were those rules applied, and if so, why would this not be sensitive. If it is not sensitive and if it violated the rules, how did that happen, and if the rules are not strict enough, they ought to be more restrictive.

Can you summarize, perhaps, the rules that applied before something can be declared surplus, like those old engines, perhaps the guts were taken out of them or they were in some way made useless other than as scrap? What are, in general, the rules before equipment can be declared surplus to avoid transferring equipment which might be militarily useful or sensitive?

Mr. GRAHAM. If it is all right, I will provide the details for the record, but the general process is that the equipment is reviewed, and it is given one of several categories of military applicability that extend all the way from not militarily applicable in any particular way and can be sold as-is—an example might be a desk or a chair—to something which is extremely militarily critical and sensitive and has to be shredded or reduced to completely inoperable and unengineerable scrap before it is made available.

There are a number of categories in between, where critical military components are removed or critical software is taken out. That is the process.

The difficulty comes in when the Defense Department attempts to do that with literally tens of billions of dollars worth of surplus equipment each year. It is very easy for mistakes or oversights to occur in the process, and that is when critical military technology manages to be sent offshore.

Senator LEVIN. Do you know what level of classification or elimination of any militarily sensitive parts were applied to, for instance, the recorder and the reproducer of that LGM–30 Minuteman? I mean, was there a mistake made in that?

Mr. GRAHAM. I would have to review the details of that and ask the government if they viewed that as a mistake or not. That is their classification problem.

Senator LEVIN. Do you know whether that was sold as-is or whether pieces were removed or what?

Mr. GRAHAM. Again, that would have to come from the Defense Department. I do know, though, that when an inquiry was made concerning the item that you saw in the display, subsequent to that inquiry from the congressional staff, the item was, in fact, destroyed before sale.

Senator LEVIN. So that, that may have been a mistake?

Mr. GRAHAM. That would have to be directed to the people who did it. Apparently, its status changed after congressional staff inquiry.

Senator LEVIN. Well, I think it would be useful to find out whether or not that was based on a misclassification or whether or not it was classified properly or whatever.

I think it is helpful to get the agencies' responses when this kind of information surfaces, so we can get the full story and find out whether or not the classification was erroneous, whether it was mistaken, if so, were steps taken to avoid that in the future, was there anybody who perhaps was disciplined if there was sloppiness or negligence in the process. I think it is useful to hear from the agency on this kind of an issue, even though something may have happened that should not have. Maybe it is too late to stop that.

At least it would sensitive agencies in terms of future activity, and if there answer is nothing inappropriate happened, we ought to have that for the record, too, I think, Mr. Chairman.

I would make the same kind of request for that information. Let's get the agencies' position on that, and again, if they made a mistake, they ought to own up to it and let us know.

Senator COCHRAN. What is your reaction to his comments, Dr. Graham?

Mr. GRAHAM. I think there are serious concerns. I think, in fact, this subject has a very long and unfortunately extensive history of items being misclassified and exported. So these are by no means singular or unique examples, and in my view, they are not even the most egregious examples.

I think either through your GAO or other organs of the Congress, you can find a great deal of information on the subject already collected.

Senator LEVIN. That is more reason, I think, to let the agencies know when this kind of information surfaces, Mr. Chairman. So I would urge that this testimony be sent off to the Department of Defense, the folks who declare things surplus, and ask for their comment on it.

Senator COCHRAN. I think we should first check with the GAO——

Senator LEVIN. Or the GAO.

Senator COCHRAN [continuing]. And see if there have been some investigations in this area and see what they have on file. We might revisit it through an inquiry handled by them.

Senator LEVIN. That would be great.

Senator COCHRAN. Is that OK?

Senator LEVIN. Then I just had a couple of questions, if I could, for Dr. Carus.

On the question of whether or not a country would deploy a missile and consider it operational, if they had not tested it—and here, I want to talk about a country which is developing its own missile, not buying a complete missile. Obviously, that is a totally different situation. Were they developing a missile, would it not be usual, just prudent to test a missile that has to re-enter and hit a target before it is deployed?

Mr. CARUS. I think in the conditions that you specify, which is to say an indigenous development where you are not merely copying something that somebody else has provided you, that you would do at least some minimal level of testing, at least one launch.

Whether you do more, I think, would depend on the extent to which you were concerned about reliability of the system.

Senator LEVIN. On the Al Husayn missile that you made reference to in your testimony, you say that in August 1987, the Iraqis reported that they had successfully tested a missile with a range. Did they report that in 1987?

Mr. CARUS. They reported it at the time of the launch.

Senator LEVIN. Prior?

Mr. CARUS. At the time of the launch.

Senator LEVIN. At the time.

And did we doubt that?

Mr. CARUS. My understanding—and I was not in government at the time, so I do not know what was officially going on, but my understanding is that, in fact, people did doubt that they had done what they claim, which is to say develop their own 650-kilometer-range missile.

Senator LEVIN. Do you know whether or not we noticed that a missile had been launched?

Mr. CARUS. Typically——

Senator LEVIN. No. I mean in that case.

Mr. CARUS. In that particular case, as I said, I was not in government at that time. I know that most of the missiles launched during the Iran-Iraq War, which, of course, mostly were 300-kilometer-range missiles, were not detected at the time of launch.

Senator LEVIN. You are talking about what range?

Mr. CARUS. The SCUD, the standard SCUD–B's. We detected some of them, but only a fraction of the ones that were launched.

Senator LEVIN. The last question is about space-launch vehicle technology and the difficulty of determining whether technology would be used for space-launch vehicles or for ballistic missiles.

How do you prevent access of nations to space-launch vehicle technology? How do you decide, or would you, which nations could have space-launch capability and which ones cannot?

Mr. CARUS. Well, I think as a starting point, one has to be skeptical of countries that formerly had ballistic missile programs, whether or not a space-launch program was going to be a way of hiding a ballistic missile program. So that, for example, a country like Brazil that pursued both space-launch programs and ballistic missile programs, one would at least have to be concerned that by giving up the ballistic missile program as the price of joining the MTCR that they may, in fact, just be trying to hide the continuation of their former ballistic missile.

Senator LEVIN. How do you act on that concern? Do you prevent them from getting technology which could be used for space launch?

Mr. CARUS. Well, in this particular case, I think the appropriate response would have been to say that under the terms of admission to the MTCR that we would ask for a termination of space-launch vehicle programs, as well as ballistic missile programs.

Senator LEVIN. But isn't the very guideline of MTCR—doesn't it specifically say that it is not designed to impede national space programs?

Mr. CARUS. Well, when the MTCR was originally negotiated, it included the G–7 countries, all of whom in one way or the other participated in space-launch programs.

However, like a lot of the export control regimes, they are technically not designed to impede legitimate activity. We also often take a skeptical view of what is going on. Thus, under the Chemical Weapons Convention, we are not going to impede chemical industries, but yet, we still pursue export controls because we recognize that while in theory chemical industries are a good thing, in practice sometimes they are not.

Given that, in fact, we have seen this overlap between space-launch programs and ballistic missile programs, it just strikes me that there is reason to be skeptical.

Now, if you take the position that it is impossible to constrain space-launch programs, I think it has some very serious implications over the long run for U.S. security because it suggests that we are going to see more ICBMs sooner rather than later.

I mean, the advantage of a program intended to impede the spread of SLV programs is that, in fact, it reduces the chances that you are going to see additional ICBMs out there, which I think from our point of view is a good thing.

Senator LEVIN. Right, but it also, then, increases the chances that people are not going to join the MTCR because every country has a right to engage in space launches, right?

Mr. CARUS. Well, the question there, I guess, is whether or not the tradeoff that you are making is one that you feel comfortable with. Whether getting somebody to join the MTCR and eliminate certain activities, while at the same time accepting they are pursuing other activities, is a fair tradeoff.

I am not convinced that it is that clear-cut in an either/or situation. To some extent, it is a matter of what carrots we are willing to offer, as well as what sticks.

Senator LEVIN. Thank you, Mr. Chairman.

Senator COCHRAN. Thank you, Senator Levin.

The *Washington Times* recently reported on the Russian and Chinese assistance to Iran, and specifically to their ballistic missile program by providing assistance in the form of wind tunnel testing of missile nose cones, the design of guidance and propulsion systems, development of solid fuel, and telemetry equipment. This sounds disturbing on its face.

How concerned should we be about this kind of assistance being provided by Russian and Chinese technicians to Iran?

Dr. Graham.

Mr. GRAHAM. Well, Mr. Chairman, there is no question that Russia and, to some degree, China are expert and experienced in these fields, and that by bringing them into Iran, they will certainly help accelerate Iranian ballistic missile development programs. These are key areas. My guess is if they have several hundred technicians in Iran, they are certainly not limited to these areas. These are critical areas in ballistic missile system design, and therefore, I think they can play a substantial role in letting the Iranians produce ballistic missiles of increasingly longer range in short times.

Senator COCHRAN. I know that we have an active effort underway with Russia to try to discuss and resolve some of these problems and threats that this may pose to the Middle East, in particular, but also to worldwide stability.

Dr. Carus, what suggestions would you give if you were a policymaker in the government about what we can do to try to help influence the actions of the Russian and Chinese governments in this area?

Mr. CARUS. Well, I think the experience we have had is that you have to be willing to elevate issues like this to a very high level.

As I mentioned in my testimony, we have been going around with the Chinese on this issue for nearly a decade now with very uneven success.

Part of the problem in that particular case is that the Chinese are aware that when push comes to shove, we are disinclined to push the issue as seriously as it perhaps deserves, and as a result, essentially believe that they can get away with whatever they are doing.

I think the same approach is likely to be true in the case of Russia. If, in fact, we take it as seriously as we should take it, it means that you have to elevate the issue to a very high level, which is to say Presidential level discussions, and you have to make it clear that if, in fact, the reports are true that the United States will take them very seriously and there will be repercussions.

Senator COCHRAN. The *Washington Post* recently described the transfer to Iraq of gyroscopes from Russian long-range ballistic missiles. This took place nearly 2 years ago, in fact. Can you explain, Dr. Graham, why such devices are important, if they are, and how much help they would be to a country like Iraq in developing a long-range missile system?

Mr. GRAHAM. Well, the gyroscopes and the associated accelerometers, Mr. Chairman, are the elements that define the accuracy of the missile. They control the guidance and navigation of the missile and are used to direct it to the target. They are precision instruments, and while instruments that can achieve city-sized accuracy are available commercially, these were even finer instruments and can achieve greater accuracy than that needed just to hit cities. So I would view them as instruments used in advanced stages of an Iraqi ballistic missile program.

By the way, they are not particularly valuable for short-range missiles—missiles of the Al Husayn type of distances. They become really valuable when you go to longer distances, where small errors in the initial guidance will end up as bigger misses at the other end. So I believe they show an Iraqi interest in moving toward longer range ballistic missiles.

Senator COCHRAN. As countries try to extend the range of their missile forces, are there technologies that are necessary for them to be able to accomplish this, and are those technologies available from the sources you described, Dr. Graham, in your testimony?

Mr. GRAHAM. There are such technologies, and I believe I identified most of them, Mr. Chairman.

I did not emphasize in my discussion the similarity between the technologies necessary for space-launch vehicles, that is, the devices to carry satellites to orbit, and the technologies for ICBMs, but if you take space-launch vehicle technology and add to it the re-entry vehicle, you have an ICBM. I believe that any notion that we can allow countries to develop space-launch vehicles and restrict their development of ICBMs is an exercise in U.S. self-delusion, and if the MTCR allows one and prohibits the other, it may be a diplomatic vehicle, but it certainly is not a vehicle of technical substance that will reduce the ICBM development of other countries.

Senator COCHRAN. Well, given the facts and the similarities between those capabilities, developing space-launch capability and the ICBM capability, can you tell us if you know what countries are trying to acquire space-launched capabilities?

Dr. Carus.

Mr. CARUS. Over the course of the last decade, there have been a lot of countries that at least have expressed an interest in this, many of which have not developed real capabilities.

In addition, to the major suppliers of space-launch capabilities, which is to say the Chinese, the Russians, the Europeans through the ARIANE program, and the United States, we also have a number of other countries that periodically put things into orbit, such as Japan, India, Israel.

In addition, there have been a number of countries which have not reached that stage, but which, in fact, are either actively pursuing or were in the recent past, which includes Brazil, Ukraine, Argentina, though that program has come to an end—South Africa, though I believe that program also has come to an end.

Mr. GRAHAM. Iraq.

Mr. CARUS. Iraq, South Korea, and Indonesia, though I think the Indonesians are in very early stages of exploration.

So there are a lot of countries that have gone through this process at some time or another in the recent past.

Senator COCHRAN. Dr. Graham, do you have any additional comments on that subject?

Mr. GRAHAM. No, Mr. Chairman. I think Dr. Carus has covered it. There may be a couple we have left off the list, but the list is long.

Senator COCHRAN. Could you more fully explain why acquisition of a space-launch vehicle aids the long-range missile program?

Mr. GRAHAM. Well, yes, Mr. Chairman. The space-launch vehicle provides a booster and the associated guidance and navigation system to take the payload from the surface of the earth above the atmosphere into space, and from that point on, it is a matter of, first, Newton's laws as to when it comes back down again or goes into orbit, and that depends primarily on the direction and speed of the payload, and then, second, where it comes down is a function of the directions and speed of the payload and the re-entry characteristics of the vehicle that protects the payload, and of course, the aerodynamic forces that work on the reentry vehicle.

These are all very well understood and have been extensively developed and documented over the last 40 years. The only piece of space-launch vehicle that is not an ICBM is the re-entry package, and the re-entry package can be developed initially in wind tunnels, on shorter-range vehicles, and through computational methods. So, very late in the development of a space-launch vehicle program, you can still turn it into an ICBM.

I would say it goes the other way, too. All of our unmanned space-launch vehicles today began life as ICBMs, or at least as long-range ballistic missiles. The Atlas was the first ICBM and now is a space-launch vehicle. The Titan is now being used as a space-launch vehicle, and the Thor is now called the Delta, and that is a space-launch vehicle. So that gives you a sense of the interchangeability of these two roles for ballistic missiles.

Senator COCHRAN. You have pointed out that we may not always know who is doing what in this missile development business—Dr. Carus specifically talked about the difficulty of knowing whether someone really had missiles available to use, until they used them—and one example we talked about was Iraq's SCUD missiles and the advanced version of the longer-range missile that it used. Isn't another good example of that situation when North Korea tested its No Dong missile in 1993? I am told that the CIA was surprised, and there was no information really obtained relating to that launch, and that some describe that as an intelligence failure. Is that an accurate statement of what the facts were?

Mr. CARUS. I would like to be brief and just say that my own involvement in that case suggests to me that in that particular instance, the intelligence community was doing a pretty good job. There were some issues and concerns, but I would say that they were not surprised at that particular time; that, in fact, they were alerted to the fact that a missile was going to be fired and had prepared—had taken steps to try to follow it.

As I said in the opening of my testimony, there are a lot of cases where the intelligence community has done a very good job. That, I would say, is a case where at least they were aware that something was going to happen when we are on the ball.

Senator COCHRAN. Is there any new technique or regime that you would suggest be considered if the U.S. intelligence process is going to be improved?

Dr. Carus, you mentioned "preconceived expectations," where you try to decide what you should expect a country to do based on a certain set of facts. Should we start thinking about the capabilities in a different way?

Mr. CARUS. I think any time you are looking at a country which is trying to develop capabilities in a different context, both economically, politically, and also technologically, you have to be worried, and one of the problems we have is that countries trying to get longer-range missile capabilities are entering with access to a type of technology that, as we have discussed, was not available when we got into the business.

So that, for example, you could imagine somebody taking a look at something like the U.S. Pegasus rocket, which is a small winged-looking vehicle designed to be launched from an aircraft to put things into orbit. That might be an alternative model for somebody to pursue from a traditional ICBM.

My guess is that if somebody were to pursue such an approach, we would not be certain what was going on, simply because it was not following a traditional development program pattern.

Senator COCHRAN. And it seems logical that some states who are seeking to develop ballistic missile capabilities may not want anybody else to know about it, and they would try to mask or obscure what they were doing from U.S. intelligence efforts or other efforts. Are there important activities that U.S. intelligence sources just would not be able to see?

Mr. CARUS. My general feeling is that if somebody wanted an intercontinental ballistic missile that they had any confidence in, they would have to test it in a way that we would pick up on it. The complexity comes in when you take the caveats to that.

Thus, for example, if somebody had a missile that appeared capable of reaching the United States, I am not sure that the reliability of it would be significant in the context of an emerging crisis.

Thus, for example, if going into the Gulf War, we had had concerns that Iraq had missiles that actually could have reached the United States, I am sure it would have had an impact on the debate here in Congress about how we should approach Iraq. Hopefully, we would have taken the same decision, but it would have completely changed the political context in which our decisions were being made.

Mr. GRAHAM. Mr. Chairman, could I add an answer to your question about intelligence procedures and processes we might follow to avoid being surprised?

Senator COCHRAN. Yes, Dr. Graham, surely.

Mr. GRAHAM. We need to change the question from "What do you see?" to "What do you have certain knowledge that countries are not doing?" That is the militarily operable question.

I believe we also have to scrutinize the assumptions that are made in intelligence analyses, assumptions such as that missiles will be developed entirely from indigenous sources without outside help, or other absurd assumptions. Nonetheless, those creep into intelligence analyses from time to time.

As any good systems analyst knows, you can get any answer you want if you have complete control of the assumptions going into the analysis.

I would also then add that we should probably develop a new variant of intelligence called intelligence anticipation. Right now intelligence only tells us about what people see, and you are not going to see anything today that is going to lead to substantial consequences 10 years from now. So we should be thinking about it and trying to analyze how countries with various stated intentions could act if they wished to carry them into the future in ballistic missiles and other areas.

Finally, I would put something I call "try-int," try intelligence—on the list; that is to say, rather than just watching to see if some country does something, if we think it is possible for a developing world country to do something, let's get a group together with the resources and education and access of that third-world country and let them try to do it and see what they come up with. That has actually been done a few times, not as far as I know by the intelligence community, but by other organizations in the government. The results have been startling and I believe profound. So I think there are many things that can be done to augment the intelligence process that would give us a better anticipation of what to expect in the foreseeable future.

Senator COCHRAN. There is a comment in your statement, Dr. Carus, about the fact that Iran, Syria, and Egypt all have obtained from North Korea information and technology for missile development. What accounts, if you know, for North Korea's apparent expertise in this area of technology?

Mr. CARUS. Well, I think it actually goes back to the points that were made earlier that there was a will and a perceived need to have this kind of capability. So the North Koreans in the early 1980's went out of their way to acquire ballistic missiles, the SCUDs, that they could use as copies.

They had earlier tried to buy them from the Chinese without success, and they basically got other people to pay the financial cost, took advantage of the fact that they had some technical expertise, and reverse-engineered this missile.

I think what that primarily reflected was the fact that they had a national leadership that made this a high priority, both for their own national security and also as an export item, because it has been a major earner of hard currency for the Iranians in the past.

In many ways, it is very surprising because North Korea is not necessarily a technologically sophisticated country. However, they clearly had the technology needed in order to pursue a 1940's, early 1950's vintage missile system.

Senator COCHRAN. There was a comment in Dr. Schriever's statement which described design requirements in terms of accuracy, operational readiness, and maintainability. If these requirements are not necessary, how much easier is it for a country to build a long-range ballistic missile?

Mr. GRAHAM. Well, relaxing these certainly make it substantially easier. Having the requirement that the missile be available on short notice, 24 hours a day, is an extremely difficult challenge because it does not mean you can launch it when you are ready. It means you launch it when you are told to, and by relaxing that, by being able to launch when you know your missiles are in good condition and full working order, it lowers the long-term reliability requirements on the missile, and that, in turn, greatly eases the engineering problems of building the missile.

Senator COCHRAN. To what extent does the assistance that comes from Russia and China to Iran to develop a missile of 2,000-kilometers range also help Iran obtain longer-range missiles?

Mr. GRAHAM. I think the 2,000-kilometer missiles are the step before you go to the longer-range missiles, and it will give them the leverage by the techniques that General Schriever discusses, either in terms of add-on boosters or add-on stages, to let them go to a substantially longer-range missile in a period that is months to years, but certainly not decades.

Senator COCHRAN. Dr. Carus.

Mr. CARUS. If I may add to that, sir, one of the biggest problems the Iranians have had in their missile program is something that the General referred to in his testimony which was systems integration. It is the reason why the Iranians, who have at least the same technical competence as the North Koreans were, in fact, forced to go to the North Koreans to buy turnkey SCUD production facilities and complete SCUDs.

The biggest concern I have about this external assistance, especially these recent reports about Russian assistance, is that the Iranians would receive help in learning how to undertake these kinds of systems integration. Once they are able to do it once, whether it is on a 500-kilometer-range missile or a 2,000-kilometer-range missile, they are going to be able to do it again and again because this is a skill that can be reapplied.

If, in fact, that is what they learn, it will have serious long-term repercussions in terms of our ability to constrain Iranian missile programs.

Senator COCHRAN. A missile that has not been operationally tested is, of course, less reliable than one that has, but can such a missile still be considered sufficiently reliable or lethal, as a threat to use in a crisis or to create enough of an impression of being useful for a potential foe of the United States or some of our allies?

Mr. CARUS. We have a little bit of experience with this. It is reported that of the North Korean-supplied missiles that the Iranians used during the Iran-Iraq War, something on the order of 10 percent of them blew up in the launch process. What that tends to suggest is that countries that have different criteria of operational effectiveness are not going to demand the same level of perfection that we would; that, in fact, for their purposes, 90 percent of them getting in the air is fine. They do not need perfection.

Similarly, from what we could see, the Iraqi missiles had tremendous problems. They were breaking up in the air. It is one of the things the Iranians noticed about those missiles. It is one of the reasons our missile defenses had problems in dealing with the Iraqi missiles. From the Iraqi point of view, that was OK. They did not need a system of the same operational and militarily effectiveness as we would demand, which again I think suggests that for some of these countries they will accept levels of quality that would be simply unacceptable here in the United States.

Senator COCHRAN. Dr. Carus, you suggested that an effective Missile Technology Control Regime will make it easier to track missile development programs, I think. If that is what you said or believe, what could be done to enhance the effectiveness of the MTCR?

Mr. CARUS. I think the first thing that has to be done is enforce its existing provisions. If a country supplies technology in violation of the agreement, whether it is because they are a formal member of the agreement or because they have agreed to adhere to its provisions, we have to be willing to apply a tremendous amount of pressure to get them to comply.

Second, I think we have to be very skeptical about efforts by countries to acquire so-called legitimate space-launch vehicle programs. At one time, the United States took a hard line on that issue. We did not allow the Argentineans to join the MTCR until they killed the Condor program, even though the Argentineans argued that it could be used as a space-launch program, which in fact is true.

In the last few years, we have been less hard line on that, and I think it has been a mistake. It would be appropriate, I think, to take another look at that policy.

Senator COCHRAN. How do we extend the controls or restrictions on the assistance provided by technologists or scientists that we have talked about and that you all have discussed as an issue and a challenge? How do we respond to that more effectively?

Mr. CARUS. Well, we have taken steps to try to help countries that want to respond to it. We have training programs that U.S. Customs and other law enforcement agencies provide to help some of the newly independent states learn how to implement export control regulations. To the extent that those countries are interested in enforcing these kinds of laws, I think there are mechanisms to help them do it better.

The difficulty comes really in cases where there is less enthusiasm for enforcing laws of this kind.

Mr. GRAHAM. As a practical matter, too, Mr. Chairman, restricting that information is going to be very difficult, and I do not think whatever actions we take, we will find much comfort in them, but, certainly, the United States could take more of an interest in the fields of study that foreign students, particularly from countries like Iran, Iraq, Libya, Syria, China, are going to pursue when they come into advanced education in the United States.

Once visas are issued, as I understand the process, the foreign student's actual course of study is neither checked or monitored by the U.S. Government. It seems to me it would make sense to review the visas in terms of what it is they say they are going to study and then periodically review what it is they are studying to see if those correspond.

I think we could go through the whole process. The professional organizations could be sensitive to the concerns of missile proliferation. I am sure they are to some degree, but that could probably be raised, and we could tighten up our own surplus equipment disposal and encourage our allies to do that as well. So I think there are opportunities all along the way.

These will have the effect of slowing down the transfer process to some degree. By no means will they stop it, however.

Senator COCHRAN. It seems, too, that the proliferation of information through the availability of the Internet and other sources creates another question, at least, about what we can do to mitigate the dangers created by the expansion and accessibility of so much information.

I am not suggesting we need a worldwide book-burning or document-shredding. That is not the answer, of course, but what is? Is there anything that we can contemplate doing about that?

Mr. CARUS. Well, I think the reality is that if a country is willing to expend the resources and devote the—and make the program a national priority, that we cannot count on successfully stopping missile development programs.

We have had successes in raising the cost and slowing programs down, and in some of those cases, there have been political changes that have led to the termination of the programs. That, I think, is sort of our best case.

However, as we have seen in some countries that are less tractable, we are not going to have successes across the board.

Senator COCHRAN. Dr. Graham.

Mr. GRAHAM. Ultimately, I believe the United States is going to have to realize that in the future, it will live in a world where an increasing number of countries, not all friendly to the United States, will have ballistic missiles of increasing range, which will eventually not only reach our allies around the world, but reach our homeland as well.

Senator COCHRAN. The export controls and multilateral regimes like the Missile Technology Control Regime can help slow the spread of missile technology, as you suggest, but even the best controls on sensitive technology are never 100-percent effective, we have found. Is the advent of the information age and the increasing availability of missile technology further undermining the effectiveness of technology controls?

Mr. GRAHAM. I think, without question, the effectiveness of it is questionable to begin with, and it undoubtedly becomes effective as information is more widely and more rapidly disseminated.

Senator COCHRAN. Well, this seems to me to be a very strong argument for a more adequate and effective defense capability. Is that a conclusion that you draw, Dr. Graham or Dr. Carus?

Mr. GRAHAM. Yes, it is, Mr. Chairman. I do not know how else the United States can live in a world of increasing long-range ballistic missiles in the hands of an increasing number of countries, some of which are quite open about their intention to be hostile to the United States and to work against our purposes in the world.

Senator COCHRAN. Dr. Carus.

Mr. CARUS. I think there is certainly, to some extent, widespread agreement on that issue. Certainly, the transformation that I have seen over the last decade in terms of theater missile defenses indicates that we have really gone a long way in that regard.

When I first got involved in that issue in the mid-1980's, I can remember the antagonism that existed towards theater-level missile defenses. In the wake of the Gulf War, I am not sure that kind of antagonism exists anymore, which I think is a good thing because it is very clear that under today's circumstances, our military forces and friendly countries are, even as we speak, vulnerable to missile attacks using certainly chemical and maybe biological warheads, as well as conventional warheads.

We have efforts underway to try to defend against those missiles, other than active defenses, but at the moment, you would have to say that those alternatives are not yet mature. We have no reliable way of hunting down and killing missile-launchers, for example.

So that the only thing that we really have to provide at least some level of protection for our forces and for our allies are active missile defense, and I do not think that is going to change any time in the near future.

Senator COCHRAN. Let me thank you both for your very generous commitment of time and effort to help us with this hearing, preparing your statements and being here presenting your testimony and answering our questions. You have been very patient and very, very helpful, and for that, we are grateful to you. We express the appreciation of our Committee for your assistance.

This concludes our hearing. We will have another hearing soon, and we will make an announcement about that. The Committee is adjourned.

[Whereupon, at 12:11 p.m., the Subcommittee was adjourned.]

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