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CHINESE ACCESS TO DUAL-USE AND MILITARY TECHNOLOGY

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before the

JOINT ECONOMIC COMMITTEE
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CONTENTS

OPENING STATEMENTS OF MEMBERS

WITNESSES

SUBMISSIONS FOR THE RECORD

CHINESE ACCESS TO DUAL-USE AND MILITARY TECHNOLOGY

Tuesday, April 28, 1998

HOUSES OF REPRESENTATIVES,
JOINT ECONOMIC COMMITTEE,
WASHINGTON, D.C.

The Committee met, pursuant to notice, at 10:00 a.m., in Room 2220, Rayburn House Office Building, the Honorable Jim Saxton, Chairman of the Committee, presiding.

Present: Representatives Saxton and Doolittle; Senator Bingaman.

Staff Present: Vaughn Forrest, Juanita Morgan, Darryl Evans, Mary Hewitt, Dan Lara, Howard Rosen, and Tami Ohler.

OPENING STATEMENT OF REPRESENTATIVE JIM SAXTON, CHAIRMAN

Representative Saxton. Good morning, ladies and gentlemen. The hearing today is about the People's Republic of China's access to dual use and military technology. This hearing will consist of two panels.

The first panel will be the Administration's perspective. To give us the Administration's position is Mr. William Reinsch, Under Secretary for Export Administration, Department of Commerce.

Mr. Reinsch, we will hear your testimony and then ask a few questions. I want to thank you for being here this morning. I know how busy your schedule is, and so thank you very much for taking time to be here with the Joint Economic Committee (JEC).

You may begin at your leisure, and we generally have a five minute rule, but due to the subject matter today and the availability of time, you may proceed.

We'll put on the light so that you can see when five minutes have transpired, and then if you could finish your statement within some reasonable time after that. Why don't you begin?

[The prepared statement of Representative Saxton appears in the Submissions for the Record.]

OPENING STATEMENT OF WILLIAM A. REINSCH, UNDER SECRETARY FOR EXPORT ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Mr. Reinsch. Thank you, Mr. Chairman. It is a distinguished Committee with a long historical tradition. I am honored to have an opportunity to testify before you, and I am particular anxious, in view of media reports and other controversies, to have the opportunity to discuss China's access to dual-use and military technologies.

This is an important issue which is central to the mission of my agency, the Bureau of Export Administration. Relations with China are in a period of transition, and this can create the potential for risks in technology transfer. Our job is to manage that potential risk so the U.S. can reap the substantial benefits posed by China's trade and for American foreign relations, as well as our economy, without adversely affecting our national security.

Let me describe how we attempt to do that, first by discussing some of the broad factors which shape technology transfer policy with respect to China.

First, with respect to trade, as you know, Mr. Chairman, China is a dynamic market with high rates of growth and real opportunities for foreign firms. The U.S. has a significant advantage in the high-value, high-tech end of the market. But we have serious competition from the European Union and Japan. At the same time, U.S. demand for Chinese goods is high and we have a large bilateral trade deficit which we would do well to rectify.

While technology transfer restrictions account for only a small portion of the trade deficit, in many cases they have a deterrent effect on trade expansion that goes beyond our national security needs.

Before 1994, when COCOM ended, we and our major trade partners had a coordinated, multilateral approach to high-tech trade with China. Since that time we have found a growing difference in how we and our allies treat high-tech exports to China. A number of our allies no longer appear to regard China as being a strategic concern and have dismantled export restrictions on a range of dual-use technologies. The result is that some U.S. controls have become increasingly unilateral, and thus ineffective, as restraints on China's ability to acquire advanced technology.

Security and nonproliferation remain central to our dialogue with the Chinese and have a profound effect on shaping high-tech trade with China. We have serious differences with them on a variety of nonproliferation issues and have consistently engaged China to bring its practices into line with the international norms. We have made notable progress in the nuclear area and are working to broaden this dialogue and promote cooperation between U.S. and China on other security issues.

China is in the midst of broad social, economic and political change. Our goal of engaging China to influence its evolution to an open, market-oriented society shapes our technology transfer policies. A stable, prosperous and open China at peace with its neighbors is in the best interests of the entire world, including the United States, and appropriate transfers of civil technology can help achieve that goal.

Export controls are one of the principal tools we use to manage technology transfer. Our regulations allow for extensive review and denial of license applications in cases where a strategically sensitive item would make a direct and significant contribution to China's military capabilities. In addition, Tiananmen Square sanctions prohibit the export of arms, satellites and dual-use items used for crime control unless there is a Presidential waiver. U.S. policy since Tiananmen Square is to deny export of controlled dual-use technology to the Chinese military and police.

The Clinton Administration has significantly improved the dual-use export control process by, among other things, strengthening the role of other agencies in the review process. The source of that is Executive Order 12981, which was issued in December of 1995. That Executive Order gives the Departments of Defense, Energy, and State and ACDA the right to review any license of interest to them. It establishes a clear system for escalation and resolution of disputes all the way to the President if necessary – but none have gone there in this Administration – and provides for an appropriate review of technology transfer cases by the intelligence community. As a result, we believe dual-use license reviews are more thorough, more complete and more carefully considered than at any time in the past.

The Commerce Department has taken a number of other steps to reinforce our ability to enforce export regulations. We have increased the number of enforcement agents in the field and have ensured they are well trained and better equipped to carry out their mission.

I can't resist a plug, Mr. Chairman: The Congress could help us in this regard by passing a renewal of the Export Administration Act, which would, at a minimum, raise the level of the penalties for export violations from those set almost a decade ago. Under current circumstances, financial penalties are little more than the cost of doing business for many companies.

Former Congressman Roth, who is sitting right behind me, spent a lot of time during his last term in the Congress trying to accomplish this. And I commend to you his efforts and hope that others will take them up.

Beyond these improvements, as part of the Administration's larger bilateral strategic and nonproliferation dialogue, we have engaged with the Chinese government on how to improve cooperation on export controls and have taken steps to help ensure that U.S. technology is properly safeguarded. The bilateral seminar on export controls held earlier this month in Washington was a good beginning of this process. It was the first time we have done this with the Chinese, and we hope to extend our dialogue with them to reach a greater mutual understanding and cooperation in export controls and end use visits.

Let me get into a couple of specific examples that would be of interest to you, Mr. Chairman, in light of subsequent testimony this morning. Satellite exports are an example of how effective dual-use export controls allow American exporters to compete and win without risk to our national security. Our controls on satellite exports to China are extensive and involve a number of measures to reduce the risk of unauthorized transfers of technology, including a bilateral technology safeguards agreement and the presence of DOD monitors at Chinese launch sites.

Also, sensitive military satellite technology remains on the U.S. Munitions List administered by the Department of State. Allowing China to launch U.S.-made satellites under these safeguards has been an important factor in helping U.S. companies dominate the satellite market. Most sales are to U.S. or third country firms who have chosen to purchase Chinese launch services.

Another good example of the nexus between security and trade is high performance computers, which I know will be a topic today, as Mr. Leitner discusses it in his testimony later on. HPCs, that is, high performance computers have obtained a symbolic importance in our debates over technology transfer which their real utility may not warrant.

It helps put the issue in perspective if you remember that some of the weapons systems found in the U.S. arsenal today were built with computers whose performance was below 1,000 MTOPS, million theoretical operations per second, in some cases with performance of 500 MTOPS. These were the supercomputers of the 1980s.

Today you can find more capable machines on many office desktops, including, I suspect, yours, Mr. Chairman. This sector is vital to the U.S. economy as a whole. Exports account for roughly half the revenues of U.S. computer companies. Ill-advised export legislation can put this vital sector at risk without a justifiable benefit to national security.

Now, Mr. Leitner makes much in his testimony of the use of computers running test simulations, but I would simply observe after a quick reading of his statement that nowhere does he mention the level of performance required of computers to conduct those simulations. If you examine that question - and we have done so at great length, and we will be shortly making more information available on this subject, you will find that many of the applications that he discusses in fact can be run on computers at levels below 500 or below 1,000 MTOPS, computers that are not much more than the common PCs that are widely available all over the world and manufactured by many countries besides ourselves.

You also find that some applications can be done, or the more sophisticated state-of-the-art simulations can be done on computers that essentially require capacity upwards of 45,000 or 50,000 MTOPS, which is far beyond the level that anybody has discussed decontrolling as part of our licensing policy.

It is also fair to point out that computers are an unusually uncontrollable technology. If you think about the basic ingredients, the chips, the microprocessors which were decontrolled during the Bush Administration, are widely available and manufactured all over Asia and Europe by a variety of companies, both for U.S. products and for clones that are also made by Asian companies. If you think about the chips, the processors, the boards, if you think about parallel processing, the ability to hook computers together, you can see that this is a technology that is exceptionally difficult to control. It is widely available on a wide variety of levels, and it is increasingly easy to scale up small computers by combining them together into larger computers to perform more sophisticated applications.

Now, let me also say in a comment on one of Mr. Leitner's points that the Administration is not rushing to judgment with respect to changing the export control levels on computers. This Administration is committed to reviewing that question every two years. We are doing so right now. We have a study that has been done for us that is not quite finished, and the President at the appropriate time will be given a recommendation, but it is not something that is about to occur.

Now, satellites and computers are only one part of our exports to China, all of which were valued at $12 billion last year. To give you a bit of data - Mr. Chairman, I am just about finished - Commerce received 849 export licenses for China in 1997 valued at $1 billion. Eighty percent of the licenses we received were given permission to export; export was not allowed for the remainder for a variety of reasons, including a lack of sufficient information. This 80 percent approval rate for China is lower than that for most other countries, including Russia.

Applications for China usually take 54 days to process, sometimes because we must wait for further information. The average for all licenses is 29 days. These figures show that China licenses are subject to extensive scrutiny and review to ensure that U.S. interests are well protected. Our nonproliferation policy is fundamental to protecting U.S. national security. But it is not without real cost to the United States, as I am sure this Committee recognizes.

These license statistics do not reflect the sales lost by U.S. firms in China because of export control policy or licensing delay. U.S. exporters face de facto unilateral controls on exports to China in several sectors where they have a demonstrated competitive advantage. For example, it has been reported that U.S. firms lost the contract for a $3 billion semiconductor project to a Japanese firm, largely because of Japan's apparent willingness to transfer advanced technology quickly and without extensive conditions.

Now, I know that this Committee has addressed this issue before, Mr. Chairman, and I know that the Committee understands that the integration of China into a stable world order is one of the paramount challenges for our foreign policy. It is apparent that there are divisions in our thinking on this subject, with some in the Congress, in the media, having apparently already decided that China is a committed adversary that we should treat the same way we treated the Soviet Union during the Cold War.

Others, including this Administration, believe the old Cold War controls aimed at the Soviet Union are not relevant to new and more complex situations like that of China, and that if we ignore the differences, we risk producing the very result we wish to avoid. At the same time, as we pursue a policy of engagement, we clearly do it cautiously with our national security in mind.

While the problems are not to be minimized, our relationship with China represents enormous opportunities for the United States if we can manage it well. That is precisely what we are committed to do.

Thank you.

[The prepared statement of Mr. Reinsch appears in the Submissions for the Record.]

Representative Saxton. Mr. Reinsch, thank you very much for your testimony. We would like to ask you a few questions at this point, and I would like Senator Bingaman to be the first questioner.

OPENING STATEMENT OF SENATOR JEFF BINGAMAN, RANKING MINORITY MEMBER

Senator Bingaman. Thank you very much. Let me start by asking about an issue that has been in the news recently. There has been a suggestion that technology was transferred to the Chinese inappropriately by scientists from Loral Space and Communications and Hughes Electronics. What part of this case, if any, did have you or your agency have jurisdiction over? Based on what you know about the case, was there any improper transfer of technology?

Mr. Reinsch. Yes, I would be glad to, Senator Bingaman. I can only provide a partial response, because the Commerce Department was not involved in the initial case. When the license for the satellite that has become the subject of some controversy was granted, the State Department had jurisdiction over these items. The State Department granted that license, and the State Department was in charge of the things that happened after that particular satellite blew up on launch.

The investigation, as I have read in the newspapers, surrounds failure analysis of that launch that the companies you referred to were asked to conduct, and the allegation has been, I gather, that the companies may have passed information as part of that failure analysis that went beyond what the license permitted them to pass as part of the launch interface process. I can't comment on the accuracy of the allegations.

The law in question is under the jurisdiction of the State Department, and the investigation of State Department cases like this is done by the Customs Service, and the Commerce Department had no role in that part of it. The subsequent allegation that was made was that the approval of a second satellite by one of the companies, Loral, to China earlier this year, may have had - may have had or may have an impact on that investigation.

What I can say with respect to that license, which was granted by the Commerce Department, because jurisdiction over these items was moved to us several years ago, is that approval was made. That license approval was made with the concurrence of the Departments of Defense and State, ACDA, and the National Security Agency. As part of the review process, lawyers at various agencies considered the approval and did not object.

That license does not allow for the transfer of any launch vehicle or satellite manufacturing technology. The conditions of approval require compliance with the U.S.-China technology safeguards agreement. The Department of Defense monitors will be in China for the complete launch preparation, launch, and post-launch activities to assure that the license conditions and technology safeguards are complied with. In the case of a launch failure, all technology transfers between the U.S. manufacturer and the China launch service provider will be strictly monitored by DOD officials. We think that provides adequate safeguards in this case.

Senator Bingaman. With regard to the license to launch the second of these two satellites, do you know of any basis for concern about inappropriate technology transfer having occurred?

Mr. Reinsch. No, sir, I don't know of any concern with regard to that one.

Senator Bingaman. And regarding the first one, you are not in a position to say?

Mr. Reinsch. That's correct. It was not our case.

Senator Bingaman. Are you familiar with a case involving McDonnell Douglas?

Mr. Reinsch. Oh, yes, it is one of my favorite stories.

Senator Bingaman. Would you please tell us that story?

Mr. Reinsch. Yes. I am sure you don't want all the details. This concerned equipment which had been located in a plant in Ohio that had been used for a variety of purposes in the past. Most of the equipment, not all of it, was 20 years old at the time. The Chinese bought a good part of the equipment in the plant - by no means all of it; much of it was sold to domestic users, but the Chinese bought a number of the machines. These were machine tools that were in the plant.

We determined that of the total number of machines, which I believe were 33 or something like that, there were 19 that required an export license, and the remainder were of sufficiently low technology that they did not require a license at all and were simply shipped. The others were bundled into a number of licenses and ultimately shipped.

The licenses in question included a condition that the company, the exporting company, which in this case was McDonnell Douglas as you mentioned, report to us quarterly on the disposition of the items and the location of the items and whether they were being used for their intended purpose. That condition was attached in part because we understood at the time the license was granted - which was before I arrived at Commerce, so I am giving you somewhat of a subsequent history - that the machine tools, which were to be for the manufacture of civil aircraft as part of the McDonnell Douglas joint venture with China, a joint venture which had been approved in the Reagan Administration and was gradually gearing up to expand its production, that the tools in question would be located at a facility that was to be constructed.

What ultimately transpired was that the facility was not constructed, and McDonnell Douglas reported in the first - at the first quarter that it had to submit a report under its license that, while most of the machines were in storage at their point of arrival and had not been uncrated, six of the machines had been sent to a different location that was not authorized in the license.

That then initiated a considerable level of activity on our part. When this happens, we do two things. One, we open an investigation to determine whether or not the law was violated; and, two, we attempt to take steps to make sure that our national security is protected by securing the machines and locating them in a place where we are confident that our national security is not going to be compromised.

In this case, to make a long story short, we had extensive interaction, largely through the company, with the Chinese, which resulted in all of the machines being moved from the place to which they had been sent, which was a facility that, among other things, had some military production capabilities. All six of the machines, five of which had never been uncrated, were removed and stored at the joint venture site where we are confident they are under American control. We are also confident they were not used for any purpose while they were in transit on this odyssey.

The investigation of what happened and whether the law was violated, and if so, who violated it, is an ongoing investigation that is in the hands of the Justice Department, and I can't comment on its status.

Senator Bingaman. I wish to ask you a question on one other area: supercomputers. We have had some instances where supercomputers were transferred to Russian facilities, as I understand it, without the licensing process having been followed.

Mr. Reinsch. That is correct.

Senator Bingaman. Can you please describe some of the problems that resulted in that case and whether there has been any similar instance with regard to China? Do you believe sufficient safeguards are in place to prevent such an instance in the case of China?

Mr. Reinsch. There were four cases that were publicized last year, Senator Bingaman, that you're referring to, two with respect to Russia and two with respect to China. All of these concern the export of computers between 2,000 and 7,000 MTOPS level of performance. The reason I cite that is, it is related to our policy with respect to export controls of high performance computers.

The President, in 1995, when he implemented the current policy, said that for countries that we placed in Tier III, which is a list of 50 countries that include Russia and China, and a number of others, many of whom, for example, have not signed the Nonproliferation Treaty, also include Israel, India and Pakistan, as well as Russia and China.

We would require an individual license, which means advance approval of the computer over 7,000 MTOPS if it were going to a civilian end user, and over 2,000 MTOPS if it were going to a military or a proliferation-related end user, that is, an end user engaged in military or proliferation activity.

The effect of that policy was to place on the companies the burden of making the judgment as to whether a specific customer was civilian or military. We worked with the companies beforehand to give them some red flags, if you will, or some warning signs to assist them in making those judgments. It is fair to say that in China it is harder to make that judgment than it is in Russia because of the practice of the PLA to engage in a wide variety of commercial activities that don't have any military application, but nevertheless, are PLA-owned and managed.

Despite our efforts, some companies, including the one you refer to, chose to ship items to end users which we believe would be military - would be considered to be military or proliferation end users.

The cases in question, the Russian cases in question, are also currently under investigation under the direction of the Department of Justice, and I can't comment further on their status. With respect to China, there were two cases made public and confirmed by the companies in question that are also under investigation, in one case, the computer which was listed in the data that we have compiled.

Because one of the elements of the President's policy was to require reporting of the sales of all of these computers so that we can say with some degree of certainty, barring, you know, fraud or some further illegal activity, where each of these has ended up, we have been able to determine in some cases that there were – in one particular case in China, that there was a resale to a facility that we would regard as a military or proliferation-related facility. And in that case, we had a dialogue with the Chinese Government, and there was a company-to-end-user dialogue that resulted in that computer being returned to the United States.

Notwithstanding the fact that the computer was returned to the United States, the case remains under investigation to determine whether or not our laws were violated, as we would do with any such case.

The companies report to us periodically. They had been reporting to us quarterly; now, because of the law the Congress passed last year, we changed the reporting requirements slightly. As the companies report, we look at their reports, we consult with intelligence sources and others on the nature of the end users. If we find independent users that we think are in the military or proliferation-related category that should have required a license and did not, we would take appropriate action.

We also have now, thanks to the Congress, a statutory requirement to visit every computer over 2,000 MTOPS sold in all 50 of those countries in perpetuity. This is going to be, if I can put in a plug, an extraordinary strain on our resources, given the rate of growth of sales of these computers. And keep in mind that the levels in question that we are talking about, midlevel workstations and servers like the one that operates the Committee LAN and the one in – the LAN in your personal office, I imagine, that is the kind of machine we are talking about here – we are going to have to visit every one of these. This calendar year my agents estimate that that will necessitate between 1- and 2,000 visits all over the world.

Senator Bingaman. Is this an annual requirement?

Mr. Reinsch. It is a requirement, it is in the NDAA, Senator Bingaman.

Senator Bingaman. How often do you have to visit?

Mr. Reinsch. Apparently, we only have to visit them once; it doesn't say we have to keep on visiting them. But we have to visit each one, which—

Senator Bingaman. Is this a provision you recommend we repeal?

Mr. Reinsch. Yes, we have and we would. Or at the very least the other parts of the law that Congress passed give the President flexibility to justify the control parameters as technology advances and what is now state of the art becomes old. This particular provision doesn't give us the authority to do that; it is 2,000 in perpetuity. If we can at least scale up, that would reduce our burden significantly.

Senator Bingaman. Thank you, Mr. Chairman.

Representative Saxton. Thank you, Senator Bingaman.

Mr. Reinsch, let me ask you several questions. As we observe the world change, there are many interesting and sometimes disturbing aspects of it. Oftentimes, I frame this discussion, at least for myself, by remembering an old friend of ours, Dick Cheney, who was the Secretary of Defense, who said to us in late 1990 that the Soviet Union was going to cease to exist as we knew it and that on the eve of going to war with Saddam Hussein in late 1990 and 1991, that – and I will always remember these words – he said, "the threat will change" because the Soviet Union is going to go away but, he said – let me repeat those words – "the threat will change."

And obviously he was right. The threat has changed recently. I traveled to South Korea to see evidence and to get other people's opinions about how that threat has changed vis-a-vis North Korea, vis-a-vis China, and even the South Koreans' concern about Iran, not in a direct way, but in a rather indirect way. But all of these discussions bear out that Secretary Cheney was right, that the threat has changed.

And that is really why we are here today, because there are two major sources of change. One is the dissolution of the Soviet Union and the subsequent use of former Soviet technology around the world in ways that we don't always like; and secondly, because we have developed very significant types of military and technological capabilities, which people in different parts of the world would like to have, too, and they go to great lengths apparently to get them.

It just prompts me, I guess, to ask a question - the proliferation problems are troubling to me - what steps do you believe we should take to try to check or stop proliferation that is not in the best interest of our country, or our friends or Americans traveling abroad?

Mr. Reinsch. Let me say, Mr. Chairman, I think that is the key question. And I think you have phrased the challenge correctly. I couldn't agree with former Secretary Chaney more. I have given speeches that say the same thing; the threat has changed.

And if I could add before answering your question, one reason why the threat has become more complicated or, if you will, the solution has become more complicated, is the erosion of the clear line between military technology and civilian technology.

As our military establishment is driven more in the direction of commercial off-the-shelf technology, both for cost reasons and timeliness reasons, to get the latest state-of-the-art systems into their system faster, the line between what is clearly civilian and what is clearly military, particularly in the electronics area, gets blurred. That makes it harder to make export control decisions, and it makes the consequences of the decision much more significant, because there are in fact large civilian constituencies buying products that are very similar to what our own Defense Department is now buying.

The key answer to your question, I think, always lies, as it did during the Cold War, but now lies even more, although it is more difficult to achieve, in a multilateral solution. There aren't very many products of the nature that you are talking about where the United States is the sole producer. We may be the best, we may be the biggest, but if you are a proliferator, that may not be the criterion you are looking for. You may be looking for adequacy. And we discovered, there are plenty of people in lots of parts of the world making a lot of equipment that we wish would not be sold to Iraq, Iran or other countries.

We work constantly with our allies to try to get them to pursue policies in close coordination with us. There are four multilateral arrangements - one for nuclear, one for chemical and biological, one for missile, one for dual-use technology and conventional weapons - all of which have somewhere around 30, 30-plus members, mostly the same with a few adjustments.

We work very hard to beef up those regimes, to put in appropriate lists of items that are critical - and I will get to the list in a minute - and to increase the discipline of the regimes, to put in no-undercut provisions; so that if we deny an item, we notify our allies so they will deny the same item, so we don't get people interpreting regime rules differently where our friends and allies have slightly different policies, as with Iran, which is probably the most obvious case. We work with them regularly; Under Secretary Eizenstat at the State Department is working with them ceaselessly to try to develop, you know, a closer coordination on their Iran policies.

We have some success, but this is incremental. And one of the things that I regularly say in these sessions with the Congress is, if one expects a multilateral agreement to spring full blown from a negotiation, to be perfect, one is going to be disappointed. These things always fall short of the mark.

What we do is, we get the best we can, and then over a period of time, we add to it. We add discipline to it. We add members to it. We add items to the list. We try to improve it as we go along.

As far as our own procedures are concerned, we have - we try to concentrate on what we would call choke-points; that is, rather than try to control everything with everybody and waste our enforcement resources in the process and paralyze our licensing process, we try to identify those items that are absolutely critical to the production of the missile system and nuclear weapons and chemical weapons and try to control those items rigorously.

These items would include things like advanced semiconductor lithography technology, large-scale, highly accurate machine tools, satellites designed for military remote sensing, jet propulsion technology, inertial guidance systems and things like that.

Going back to my previous comment, we would not consider a computer, for example, a choke-point technology. But we think that by identifying those technologies, clearly obtaining multilateral agreement on a control is the best way to go.

Representative Saxton. Thank you.

Senator Bingaman earlier asked about the Loral-Hughes situation; there have been news reports and other discussions relative to that issue. As a matter of fact, *The New York Times* on April 12th ran a front page article which I would just like to read a couple of paragraphs from. The headline is, "U.S. Business Role in Policy on China is Under Question; Satellite Technology Exported by Companies that Gave Money to Democrats."

I wasn't going to bring in the political aspect of this actually, but let me just read a couple of the paragraphs I think speak to the substance of the issue.

It says, in May 1997, the Administration was jolted by a classified Pentagon report concluding that scientists from Hughes and Loral & Communication - Loral Space & Communications had turned over expertise that significantly improved the reliability of China's nuclear missiles. The fact that the report's existence has been secret prompted the criminal investigation of companies which officials said was undermined this year when Mr. Clinton approved Loral's export to China of the same information about guidance systems.

And this was a front page *New York Times* story. *The New York Times* has never been accused of being part of the so-called "right-wing media." Tell us about what you think about the Loral-Hughes case, and if you think *The New York Times* article is correct or incorrect.

[*The New York Times* article, "U.S. Business Role in Policy on China Is Under Question," by Jeff Gerth, on April 12, 1998, appears in the Submissions for the Record.]

Mr. Reinsch. Well, as I said to - in response to Senator Bingaman, Mr. Chairman, I can't comment on the May 1997 report or the first part of the case. I have not seen that report. We are not - the Commerce Department is not part of the investigation, and I can't comment on the facts of what may or may not have happened with respect to that license.

I can comment on what is, in essence, the second part of the quote you read - which is whether or not the investigation into the first launch was undermined by our approval of the second. And on that issue, I would say that I believe the answer to that question is no. I believe the answer to that question is no for several reasons, the main one being the existence of the elaborate safeguards, including the presence of Department of Defense officials at the launch site and in all the discussions that the company will have with the Chinese that were attached to the license that we granted.

So I don't think that there is a reasonable possibility of the second license having the kinds of problems that are allegedly associated with the first. It would take probably a lawyer, and I am not one, to comment on why a second situation like this would undermine an investigation of the first.

The facts are the facts. The question in an investigation of this kind – and as I said, we are not doing this one, but we do them in other cases – the question is whether the law was violated, whether the terms of the license were violated. That is a fairly clear-cut question; it demands some investigation. But what we do in the second case wouldn't have any bearing on that.

As I said, we now license these only in consultation with the agencies I reference, which include State, which include Defense, in other words, which include the relevant parties that were involved in the first case. They had no objection to the second one. They had an opportunity to review it. They apparently concluded that there was no problem.

I don't think that it would be appropriate for us in the absence of any conclusion about someone's guilt, you know, to make a judgment about what we ought to do in separate unrelated cases. We have over 1,700 cases pending in our department right now that are enforcement cases in varying stages. I wouldn't think, as a matter of policy, we want to say that every company that is subject to one of our investigations ought to be denied the right to export into the future until the investigation is resolved. We take these things one at a time.

Representative Saxton. You asked us the question as to whether or not the law was violated by any of the parties referred to in this article. Do you believe the law was violated?

Mr. Reinsch. I don't know, Mr. Chairman. I don't have the facts.

Representative Saxton. Okay. Also, there is another article which is actually an opinion piece by a Gary Milhollin.

Now, apparently, Mr. Milhollin is an individual who works with the Wisconsin Project on Nuclear Arms Control. Again, I don't believe the Wisconsin Project on Nuclear Arms Control has ever been classified by anybody as other than a centrist organization or maybe an organization left of center.

And they write that since January the Clinton Administration has been quietly circumventing a new law intended to keep America's supercomputers away from Third World bomb and missile makers, et cetera, et cetera. They say most recently that the Commerce and Energy Departments are trying to drop more than 20 countries that are now covered by the law; that is, to keep us - our American companies, apparently, from exporting to them. They want to allow supercomputer exports to Algeria, a terrorist plague state that is planning to process plutonium.

The New York Times states that the Commerce Department does want to drop these countries currently denied technology upon review, but wants to include Algeria. Do you believe we should export supercomputers to Algeria?

Mr. Reinsch. I am familiar with that article, Mr. Chairman. In fact, I have it here. We are preparing a response to it, as a matter of fact, today. And I wouldn't, just in passing, characterize the Wisconsin Project as a centrist organization.

Representative Saxton. You would or would not?

Mr. Reinsch. I would not.

Representative Saxton. How would you characterize it?

Mr. Reinsch. I would think left of center would be an appropriate characterization.

Mr. Milhollin bases his conclusion on fragmentary information that was apparently leaked to him that doesn't provide him the full facts, specifically with respect to his references to some of the companies in the early part of the article.

What he is referring to with respect to the countries is that when the President makes a judgment about export controls with respect to computers, as I indicated earlier, he has based that judgment on two parameters, country categories and levels of performance. And in 1995, he created three tiers of countries - Tier I being sort of NATO allies; Tier

II, friends but not allies; Tier III, the countries I referred to earlier; and Tier IV, the embargoed countries.

As we go through the process of reconsidering the control parameters for supercomputers or high performance computers, one of the things that we will reconsider are the country lists and whether countries are appropriately placed on those lists. As I said with respect to the Tier III countries, many of those countries, Vanuatu I think would be one, are placed there entirely because they have not signed the NPT.

It seemed to us in some cases that if a country was on that list solely for that reason and if they subsequently did sign the NPT, it would be appropriate to consider moving them as we moved everybody else signing the NPT. However, I can't speak for the Energy Department in that regard.

Has the Commerce Department suggested moving some countries from one tier to another, not dropping them but moving them from one tier to another? Yes, we have. Is it 20? I don't know, because I don't have the list. This has just not gotten to my level of discussions. We have not made any decisions in this area.

I can tell you in the two years or so since this policy has been in effect, no high performance computers have been exported to any of the three countries that Mr. Milhollin mentions in his article. Whether the President will choose to move these countries from Tier III, which is I believe where they are to another tier, I couldn't tell you, no decision has been made yet.

Representative Saxton. You work with these issues on an ongoing daily basis. Is it your opinion that Algeria is the kind of country that we would want to consider exporting supercomputers to?

Mr. Reinsch. I would be surprised if the President decided to move Algeria to a different tier, Mr. Chairman.

Representative Saxton. Just for the record, supercomputers are also used in modeling for biological weapons, as well as chemical and nuclear weapons; is that your understanding?

Mr. Reinsch. Well, I think the modeling that I am familiar with, with respect to those biological and chemical weapons, are – I guess what I would call gaseous cloud dispersion. You know, I would put it in blunt terms, they drop one over the Capitol how long does it take it to get to Bethesda, and you know, what will – under different prevailing wind scenarios and temperature scenarios, what will happen to the particles that are let loose? That is the kind of analysis which you also do, for example, for an explosion, where you want to analyze the movement of a very, very large number of molecules, and you want to count literally every molecule, if you can.

This is an analysis that can be done by a computer at most levels of computer performance; it can be done with greater granularity and greater sophistication at higher levels of performance. So, yes, it is used for this purpose, but you can use lower level and higher level computers. You just get better results the higher you go.

Representative Saxton. Thank you very much. Let me ask Mr. Doolittle if he has any questions.

OPENING STATEMENT OF REPRESENTATIVE JOHN DOOLITTLE

Representative Doolittle. Just a couple, Mr. Chairman.

Mr. Reinsch, the April 24, 1998 *New York Times* article, indicates that the expertise turned over by Hughes and Loral had significantly improved the reliability of China's nuclear missiles, officials said.

Did you accept that conclusion?

Mr. Reinsch. I don't know, Mr. Doolittle, because as I said, that was not a case in which the Commerce Department participated. We didn't grant the license. We are not involved in the investigation. I don't know what was turned over in that case.

Representative Doolittle. If it were the case that the reliability of China's nuclear missiles had been significantly improved, would that be of concern to you?

Mr. Reinsch. Yes, it certainly would, and that is precisely why we have the very strict safeguards on these licenses that we maintain. And I would say if the information referred to was in fact turned over - and as I said, I don't know that, but if it were in fact, I am confident that would be a violation of the license of the State Department granted too. And they had very tough safeguards when they were licensing these things.

Representative Doolittle. Well, as I understand it, the issue is whether the State Department actually was consulted about this incident.

Mr. Reinsch. Well, it was the State Department that issued the license. In addition, most of these licenses require the Department of Defense presence during the launch and during discussions about the launch or the launch interface or, presumably, post-launch, because the Department of Defense technicians are the people that are in the best position to make a judgment as to whether the technology being transferred is appropriate and within the terms of license, or whether it goes beyond the license. You might consult with them on that question.

Representative Doolittle. Well, the problem here, as I gather from reading the article, was that after the rocket or the satellite crashed, the officials from Loral and Hughes were called in to consult with the Chinese and in the process provided information about other aspects of the rocket's guidance and control systems.

Mr. Reinsch. That is the allegation, yes.

Representative Doolittle. Yes. And doesn't that strike you as unusual that the Defense Department wouldn't have been involved at that point?

Mr. Reinsch. I would say if it were one of our licenses, the Defense Department should have been involved, and had they not been, it would have been a problem. Not having seen the State Department license, I don't know what the terms of it were, but I would imagine they were the same.

Representative Doolittle. Maybe I should address the question momentarily to the Chair and just inquire, Mr. Chairman, is this Committee going to have the opportunity to have the State Department, and the Defense Department comment at some point upon these issues?

Representative Saxton. We have no plans to do this at this particular time; however, if the membership decides that it would like to, we can certainly hold future hearings, and that may be something that we would like to do.

Representative Doolittle. Thank you.

I notice, apparently the Pentagon did conclude that the U.S. national security had been harmed. Is that your understanding?

Mr. Reinsch. Well, I gather from the article there is a report to that effect. That report has not been shared with us. We are not conducting the investigation.

Representative Doolittle. Well, I would certainly be concerned, but it seems like we don't have all the parties that could share the information necessary to perhaps form the more definite conclusion about this. But this is a very disturbing newspaper article, I think, Mr.

Chairman. I hope we will have an opportunity to pursue this a little bit further.

Thank you.

Representative Saxton. Thank you, Mr. Doolittle.

Senator Bingaman?

Senator Bingaman. Thank you very Mr. Chairman.

Last me ask you about one other issue. Dr. Leitner, in his testimony, speaks of the level of irresponsibility displayed by the Administration toward our national security needs. As one example, he says this was "demonstrated by the February 1998 U.S. proposal to the Wassenaar export control forum for the accelerated delisting of virtually all telecommunications technology and equipment. If this proposal goes through, it would result in free and open access by even the rogue states to state-of-the-art optical fibers, transmission equipment, switches, repeaters, high-speed computer network systems, advanced encryption."

My impression on the issue of telecommunications equipment is that it is a fairly competitive arena and the United States is not the only producer of telecommunications equipment. Given this, is it productive for us to try to restrict the sale by U.S. companies of telecommunications equipment in world markets?

Mr. Reinsch. Well, we have done so in the past, Senator Bingaman, on security grounds, largely at the behest of the National Security Agency for reasons that I probably shouldn't go into in open session. You are correct that it is one of the most competitive areas of high technology around. There are numerous companies, particularly in Europe that are active, credible, ferocious competitors with American companies, including Canadian companies as it happens.

There has been some evolution in thinking about telecommunications technology over the last few years, partly because of its very rapid advance. It has made a lot of things that were cutting edge in 1989 old news in 1998. I can't comment publicly on U.S. negotiating positions which are confidential, and I am surprised, frankly, Mr. Leitner has chosen to comment on a confidential American Government negotiating position in his testimony. We don't usually let those out. We don't think that helps the negotiations.

I would also say that I don't think he has the facts entirely correct, but that is a question you can take up with him. I would say that the items he referred to are not controlled by the Missile Technology Control Regime for MTCR purposes. And without going into a lot of detail, I would say the NSA no longer has the level of concern about many of these technologies that it used to, which was the primary reason that we maintained controls on them.

So I think that you will find our attitude, as well as Europe's attitude, evolving somewhat, not entirely for competitiveness reasons, but also for reappraisal of their relevance to security.

Senator Bingaman. Thank you, Mr. Chairman.

Representative Saxton. Mr. Reinsch, I have no further questions at this time. I would just like to thank you very much for taking time out of your busy schedule to be here.

If we have any further questions, we may submit them to you in writing, and if you would be kind enough to accommodate us in that regard, we would appreciate it. Thank you for being here.

Mr. Reinsch. I would be glad to. Thank you very much, Mr. Chairman.

Representative Saxton. Our second panel is made of up Mr. Harold Johnson, Associate Director of the International Relations and Trade Group. And as has been noted, Dr. Leitner, who is the author of *Decontrolling Strategic Technology*, also testified previously. If we can move the second panel into place, we would appreciate it.

Thank you for being here, gentlemen. Back in June of 1997, I contacted the GAO and asked them to investigate high-tech transfers of dual-use technologies of a military nature to China that included materials and/or high-tech information from the United States and other countries to the People's Republic of China. I am very pleased that the GAO has concluded the initial phase of that investigation.

As I noted earlier, Mr. Harold Johnson, Associate Director of the International Relations and Trade Group from GAO, is here today to give us an update. In addition, Dr. Peter Leitner, the author of *Decontrolling Strategic Technology*, also testified last year, and it was fascinating testimony. So when I heard about Dr. Leitner's article on super-computers, I asked him to come back and talk to us about it.

Welcome to both of you.

Mr. Johnson, before you begin, I would like to just say that the thoroughness, competence and professionalism of your staff are of the highest caliber, in my opinion, and you are to be commended.

And so, Mr. Johnson, if you would like to begin, we would appreciate it very much.

OPENING STATEMENT OF HAROLD JOHNSON, ASSOCIATE DIRECTOR, INTERNATIONAL RELATIONS AND TRADE, GENERAL ACCOUNTING OFFICE

Mr. Johnson. Thank you for your comments.

Representative Saxton. Let me just note we will have a green light and red light; if you could summarize at some point after the red right goes on, we would appreciate it.

Mr. Johnson. Thank you very much. We are pleased to be here today to discuss the status of our work. The initial phase of this effort and what we will be reporting on more thoroughly in a month or so has to do with the status of the arms embargo by the European Union and the United States following the Tiananmen Square incident.

So specifically what I want to talk about are the terms of the EU and U.S. embargoes, the extent to which the EU and U.S. sales of military items to China have taken place, and the potential role that such items would play in addressing China's defense needs. As you requested, we developed this information regarding the arms sales to China, but we did not assess China's military modernization efforts.

I would like to emphasize that it is within the context of modernization that all of this has to be considered. In mid-1980, China adopted a military doctrine that emphasized the use of modern naval and air power in joint operations against regional appointments, in other words, a more outward-looking doctrine. It later began buying foreign-made hardware to support this doctrine.

The Tiananmen Square incident ruptured China's growing defense relationship with the United States and Europe; and since then, China has relied heavily on other nations, such as Russia, for its military imports.

Also, before I begin, I want to reemphasize that we did look at the sales of items on the U.S. Munitions List, in other words, those that are controlled by the Department of State. We did not – I would mention that this list includes both lethal and nonlethal items that cannot be exported without a license. We did not address specifically at this time the dual-use items, because the embargoes do not bar sales of such items to China, although experts believe, and I think it is fairly clear, that dual-use imports are an important source of high technology for the Chinese military.

I would also note that the information we are presenting today comes from open sources, and therefore, the absolute completeness and accuracy may be subject to some degree of uncertainty, although we are fairly confident of the information.

Let me first focus on the European Union. In reaction to Tiananmen Square, the European Council, the EU's decision-making body, imposed several sanctions, including an embargo on trade and arms with China. However, according to experts, the council's declaration is not legally binding. It also does not specify the embargo's scope.

For example, it does not state whether the embargo covers all military items, including weapons platforms, lethal or nonlethal components. European officials told us that the EU has left it up to the individual countries to interpret and enforce the declaration, and that members have interpreted the embargo in different ways.

Officials in some countries informed us that they have embargoed the sale of virtually all military items to China. In contrast, the United Kingdom does not bar exports of nonlethal items such as avionics and radar. The U.K. embargo is limited to lethal weapons, such as bombs and torpedoes, things that go bang according to them - specifically, components of lethal weapons, ammunition, military aircraft, helicopters, war ships, et cetera.

European Union officials also told us that the EU members tried during the early 1990s to develop a Union-wide interpretation of the embargo, but could not agree on a uniform approach. As of today, the best we can determine, no EU member appears to have entered into new agreements to sell lethal weapons to China since the imposition of the embargo. However, as you will note on the first slide here, EU members have delivered or agreed to deliver military items to the China since 1989, and two countries have agreed to sell nonlethal weapons subsequent to the embargo, Italy in 1993 and the U.K. in 1996. Those dates are not indicated on that slide, but they are in the table in my prepared statement.

While there have been no new agreements, two of these deliveries were of lethal weapons, the French ship-to-air missile, and the Italian air-to-air missile. They appear to have been in connection with pre-embargo agreements. Similarly, a French-licensed Chinese projection of helicopters, which continued into 1990, began prior to 1989. Also, the U.K. honored the pre-embargo agreements to provide China with radars, displays and other avionics for the F-7M fighter aircraft.

As I mentioned, during the 1990s Italy and the U.K. agreed to sell China nonlethal military items. Italy agreed to sell fire control radars, for the F-7M and F-7MP export fighters, and the U.K. agreed to sell China the Searchwater airborne radar warning system. I think those are the indicated on the chart.

Let me turn now to the U.S. embargo. Immediately after Tiananmen Square, President Bush announced the sanctions against China to protest its actions and, in February, Congress put these sanctions into law. The law suspended export licenses for items on the U.S. Munitions List and specifically barred the export of U.S.-origin satellites for launch on Chinese launch vehicles. It exempted from this prohibition U.S. munitions list items that are designed specifically for civil purposes, such as navigational equipment for commercial airlines, unless the President was to determine that the end use was for the Chinese military. Because the munitions list includes nonlethal equipment, in addition to lethal equipment, the U.S. prohibition on armed sales to China covers a broader range of items than the European Union embargo.

Under the law, munitions list items can be exported to China if the President reports to Congress that there is a national security interest in allowing the export. Both Presidents Bush and Clinton exercise this option and issued waivers for the export of munitions and satellite equipment to China based on determinations that presented a national interest to do so.

As shown – I guess we don't have the numbers on this next slide, but as you will see in my prepared testimony, the United States has delivered or exported to China about $350 million worth of items that were on the munitions list since 1990. These exports were made in two ways, either through government-to-government agreements managed by the Defense Department under the foreign military sales program or commercial exports licensed by the State Department. The majority of these were related to launches of U.S.-origin satellites in China. All were authorized under presidential waivers or were specifically exempted from the sanctions under the law.

In December, President Bush issued a waiver allowing the export of military equipment to close out the government-to-government programs that have been suspended.

Representative Saxton. Excuse me, that was December of?

Mr. Johnson. Of '92, I am sorry. In December of '92, the waiver was issued to close out the previous programs. The waiver stated that these deliveries would not significantly contribute to China's military capability and closing those cases would improve the prospects of future cooperation with China on nonproliferation issues.

The total value of these exports was about $36 million, and those are the ones that are shown here, even though the dollar amounts are not there, and I think you have slides in your packet. The value is about $36 million. No new government-to-government agreements have been opened since 1990.

There are now no open or unfilled agreements pending between the U.S. Government and the Chinese under the foreign military sales program. The equipment ending these programs was delivered between 1993 and 1995, and they include the items that are listed on the board.

The next graphic will show the approvals that the State Department has made. These are valued at about $313 million, and about $237 million of these exports involve the launch of U.S.-origin satellites from Chinese launch vehicles. These shipments involve 11 presidential waivers that have been issued for 21 satellite programs. Waivers were also issued to permit the export of encryption equipment. Also, export licenses were approved for munitions list items designed for inclusion in civil projects. These exports do not require a presidential waiver and involve primarily navigational aid for civilian commercial aircraft.

Between 1992 and 1996, controls over exports of commercial encryption and satellites were moved from the munitions list to the Commerce Department's commodity control list. Since U.S. sanctions restrict the export of munitions list items and do not prohibit the export of dual-use items, commercial encryption equipment generally can now be exported to China without a presidential waiver.

U.S.-origin commercial satellites, however, although no longer on the munitions list are specifically covered by the law and still require a presidential waiver.

While the small amount, relatively small amount of EU and U.S. military items that have been sold to China since 1989 could help address some of China's defense needs, their importance to China's overall modernization is overshadowed by the much larger amount of military equipment provided by Russia and the Middle East, and I think that is shown on the next slide.

Moreover, according to Chinese experts, before they can fully exploit either the equipment that they purchase from the West or from Russia or the Middle East, they need to upgrade command and control, training, maintenance. They have severe problems in those areas.

With time running short, my prepared statement outlines a number of areas of examples of how both U.S. and EU equipment can be of benefit to the Chinese military. I will leave that for the time being.

I would note that the amount of equipment that has been sold to China by Russia represents about $3.5 billion. I don't have the exact number, but it is about $3.6 or $3.7 billion dollars. So that is a sizable amount. They have also sold items that are far more lethal than have been purchased from the West and these include destroyers, ship-to-air missiles, helicopters, fighter aircraft, the SU-27 fighter aircraft that are similar to the F-15s, and assault helicopters.

They have purchased four kilo class diesel electric submarines, including two of the very quietest that the Russians produce and that they have not exported before.

Also it is of note that Israel has helped China with the development of their F-10 fighter aircraft, which is similar to the U.S. F-16 fighter, using technology developed in the - for the LAVI project, and also they have sold various types of missiles.

As I mentioned, according to experts, China will have to overcome several persistent problems before it can effectively use all of this equipment to support its new military doctrine and reinvigorate its domestic defense industry. China lacks the command and control capability needed to effectively integrate its armed forces in the fast-moving joint offensive operations called for by the new doctrine.

China's air force is hampered by its inability to communicate with air defense, naval and ground units. China also lacks reliable air defense intelligence systems, and while the early airborne warning system will help – the systems that were purchased from the U.K. – will help address these problems, China still has to learn how to integrate distances into its overall defense air system. Many experts that we talked to informed us that military system integration remains a weakness for China.

In closing, I would like to comment just briefly on what the future of the embargoes may be. First, it seems fairly clear that U.S. and China relations have slowly improved since 1989. According to the press reports, the executive branch is now considering easing restrictions on commercial satellite projects in China, in part, through the use of blanket waivers. Moreover, for the first time in several years, the United States recently decided against sponsoring a United Nations resolution condemning China's human rights policy, in Geneva.

Also, we found that support in Europe for continuing the embargo seems to be weakening. According to European officials, the EU embargo could be formally ended by unanimous consent or informally ended simply by individual members resuming military trade with China, because as you recall, there is not a legal basis for the embargo on arms sales to China.

EU members whose defense firms are faced with severe economic pressure could move to modify their participation in the embargo if they believe China's human rights situation is improving. And recent EU reports note that human rights in China, while still far from the international norm, has improved. There are signs that some EU members have sought to increase military sales to China.

We found that at least two EU members are now reassessing whether the embargo should continue. In light of this apparent weakening, in support for continuing the embargo by some European governments, the question, it seems to me, that is facing the U.S. Government is how the U.S. should respond in the event that the embargo in Europe erodes significantly or ends in the near future.

Thank you very much.

[The prepared statement of Mr. Johnson appears in the Submissions for the Record.]

Representative Saxton. Thank you very much, Mr. Johnson.

Mr. Leitner? Is it Mr. or Dr.?

Mr. Leitner. Doctor. I answer to almost anything.

OPENING STATEMENT OF PETER LEITNER, AUTHOR OF *DECONTROLLING STRATEGIC TECHNOLOGY 1990-1992*

Mr. Leitner. Mr. Chairman, Members of the Committee, I really appreciate the opportunity to be here today to discuss transfer of so-called dual-use technologies to potential military adversaries in countries engaged in nuclear, chemical and biological, and missile proliferation. At the end of my presentation, I would like the opportunity to make some comments on what Mr. Reinsch said in his testimony, which I feel deserves some response.

As we meet today, the Administration appears poised to announce yet another round of supercomputer decontrols. This time, it is feared by many that the Administration excesses that occurred a couple of years ago will be further exacerbated and go well beyond the 7,000 MTOP range, maybe into the midteens or higher level of MTOPS to be decontrolled.

The underlying problem here is that providing access to even greater processing power, which is to some extent on the world market today, will impart to potential adversaries and proliferators the ability to pursue design, modeling, prototyping and development work across the entire spectrum of weapons of mass destruction. The nuclear and biological weapons design establishments of Russia and the People's Republic of China will reap the greatest benefits from such decontrol. That is not to say that Iraq, Syria and a host of other potential proliferators will not benefit from this decontrol as well.

It is an interesting quote that was given by the Russian Minister of Atomic Energy, who has recently been sacked along with most of the Russian Government. The name is Mikhaylov, and a couple of years ago he said in relation to the Comprehensive Test Ban Treaty and negotiations that were going on at the time that it was in the interest of signing the Comprehensive Test Ban Treaty in the shortest possible time that U.S. and Russian experts mutually agreed on the necessity of selling modern, high performance computers to Russia.

It was an interesting juxtaposition which has occurred over the years, where during the 1980s the Russians were the ones that were trying to push the Comprehensive Test Ban Treaty, and it was the U.S. that was reluctant to go along. But with the explosion of supercomputer technology and the great acceleration of the technological capability available to the United States and to our allies, the Russians felt that because of various embargoes that were imposed upon on them, they were falling further and further behind in the ability to engage in modeling, testing and simulation.

48-028 98 - 2

And yet those types of capabilities are essential if you are going to maintain your arsenal, develop new weapons and further proceed down the nuclear path in a realm that is dominated by a Comprehensive Test Ban Treaty. In short, the elimination of the physical testing requires, if you are a nuclear power, or an aspiring nuclear power, the ability to do that testing in some other way. And that way happens to be, because of the software and computer technology available today, in the virtual realm.

Now, while very few experts would agree that going virtual is a total substitute for physical testing in an era that is dominated by treaties which prohibit testing, it is the only avenue available. If you are a potential proliferator, lessons were really learned when the Israelis bombed the Osirak nuclear reactor outside of Baghdad several years ago during the Reagan Administration.

The only counterproliferation and nonproliferation program that has had any real effect in the today was the one exercised by the Israelis and Menachim Begin many years ago. And that was basically, seeing was a threat that was looming and taking it out in a very physical way.

The lesson learned by proliferators is, you can't have an above-ground, obvious testing program or a nuclear program that would be subject to some sort of preemptive attack to dissuade you from going any further. That is where computers come in big time. The ability to use a computer that was purchased by, let's say, for a hypothetical example, the Central Bank of Syria in Damascus, to do the modeling and simulation necessary, not to fully substitute for a program of testing and development of nuclear weapons, but to give the governments involved or the terrorists involved, a level of confidence in their design, in the functionality of the weapon and its performance sufficient to allow it to be introduced as an instrument of power.

And that is what advanced supercomputers would provide a proliferant – not a complete substitute, but to give them enough confidence where the designs would be proven well enough that they would be willing to actually use them as an instrument of policy. And that is where destabilization takes place and surprise, strategic surprises, occur.

The same computers with little differences in software, can also be used to model – not only the plume-type modeling that Under Secretary Reinsch talked about for biological and chemical weapons, but the actual development of these weapons, the ability to disperse them at high or low altitude, the development of the actual dispersal agents or the mechanics that would be used to get the proper degree of exposures. These are the types of things that can be modeled on high performance computers.

Atmospheric and meteorological software is almost identical to the type of software one would use to find how your weapons are going to actually propagate in the environment. It is absolutely critical, if you going to introduce weapons into a combat theatre, to understand what the dynamics of those weapons would be, once they are released. You don't want them to blow back on your own forces. You want to limit as much - at least most civilized countries want to limit, collateral damage as is possible. That may not apply in other parts of the world. Collateral damage might be exactly what they are after, particularly for a wholesale war scenario or a scenario of genocide, something that the Iraqis, for instance, would be very willing to wage upon the Kurds in the northern part of the country.

One of the big problems with going virtual is that the trillions, literally trillions of dollars the U.S. has invested over the years in detecting chemical, biological and nuclear weapons developments and testing will be negated or made obsolescent by the move to decontrol and promote the growing availability of computers.

If the Administration has its way and continues the decontrol process, there is going to be a very serious elimination of our national technical means of surveillance. These satellites and ground, air, and shipborn sensors will become irrelevant. Future testing will predictably not be as obvious. For instance, U.S. Vela satellites detected a unique double flash in the Indian Ocean, back in the 1970s, which indicated that somebody conducted a test near the surface of the Indian Ocean, a nuclear test, that type of intelligence and indicators will not be available any longer.

Everything will be done, every model will be done in a laboratory. It will be done in some setting in a university, which will be far away from the sniffer planes that we run, looking for chemical traces or gases, which are slowly seeping from otherwise hidden test sites.

You are not going to find these unique situations any more; you are not going to find them unless they are actually introduced into a real-life action. So what happens again is the level of strategic surprise, which the

U.S. will fall victim to, continues to grow. The probability, indeed, the likelihood, that we will be a victim of strategic and tactical surprises in the future continues to multiply because we decontrol this key technology; we are promoting obscurity and increasing opacity, not transparency, we are going the wrong way.

For instance, in the past when you had a – when you were trying to develop a cruise missile, a long-range cruise missile, you would have instrumented test ranges, replete with wind tunnels, and other large physical facilities. Most of the wind tunnel modeling can now be done on high performance computers of the type we are talking about. The modeling of the re-entry characteristics of warheads, and the effects of aerodynamic heating and ablation caused by atmospheric friction on the accuracy of the missile can be performed. Methods of compensation using different materials on the warhead can all be modeled now.

The computational fluid dynamics software which runs on high performance computers, has basically been decontrolled. Finite element analysis software, which can detect microfractures, structural discontinuities in reentry vehicles coming back into the atmosphere at 25,000 miles an hour is now being made available. The only thing left to control are the platforms capable of really running the analysis – the high speed computers. Unfortunately, those, too, are continually being decontrolled.

If one does an analysis of the percentage of high performance computers as the total percentage of the computer market that exists in the world today, it is an infinitesimal fraction of the market. In terms of economics, in terms of market share, it represents a very, very, very small part of our economy. Yet, in terms of the strategic threat, their decontrol represents probably the major threat to our long-term security in the future.

It was interesting to note on the telecommunications issue, that the U.S. took the lead in decontrolling this technology. Mr. Reinsch mentioned that it was a classified or a confidential fact. But yet it was a reporter who called me and asked me if this is – or is not true. He asked me, why did the Administration decontrolled telecommunications equipment and where did the proposals originate? I said, I have no idea. It was the first I had heard of it.

The reporter then asked, why is it that the British are interested in controlling it and why, after talking to several other delegations there was absolutely no ground swell in favor of the U.S. decontrol proposals? He asked, as there was no pressure on the part of the United States to forward such a proposal; why did it happen? I said, I have no idea. Those are the questions you should ask the Administration. They are the origin of the telecommunications decontrol package. I am still bewildered by it as to why it actually happened, particularly when there wasn't apparently a ground swell of support.

One of the problems Mr. Reinsch noted was the whole issue of trying to focus on enforcement, on trying to get more money for higher fines or more agents in the field to look for diversions of technology and more heavily penalize individuals, who are found guilty of export license violations.

I don't think that issue is really the focal point. The issue is one of leadership. Industry and exporters basically look at the atmosphere in which they are living, and they see an Administration continuing to enact a set of policies which further weakens and decontrols technology. In that type of an atmosphere, where there is no bottom line to what constitutes strategic goods, strategic technology, and what is an entity of concern, you have a continual free-fall.

In that type of free-fall, with the quality of current leadership, you have excesses that occur. But I think it is more attributable to leadership issues than it is to any greater corruption that exists today in the export control process than ever existed before. I think people are operating basically as they have in the past - only more so.

An interesting feature to note, as one tries to assess the implications of dual-use technology transfer, is the continuing weakening of Wassenaar. Wassenaar, as I have stated in my written testimony, addresses this concept. There is a series of little trapdoors throughout the Wassenaar agreement, which we are about to spring open in the next few months; and these trapdoors are basically timed events which state, for instance, that machine tools, which have been controlled to some extent in the Wassenaar regime were only agreed to be controlled for a two-year period.

Well, that two-year period expires this fall, and unless there is unanimous consent on the part of the Wassenaar members, they will simply disappear from control, which means that China and others will be free to acquire the most advanced machine tools that they can possibly get their hands on, for aerospace, submarine propulsion, and a whole variety of missile issues.

Because countries that are subscribers to Wassenaar have their domestic legislation linked to that particular agreement, like they were to COCOM before, once the technology is released in that international forum, they have no unilateral, legal basis to control the technology any more. That is the linchpin for most of their systems of control.

So we are coming up on a period of great turbulence where more and more technologies are going to drop off the list, you are going to have more and more proliferation from other countries because the Wassenaar regime is so weak and continuing to weaken.

One initial item I point to in my testimony - I am just trying to summarize, I hope not to take too much time - is the MD-17 issue, which I have been asked to talk about. The MD-17 is basically the C-17 strategic airlifter, which was developed at the cost of several billions of U.S. taxpayers' dollars. GAO has a number of studies trying to actually peg the actual number of billions that C-17 cost the U.S.

In the last few months there have been a lot of open press reporting in Janes and Aviation Week and other journals showing the arrival of a new plane called the MD-17, which is essentially the C-17 with a different paint job and a couple of minor modifications. The powers that be are attempting to classify the aircraft as a civil airliner, saying there is some substantive difference between the C-17 and the MD-17. If it is classified as a civil airliner, it will now be eligible to be taken off the State Department ITAR, the International Traffic and Arms Regulations list and moved over to the Commerce Department's, CCL, commodity control list, for dual-use goods.

There is a great deal of fallout that will occur if that does happen. One thing is that once it moves over to the Commerce list, the Tiananmen sanctions will no longer apply. The sanctions are basically creatures of the ITAR, and apply only to military goods and technology, of which the C-17 happens to be a main line item. So if they are transferred to the Commerce list, they will be freely able to be exported into China. They may or may not need an individual validated license to ship to the Chinese. But the presumption in most of these cases is one of approval, and the Commerce regulations are extraordinarily nonspecific when it comes to nonmilitary transport aircraft.

I would predict, in my opinion, that you could expect to see within a few years the PLA air force flying MD-17s in future military operations. Some of the arguments I have seen concerning the MD-17, speak of the need for commercial competition in the large, outsize, cargo-handling market and point the Russian AN-124 Condor as the main competition.

The Condor is a huge airplane. It is the largest airplane on Earth and can handle very, very large cargo, including military cargo; that is what it was developed for. It is operating in some limited commercial markets, but its performance, its reliability, its versatility or its ability to operate on short unimproved runways, is quite different than the capability of the MD-17. One study, for instance, showed that the MD-17 in South America alone will be to able operate from 601 airfields compared to only 116 for the AN-124 - major differences in technical capability. And that translates into operational and tactical advantages when you go to war as well.

There was an article discussing the British proposal for leasing some MD-17s. And they said they were too expensive to buy so they would prefer to lease them. In the article describing this, there was an interesting statement as to what will happen to those airplanes in a time of war, and they said that, "very quickly people with dark blue suits would be flying the MD-17s in support of military operations."

So with all of this is going on at the same time as the decontrols mentioned earlier, the attempt is to label the C-17 as a civil airliner should come as no surprise. As was discussed earlier, the diversion of machine tools from Columbus, Ohio at the McDonnell Douglas plant - which, by the way, was the plant that produced the main structural parts for the C-17 - those machine tools that produced those parts are now in China.

As part of the normal process of dealing with the Chinese in selling aviation products, one can readily envision a very simple scenario where they demand some sort of coproduction. This is a normal pattern of business today in trying to sell aircraft. The Chinese would be well situated for producing parts for the C-17, they only have to use the machine tools that are sequestered or stored in Shanghai right now, as part of the diversion of the machine tools from Columbus which is currently under investigation.

Representative Saxton. Dr. Leitner, if you could move to several perhaps main points that you have so that we can ask some questions.

Mr. Leitner. I would be happy to. Basically, I would just like to summarize that somewhere out there there is a critical mass, an issue of thresholding, which nobody quite understands, as to when and how this infusion of dual-use technology will translate itself into a military venture, an actual capability that the U.S. will be forced to contend with. The infusion of Western dual-use technology is today manifesting itself in Chinese military capability.

Where the "red line" exists between the PRC's strategic calculus between capabilities, confidence and mission requirements can only be inferred right now, but what is certain is that the unique Chinese world outlook, their practical nature, their military doctrine, their national requirements and geopolitical military position will result in strategic surprise for the United States, both in terms of where they will apply military force, and the unique manner in which it will be applied.

Recent head-to-head competition between Russia and China to supply Iran with a nuclear reactor complex demonstrates the increasing - or the continued willingness of China to collaborate with potential customers rather than cooperate with the West on nonproliferation issues. The current portrayal of the Chinese as being forthcoming on proliferation matters, I believe, is a political fiction. Their backing away from the earlier nuclear cooperation deal was a result of losing out to the Russians on the reactor complex deal.

Any appearance of a more judicious approach by the PRC is just that, "appearance." If the Russians fail to deliver under their new contract, then the PRC will certainly be first in line to fill the gap, even on issues of nuclear cooperation and reprocessing plants and anything else that the Iranians might have on their shopping list.

Thank you.

[The prepared statement of Mr. Leitner appears in the Submissions for the Record.]

Representative Saxton. Dr. Leitner, thank you very much.

Let me ask both of you to clarify the basic question. With regard to arms deliveries to China, we still have the chart on the easel. It shows that Russia or the old Soviet Union, apparently provides close to 72 percent of all the military transfers into China, which is very bad from our point of view.

And that the United States in providing items that might have dual-use technology or direct military use, is only about 6-1/2 percent. You could say that the Soviet Union, from our point of view, should go in one direction and that it would be a bad idea for us to go from the standpoint of our exports to China. And the other direction would be very bad, in other words, by increasing the amount of exports that we have to the Soviet Union to the Chinese, it would be obviously moving in the wrong direction.

Yet, from both of your testimonies, I think it was fairly clear that you have some fear that there may be in motion or already existing policies that would provide for an increase in the roughly 6-1/2 percent of Chinese imports relative to these issues and this material, that that may increase; is that correct?

Mr. Johnson. That would not be correct for the items on the munitions list. I don't see any particular movement in the U.S. side to increase exports of items that are currently listed.

Representative Saxton. It would be directed on dual-use?

Mr. Johnson. Probably so.

Representative Saxton. Probably so. Such as the MD-17?

Mr. Johnson. Well, I want to comment on that. It is not clear to me – and we haven't looked into that issue specifically, but it is not clear to me that that would – if it were resurrected as a commercial airlift capability, that it would even be on the Commerce list that would require an individually validated license. It may go – it may just be uncontrolled.

Representative Saxton. Thank you. I think we will get into the C-17, MD-17 a little bit later.

Dr. Leitner, is my conclusion correct that your fear is that U.S. Government policy, either through a waiver policy or through previously existing agreements, will lead to a greater export to China of dual-use or strictly military technologies?

Mr. Leitner. Yes, I share that concern. One of the problems that you have ongoing in the export control process is something that is closer, more akin to a shell game on the streets of New York City, where you have items in different categories being shuffled back and forth with sleight of hand from one list to another, dropped from a list, implied that it is going to be picked up by another list.

Right now we have a multiplicity of lists. You have a nuclear supplies list. You have a chemicals list, a bio-list, a dual-use list, and you have a munitions list. How you transfer things from one list to another determines exactly what falls out. Right now in the dual-use area, there are, a number of concerns that exist about what is going on in China. You see from public reporting, advanced materials companies moving into China to sell advanced materials for aerospace applications.

At this point we are talking about composites. We are transferring to China prepregs, resins, lay-up machines, filament winding machines, tape laying machines, and other types of commodities which basically make up what we consider our advanced composites industry. That goes directly into Chinese aerospace, and you have low observability, improved strength-to-weight ratios, more versatility, and stealthy applications for aerospace, both missiles and airplanes.

It happens very quickly. And it happens almost in an indirect way.

Take for example civil helicopter programs that are being pursued in China that make use of advanced composites - one happens to be teaching the Chinese how to make composite sections for so-called civil helicopters - whether it be a tail boom or a fuselage component it is identical to the composite technology you would use for military aviation. The helicopter knows no difference, if it is carrying a rack of TOW missiles or sidewinders or whether it is carrying, a couple of litters or stretchers as a rescue helicopter.

These types of technologies are being transferred by the Clinton Administration and they are going at a rate which is almost dizzying. And it is very, very difficult to track.

Representative Saxton. Dr. Leitner, we referred several times earlier in this hearing to the U.S. business role in policy on China being under question, this *New York Times* article.

Are you aware of any incidents similar to the Loral-Hughes case used where Federal officials used their offices to, in any way, promote or cover up alleged violations of the law or the ex post facto approval of an activity hither to not authorized?

Mr. Leitner. One that comes to mind but it is different since the company was not yet indicted for wrongdoing - and is subject to current investigation - would be the sale of the machine tools from the McDonnell Douglas plant in Columbus, Ohio, and then retransferred and diverted by the Chinese once they got them into the country.

After that occurred, there was a big attempt to try to get a new license issued or a modification of a license to gather up machine tools and move them down to Shanghai. Instead of demanding the machine tools be repatriated to the United States, strategic machines that went for an end user which didn't exist and then later were diverted to an end user that made missiles the Administration allowed the machines to stay in China, even though there was no legitimate end use for the machines in China.

I think the substance of this case is quite different from the Loral-Hughes issue. But it is an example of government attempting to legitimize an action by allowing commodities to stay in a country which had no business being in the country after the whole deal was blown up.

Representative Saxton. Dr. Leitner, both you and Mr. Johnson have made reference to the aircraft to be proposed, to be called the MD-17. And I must say that I have had some experience with this basic aircraft and was under the impression, until recently, two or three weeks ago, that the MD-17 would, in fact, be a commercial carrier that could carry so-called outsized cargo, and that its military application would be extremely limited.

Today, I am not so sure of that. In fact, I have changed my position recently relative to any consideration of selling this aircraft to the Chinese, at least until a clarification is made on what the MD-17 is going to look like.

I came here in 1984, late that year, and one of the first issues that I remember hearing about as my role on the National Security/Armed Services Committee was the development of the C-17. For a dozen years, we worked with, and sometimes against, McDonnell Douglas to develop a state-of-the-art airlifter with all kinds of modern technology, military technology, dual systems for use in places where it is difficult to fly because of military activities; all kinds of defensive systems that have been used relative to the airplane for military reasons, flare systems, chaff systems, steep angle-of-attack systems to land on short runways, et cetera, et cetera, et cetera.

And that is why I originally thought maybe the sale of a commercial MD-17 might not be a bad idea, because I had no clue that we would ever even consider selling those systems to the Chinese. No clue.

It is unbelievable to me, and yet it seems that the development of the so-called MD-17 may, in fact, include some of those systems that took us 12 years and, as you, Dr. Leitner, correctly pointed out, billions of dollars to develop for our own national security purposes.

You referred to in your testimony or in answer to a question earlier that many of these same systems would be or might be or are considered to be part of the MD-17. Can you clarify that for us?

Mr. Leitner. My knowledge about the MD-17 and my knowledge of export control regulations would be, there is no legitimate reason for the plane to be taken off the ITAR list – the ITAR does not prohibit a commercial variant from being sold to a country where you have no concern – to a NATO country, to Japan, to allies around the world, you can still sell them under the ITAR.

Now, the question is, the big value that the ITAR gives you is that it prohibits it from being sold to the Chinese, that would be the one greatest value.

If the plane is delisted from the ITAR and moves – sold as a new item with certain modifications – minimal modifications would be required. I agree with Mr. Johnson, it is questionable as to whether or not the plane would require an export license; its engines are commercial, so-called off-the-shelf engines. Most of its systems are standard aerosystems. The magic in the plane is the integration of thousands of subsystems, capabilities, advanced materials, specialized landing gear and other components, which give it this incredible character of being, arguably the best airlifter the world has ever seen. It is specially designed to capable of operating in-theatre, in an austere strategic environment, certainly not the conditions found in a commercial environment.

Using their logic you can take an M-1 tank and turn it into a hell of an off-road vehicle, and call it a commercial product. Just take the gun off of it. We will quickly face a series of problems, with that plane that if it is controlled under the CCL by being taken off the ITAR. Its control under the CCL would be highly ambiguous, and it is not clear as to how it would be caught since it would be called a civil transport. Whether there will be any will to deny it to countries like China, who sorely need the power projection capabilities which a strategic airlifter like this can provide, is strictly a political question.

Representative Saxton. Thank you very much. This is obviously an issue of great concern, frankly, personally to me, because the development of the C-17 without half a dozen of us on the House side would never have happened, because we would have cut funding for it. Just the thought of any variety of that system that would have a commercial dual-use military capability is - I don't much understand.

Senator Bingaman, do you want to ask some questions at this point?

Senator Bingaman. Thank you, Mr. Chairman. Mr. Johnson, in your statement you talk about China's very inefficient defense sector.

Mr. Johnson. Yes.

Senator Bingaman. You say that, according to experts, China will have to overcome several persistent problems before it can effectively use its imported arms to support its new military doctrine and help reinvigorate its defense industry. You go on to say that China lacks command and control capabilities, China's air force units are hampered in their ability to communicate with air defense, naval and ground units, and China lacks a reliable defense intelligence system.

Mr. Johnson. Right.

Senator Bingaman. Is it fair to say that your basic assessment of the Chinese military capability at this point is that it is not formidable as compared to many of the military capabilities in the world or in that part of the world?

Mr. Johnson. I think that is a fair judgment of the experts that we have spoken with, and we have spoken with a large number of experts on these matters, that they lack some of the capability to integrate. They lack clear doctrine on operations. They lack some of the systems necessary to carry out joint operations.

And I think one of the examples that we learned about that is indicative: they have only a few helicopters, many of the soldiers in the PLA have never exercised with helicopters, even though they may be called on to participate in operations that would require that. So there clearly are deficiencies.

That is not to say that they intend to let those rest, they want to overcome those deficiencies in the future, but at this point, the nature of the threat has to be considered with that in mind.

Senator Bingaman. So you would say that at this point singling out China as a military threat in that region or worldwide, relative to threats posed by other countries, is a little inappropriate?

Mr. Johnson. Well, I think you have to - you have to consider what other countries in the region are also doing in the way of modernization. As I mentioned, we did not do a modernization assessment, so - but I did want to put the purchase of military items in that context. I think, based on everything that we heard during this study, as well as previous studies that we have done regarding this matter, it needs to be considered within the overall context of the capabilities, that of the Indonesians, of Thailand, of other countries in the region, as well as Japan, the U.S. and other countries that border China.

Senator Bingaman. Okay. Dr. Leitner, I would like to ask you about a statement in your written statement which I referred to earlier. The statement reflects your concern about the irresponsibility displayed by the Administration in putting forward its February 1998 proposal in the Wassenaar export control forum. What role did the Defense Department have in the decision to put that proposal forward?

Mr. Leitner. It is a good question. I am not aware of what role it had. I was told by the person who called me up that many people were surprised by this proposal. I am not sure what the role of the Defense Department was, so I can't really speak to it.

Senator Bingaman. Based on your understanding of the interworkings of the various agencies, if a U.S. proposal to accelerate the delisting of virtually all telecommunications technology and equipment were put forward, what role would you expect the Defense Department to have in making such a proposal?

Mr. Leitner. Well, normally, there is an interagency debate which ensues on any set of proposals, and then there is an interagency working group, which tries to hammer out differences and come up in an effort to create a cohesive American position. In generic terms, this is true of almost any negotiation. If there are disputes which arise, they can be escalated to the NSC or some other forum, and a position will be established one way or another.

Now, I am speaking as an author and not as a representative of the government or the Defense Department, so my answers will be limited to characterizations of general process.

Senator Bingaman. But do you have any reason to believe that the normal procedure for arriving at a U.S. position was not known?

Mr. Leitner. No, I don't have any reason to believe that.

Senator Bingaman. So if the normal procedure was followed, and this is what resulted, then your concern about the disregard for our national security and the irresponsibility being displayed by the Administration would apply to the Defense Department too, would it not?

Mr. Leitner. Most definitely, the entire Administration, including Defense Department.

One of the things that is lacking in 1998 and for the past several years in the national security process is any real creative tension. If you look back at the Carter Administration, for all of its foreign policy problems, it did have two poles of thought, of reasoning, within it on foreign and national security issues. You had Cyrus Vance on one hand and Zbigniew Brzezinski on the other at State and the National Security Council. And there was a lively debate on policy issues. There was a give and take; there was a great deal of discussion which ensued.

In the current Administration, there is very little in the way of tension between the various departments of the government. It is more akin to consensus or groupthink on many of these issues, as opposed to real debate.

Senator Bingaman. Take this specific instance of whether or not to restrict the sale of telecommunications equipment. Might the nature of the decision have changed from controversy to more of a consensus as a result of the fact that the world situation had changed, and that it was now generally agreed that telecommunications equipment was being manufactured, sold and made relatively available by many countries? So the fact that people in the Defense Department might agree with the rest of the government on this decision may not have been a bad thing. Would you agree?

Mr. Leitner. That is very possible. No one is going to argue the world has not changed dramatically in the last decade. However, as Mr. Johnson pointed out in his analysis of the deficiencies which currently plague the PLA, if you look at their military deficiencies particularly C4I state-of-the-art telecommunications and computers are the types of things which they lack. These technology decontrols will dramatically enhance their ability to manage complex aircraft traffic control and battle management for instance.

These are the types of deficiencies which require high-speed computers, telecom switches, and fiber-optic links. They will enable the hand-off of information from one air traffic control center to another so you don't lose targets that you are trying to track. These telecom links will allow the integration of sophisticated radars which they are buying to track, hundreds, if not thousands, of targets independently or simultaneously.

When you put all these pieces together, they add up to a major strategic system or a military capability, of the type, as the General Accounting Office has noted, that the current Chinese force is deficient in structure. It does have an effect. It does have an impact.

Senator Bingaman. Let me first ask, Mr. Johnson, about your 17 percent for the Middle East. I assume that is Israel, isn't it?

Mr. Johnson. I believe, by and large. But there are others. We lumped countries together to create that.

Senator Bingaman. Does it concern you, Dr. Leitner, that Israel and Russia are free to, and are proceeding to sell not just telecommunications equipment, but arms of various kinds to Russia, with no limit? It seems perverse to me that we have subjected ourselves, and I guess the Europeans voluntarily have subjected themselves, to all of these restrictions on arms deliveries, while the arms deliveries continue.

According to Mr. Johnson, they are not posing a substantial military threat, but if I were manufacturing arms in this country, I would ask, why restrict just us? Why aren't the Israelis or the Russians, or some of the rest of them, subject to the restrictions?

Representative Saxton. Senator, would you just yield for a minute?

Senator Bingaman. Sure.

Representative Saxton. The 17 percent Middle East concerns me too. I would just ask either witness, I believe a substantial amount of this technology may have been the Israeli airplane known as the LAVI, which we helped them finance. Is that true? Is that what this technology transfer is, and is it the technology that we helped to develop?

Mr. Johnson. Yes, some of it is. I don't know precisely what percentage would constitute technology from LAVI, but some of it does.

There are also other items included in there. Iran apparently has provided some in-flight refueling capability that they had on hand at the time that the Shah fell. And I understand that they have also provided some fighter aircraft, Russian fighter aircraft that they captured from Iraq.

But there are other pieces of equipment that are included in that 17 percent. Clearly some of the technology that found its way through the LAVI has been used in providing assistance to China.

Senator Bingaman. Did you recall my question, Dr. Leitner?

Mr. Leitner. About the flow of technology from Russia and Israel, yes, I am profoundly concerned about the flow from those two countries. If we go back to the LAVI program for a minute, and if you speak to the engineers that participated in the development of the wings for the LAVI, the first thing you will see is their faces glow red. These Grumman employees saw American technology simply, retransferred to the Chinese for their new, heavily composite material F-10. And, so yes this is a major concern.

The flows from the Russians are a major concern as well. But we have to recognize that, as a government. It is within our prerogative to approach those countries to stop the sales. I would think the Israelis would be particularly responsive to U.S. overtures, given their dependence upon the United States for their own military well-being.

The Russians don't see any programs of penalties for their actions. They only see programs of rewards. We see all kinds of nuclear programs going on with the Russians and a variety of U.S. taxpayer financed cooperative arrangements, but there haven't been any negative actions, as far as I have read in any newspapers.

Senator Bingaman. Thank you very much, Mr. Chairman.

Representative Saxton. Senator Bingaman, thank you for being here, and I have no further questions at this time.

I would just like to thank you, Dr. Leitner, for being here. Mr. Johnson, thank you and your staff for the fine job that you have done. We will look forward to talking with you and dealing with you both as we progress down the road on these issues.

Thank you very much.

[Whereupon, at 12:10 p.m., the hearing was adjourned.]

SUBMISSIONS FOR THE RECORD

PREPARED STATEMENT OF REPRESENTATIVE JIM SAXTON, CHAIRMAN

Good morning ladies and gentlemen.

This hearing today is about the People's Republic of China's access to dual use and military technology.

This hearing will consist of two panels. The first panel will be the Administration's perspective.

To give us the Administration's position is Mr. William Reinsch--Under Secretary for Bureau of Export Administration, Department of Commerce.

Back in June of 1997, I contacted the General Accounting Office (GAO) and asked them to investigate high-tech transfers of a dual use and military nature to China. The GAO concluded its eight-month investigation into the effectiveness of Tiananmen sanctions restricting technology transfer. The Committee will hear about the Loral Space and Communications case, which is described in a Pentagon finding as increasing the accuracy and reliability of Chinese missiles because of corporate assistance from Loral and Hughes Electronics. The Committee will also hear about the McDonnell Douglas case in which sophisticated equipment was sold to China.

I am very pleased that the GAO has concluded the initial phase of that investigation, and Mr. Harold Johnson, Associate Director of the International Relations and Trade Group, is here this morning to give us an update.

Dr. Peter Leitner, the author of *Decontrolling Strategic Technology 1990-1992*, also testified before the Committee last year, and it was a fascinating testimony. Upon hearing about Dr. Leitner's article on supercomputers, I asked him to testify before the Committee again.

Mr. Johnson, I'd just like to say that the thoroughness, competence and professionalism of your staff is of the highest caliber in my opinion and you are to be commended. Welcome to you both.

Mr. Reinsch we will now hear your testimony and then ask you a few questions.

Please begin.

The New York Times April 12, 1998

U.S. BUSINESS ROLE IN POLICY ON CHINA IS UNDER QUESTION

AID TO MILITARY IS FEARED

Satellite Technology Exported by Companies That Gave Money to Democrats

By JEFF GERTH

WASHINGTON, April 12 — In the 1992 election, many of America's aerospace manufacturers backed Bill Clinton. But when President Clinton took office, he immediately disappointed some of them on a key issue, barring them from launching their most lucrative satellites on China's low-cost rockets.

The aerospace companies' counterattack was vehement — and effective. After a lobbying campaign that included appeals to the President by C. Michael Armstrong, then the chief executive of Hughes Electronics, Mr. Clinton gradually came to take the industry's side.

But there was an important caveat: The companies had to keep a tight rein on sophisticated technology sought by the Chinese military.

So in May 1997 the Administration was jolted by a classified Pentagon report concluding that scientists from Hughes and Loral Space and Communications had turned over expertise that significantly improved the reliability of China's nuclear missiles, officials said.

The report, whose existence has been secret, prompted a criminal investigation of the companies, which officials said was undermined this year when Mr. Clinton approved Loral's export to China of the same information about guidance systems. Loral's chairman was the largest personal donor to the Democratic Party last year.

An examination of the Administration's handling of the case, based on interviews with Administration officials and industry executives, illustrates the competing forces that buffet Mr. Clinton on China policy. In this instance, the President's desire to limit the spread of missile technology was balanced against the commercial interests of powerful American businesses, many of which were White House allies and substantial supporters of the Democratic Party.

"From the Chinese point of view, this was the key case study on how the Administration would operate on contentious issues," an Administra-

The New York Times April 12, 1998
Page 2 of 3

Continued From Page A1

tion expert on China said. The message, the official added, was that Administration policy on issues like the spread of weapons and human rights abuses "could be reversed by corporations."

The White House denied any political interference in the issue.

"I am certainly not aware that our policy has been influenced by domestic political considerations," said Gary Samore, the senior director for nonproliferation and export controls at the National Security Council. "From where I sit, this has been handled as a national security issue: seeking to use China's interest in civilian space cooperation as leverage to obtain nonproliferation goals."

The Administration's China policy has come under intense scrutiny in the last year. Congressional investigators have been examining whether China sought to influence policy through illegal campaign contributions to Democratic candidates in 1996. That connection, first suggested in intelligence reports and echoed by Senator Fred Thompson, the Tennessee Republican who led hearings on campaign finance, was never proved.

The handling of the satellite case raises questions about the influence of American contributors on China policy, according to officials.

2 Companies Tilt Toward Democrats

Since 1991, the aerospace industry has divided its political contributions equally between Democrats and Republicans. In the same period, however, Loral and Hughes tilted toward the Democratic Party, giving $2.5 million to Democratic candidates and causes and $1 million to the Republicans.

Administration officials say the contributions played no role in the decisions to permit China to launch American satellites.

"The Government has to balance risks: the risk in not letting American companies get their satellites launched by the Chinese, which would reduce our high-tech advantages, and the inherent risks of technology transfer," said James P. Rubin, the State Department spokesman.

"That's why we impose such strict safeguards, and we are determined to investigate and use our laws to prevent that possibility," Mr. Rubin said.

Waivers Required After Tiananmen

The criminal investigation of Hughes and Loral has its roots in 1989, when sanctions were imposed after the massacre of pro-democracy demonstrators at Tiananmen Square, requiring a Presidential waiver for satellite launchings. Eleven such waivers have been granted by President Clinton and his predecessor, George Bush.

But in late 1992, American intelligence discovered that Chinese companies had sold missile technology to Pakistan, raising tensions on the subcontinent.

In the first months of Mr. Clinton's Presidency, Democrats and Republicans in Congress pressed the Administration to take action. Mr. Clinton responded with sanctions that barred American companies from sending military goods to any of the Chinese concerns involved in the Pakistan deal.

The move had the effect of halting several pending and future American satellite deals because the Chinese rocket-launching company was one of those under sanctions.

Mr. Armstrong of Hughes, a subsidiary of the General Motors Corporation, wasted no time in getting the President's attention. He wrote two blunt letters in September and October 1993 that reminded Mr. Clinton of his support for several Presidential policy initiatives like the North American Free Trade Agreement, officials said.

He bemoaned his company's loss of business to foreign competitors and requested Mr. Clinton's personal involvement. Hughes's biggest loss, the company says, was the opportunity for a joint satellite manufacturing plant in China, which the Chinese awarded to a European competitor.

Clinton Confronts Department Tussle

A key issue was whether Hughes satellites were civilian or military, a murky question in the export control laws. If the satellites were labeled commercial, the sanctions invoked over the Pakistan deal did not apply. Mr. Armstrong told Mr. Clinton, officials said, that Hughes satellites should not be considered military because their technology did not have military applications.

Soon after the letters, Mr. Clinton assured Mr. Armstrong in an open meeting that he was trying to resolve the tussle between the State Department, which licensed military exports and wanted to keep authority over satellites, and the Commerce Department, which licensed all other exports and was on the side of the satellite industry.

"I'm trying to get on top of this to decide what to do," Mr. Clinton told Mr. Armstrong.

At about the same time, the Administration gave signals that it was moving toward the industry's position. After one signal, Mr. Armstrong sent a letter to a senior White House official relaying a positive reaction from Chinese officials, White House officials said.

In early January 1994, the President sent another positive signal — what Hughes officials then called a "a good first step." Three satellites were labeled as civilian, including one slightly modified Hughes satellite, which allowed their launchings to proceed.

Mr. Clinton's decision helped the industry. But the satellite makers wanted a broader decision that made the Commerce Department the primary licensing authority for virtually all satellites. The Commerce Department weighs the economic consequences when it considers an export license. The State Department looks at security concerns.

In 1994, Loral's chairman and chief executive, Bernard L. Schwartz, went to China with Commerce Secretary Ron Brown. Mr. Brown helped Loral close a mobile telephone satellite network deal in Beijing.

A few weeks later, the President's

top political aide, Harold Ickes, wrote a memo to Mr. Clinton in which he said Mr. Schwartz "is prepared to do anything he can for the Administration."

In December 1994, the President selected Mr. Armstrong to head his Export Council.

And the sanctions stemming from the Pakistan sale were lifted in late 1994 as China promised to curb missile sales to other countries.

Still, the satellite industry had not achieved a major objective. So in 1995, Mr. Armstrong sent another letter to Mr. Clinton, signed by Mr. Schwartz, arguing that the Commerce Department should become the primary licensing authority for satellite exports, an industry executive said. (Mr. Armstrong, who recently became the chief executive of AT&T, declined through a spokeswoman to comment.)

The debate not only affected national security but also had enormous commercial implications. The businesses that rely on satellites are highly competitive, and European companies were more than willing to take advantage of China's low-cost services. Without the Chinese, American companies faced long waits to get their satellites sent into orbit because of a shortage of rockets. Satellite technology is crucial to an increasing number of businesses, from cellular telephone networks to global broadcast conglomerates.

Chinese Rocket For Loral Crashes

Finally in March 1996, Mr. Clinton shifted major licensing responsibilities for almost all satellites to the Commerce Department. The State Department retained control over a few highly sophisticated satellites as well as any sensitive support activities, or technical assistance, in connection with civilian satellites.

The industry and the Chinese applauded the action. But the events that followed a failed launching in China immediately raised questions about whether the new policy sent a wrong signal.

On Feb. 15, 1996, a Chinese rocket carrying a $200 million Loral satellite crashed 22 seconds after liftoff at the Xichang Satellite Launching Center in in southern China.

Chinese officials needed to figure out what went wrong. By April an outside review commission, headed by Loral, was assembled to help the Chinese study the accident. It included two scientists from Hughes.

On May 10, the commission completed a preliminary report, based on over "200 pages of data, analysis evaluation and reports," documents show. It found that the cause of the accident was an electrical flaw in the electronic flight control system.

But the report, which was promptly shared with the Chinese, discussed other sensitive aspects of the rocket's guidance and control systems, which is an area of weakness in China's missile programs, according to Government and industry officials.

The State Department learned about the report and made contact with Loral.

Loral, in what officials said was a cooperative effort, provided the review commission's report and a long letter explaining what happened. Loral told other commission members, including the two Hughes scientists, to retrieve all copies of the report because of the serious security concerns of the Government, officials said.

But the two Hughes employees believed that there was no legal obligation to comply with the request, officials also said. In late May, Hughes received a letter from the State Department charging that the transfer of information was a violation of the arms export control laws, according to officials. Loral received no such letter.

One year later, the Pentagon completed its damage assessment of the incident. It concluded, officials said, that "United States national security has been harmed."

The Pentagon report prompted a criminal investigation into Loral and Hughes by the Justice Department and the Customs Service. The companies say their employees have acted properly, but they decline to discuss the matter.

One key issue is whether the data turned over to the Chinese required a State Department license and, if so, whether company officials were aware of that fact. The criminal inquiry has found evidence that several days before the review committee had its first meeting with Chinese officials, Loral executives were told by their security advisers that any sharing of information required a State Department license, according to Administration officials. Loral never sought a license, but it may have sounded out the State Department.

An industry official said Loral had immediately told the State Department about the review commission meeting with the Chinese but had received no reply.

More High-Tech Data Exported Recently

Whatever the evidence, criminal charges may never be brought because Mr. Clinton approved the export to China by Loral of similar satellite guidance information two months ago. He acted despite the strong opposition of the Justice Department, whose officials argued that the approval would seriously undercut any criminal case.

The required notice to Congress by the President of his action was sent during a recess.

Administration officials say the decision was politically sensitive but correct because no wrongdoing had been proven and Loral had subsequently acted responsibly.

Since the inquiry began, Beijing and Washington have been exploring even more space cooperation.

Last fall President Jiang Zemin visited the United States and stopped at a Hughes site to talk about satellites. In advance of Mr. Clinton's trip to China in June, the Administration is seeking a broader agreement with Beijing on space cooperation.

But the chairman of the House International Relations Committee, Benjamin A. Gilman, Republican of New York, says the Administration should provide a "thorough review" of the Hughes-Loral case to Congress before it goes ahead with a plan to expedite approvals for American satellite launchings by China.

U.S. Department of Energy

THE NEED FOR SUPERCOMPUTERS IN NUCLEAR WEAPONS DESIGN

JANUARY 1986

Los Alamos National Laboratory

Lawrence Livermore National Laboratory

Sandia National Laboratories

UNITED STATES DEPARTMENT OF ENERGY

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PREFACE

This document has been prepared to supplement a viewgraph presentation on the need for supercomputers in nuclear weapons design. The viewgraphs actually used (upper right-hand corners of the pages) are indicated in the text by a number within a circle.

Additional supporting material, identified by a blue background and set off from the main text, is also found in the document.

For the reader interested in a concise summary of the main message, the numbered viewgraphs by themselves should be sufficient. The table to the right will facilitate location of important highlights from the presentation.

HIGHLIGHTS

THE USE OF HIGH-SPEED COMPUTERS
AND MATHEMATICAL MODELS TO SIMULATE
COMPLEX PHYSICAL PROCESSES HAS BEEN
AND CONTINUES TO BE THE CORNERSTONE
OF THE NUCLEAR WEAPONS DESIGN PROGRAM.

(1)

INTRODUCTION

The U.S. Department of Energy weapons design laboratories—Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratories (SNL)—have assembled the world's largest concentration of computer power necessary for the design of nuclear weapons. It is the purpose of this document to explain the essential nature of large-scale computers in carrying out the weapons design mission of the laboratories.

Many of the same arguments and conclusions presented in this report are contained in an earlier (1978) report by Gold and Mattern. We urge the reader to obtain a copy of that excellent summary. Since that 1978 report, computer technology has undergone a revolution: computer capability at the design laboratories has increased more than twenty-fold at only a moderate increase in cost. This capability has made possible the development of several new nuclear weapons concepts. Also, design requirements have become more complex. We shall illustrate some of these complexities in what follows.

We have organized this document to enable it to double as a briefing aid when used along with a set of viewgraphs (overheads). The essential viewgraphs (or, in this document, figures) are numbered consecutively, beginning with the figure on the preceding page.

ГHE MISSION OF THE DOE WEAPONS DESIGN LABORATORIES IS FAR-REACHING

The mission of the DOE weapons design laboratories is to maintain technology necessary to support nuclear weapons as an element of U.S. national defense policy. This requires . . .

- MAINTAINING THE STOCKPILE
- ADAPTING THE STOCKPILE TO CHANGING REQUIREMENTS
- UNDERSTANDING THE SCIENCE AND ENGINEERING SUPPORTING U.S. WEAPONS CAPABILITY
- EXPLORING THE LIMITS OF TECHNOLOGY
- SUSTAINING A WEAPONS EXPERTISE THAT IS "SECOND TO NONE"

2

The Department of Energy weapons design laboratories have a far-reaching mission in support of U.S. national defense policy. To accomplish this mission, the laboratories must, first of all, maintain the current U.S. nuclear stockpile, i.e., maintain nuclear readiness. Then, the laboratories must support the evolution of U.S. nuclear weapon systems to meet changing requirements, such as new Soviet deployments of intercontinental missile systems, submarines, or super-hard silos. Our stockpile must be adapted to meet whatever new delivery system requirements may be placed upon it. Additionally, the design laboratories are required to maintain the scientific and engineering expertise and technology necessary to support the U.S. nuclear weapons capability.

Perhaps the most challenging part of the DOE design laboratories' responsibilities is to explore the limits of technology, to be aware of new technological possibilities in the area of nuclear weapons (an example of which is the nuclear-driven x-ray laser), and to avoid technological surprises. We must sustain a weapons expertise that is second to none.

LARGE-SCALE COMPUTERS ARE ESSENTIAL TO OUR MISSION

Large-scale computers are essential to carrying out the weapons design mission. Computers enable us to . . .

- UNDERSTAND AND SIMULATE COMPLICATED PHYSICAL PROCESSES WHICH OCCUR IN A NUCLEAR WEAPON
- EVALUATE THE EFFECTS OF THE STOCKPILE ENVIRONMENT ON NUCLEAR WEAPONS PERFORMANCE AND SAFETY
- VERIFY DESIGNS WITHIN TESTING LIMITS
- REDUCE THE NUMBER OF EXPERIMENTS IN THE DESIGN PROCESS
- EXTRAPOLATE TO NEW CAPABILITIES

3

Large-scale computers are essential to carrying out the weapons program mission. Computers provide essential understanding and enable us to simulate extremely complicated physical processes (see Figure 5, page 13). Nuclear weapons are designed to perform in circumstances and surroundings differing markedly from their stockpile environment. Computers enable us to evaluate performance and safety over the decades of a weapon system's lifetime. If an anomaly is found by a surveillance test, extensive computer analyses are performed to understand the possible effect of the finding on the stockpile readiness or safety. We cannot perform enough testing of the nuclear portion of a weapon to get statistics as one can with light bulbs or even high-explosive detonators.

As we will discuss in greater detail later, computers enable us to verify weapon designs within testing limits. These limits are technical because of the unequaled scientific and engineering complexity of nuclear weapons (these are the most complex problems for which we at least understand the governing equations), economic because of the enormous cost of nuclear testing, and, of course, political in nature.

With large-scale computers, we have been able to improve our designs by optimizing design parameters, while reducing the number of costly experiments in the design process. (Tests involving high explosives have been reduced from 180 tests for a 1955-vintage weapon to fewer than 5 for today's weapons because of computation.) Furthermore, computation enables us to optimize what we learn from each experiment. We will return to these points often throughout this report.

The final point to be made from Figure 3 is that, by providing us with a tool to simulate complex processes and improve our understanding, computers enable us to extrapolate to new capabilities. As we shall see, it is this computational capability, driven by the needs of the weapons design, that has made possible new concepts and enhanced safety in weapons.

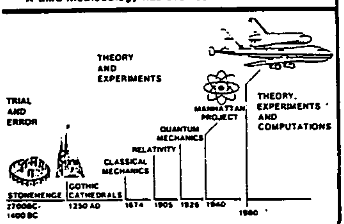
TODAY'S COMPUTERS PROVIDE INCREASED CAPABILITY

The concepts of "capacity" and "capability" are important to our discussion of supercomputers. We will attempt to illustrate these concepts by way of historical analogy. We will also discuss the emergence of computation as a scientific methodology and its impact on the scientific method.

A Historical Perspective

As shown in the figure, we represent Stonehenge as one of :he earliest, and the U.S. space program as one of the most recent, of mankind's great engineering achievements. It is ·nteresting that several economic historians have compared :hese two efforts from the points of view of manpower ·equirements and fraction of national resources consumed. 3oth projects employed several thousand people full-time and ·equired approximately one percent of the gross national in- :ome of the society at large. The British Broadcasting Corpora- ion concluded by direct experimentation that 800 man-years were required to complete the earliest version of Stonehenge known as Stonehenge I, ca. 2750 B.C.), while 5000 man-years were devoted to the final project (Stonehenge III, ca. 1400 B.C.). 'he largest fraction of the effort was dedicated to the transport of the enormous Sarsens and Bluestone rocks from distant ocations.

A third methodology has evolved



is surprising, however, that despite the enormous increase in e level of effort between Stonehenge I and Stonehenge III (a :tor of 6), and despite the 1100 years that separated the ojects, the final products, to the best of our knowledge, func- ined in approximately the same way. Both were capable of edicting certain motions of the sun and moon for agricultural anning, and both might have served religious purposes. But ere seems to have been no significant functional advance hieved in Stonehenge III. Apparently, the early Britons had t been able to improve their *capability* to develop something w but had only increased their *capacity* to carry more stones employing more people.

the late Middle Ages, Gothic cathedrals were being built in es throughout Europe. Citizens dedicated their entire lives to construction of a single cathedral, often in competition with ter city-states for the highest or widest building. Each new ign attempt (at a new height or expanded interior width) took a generation, say 40 years, to test out. Buildings frequently fell during or after construction because the early designers had no theory to design with and no capability to take such factors as wind loads into account. By trial and error, they refined their craft in 40-year-long experiments, with the result that they could increase their *capability* to design very slightly. However, they could easily increase their *capacity* to build by adding resources. The medieval cathedrals were built in the absence of a predic- tive theory. Their designers understood geometry and aesthetics but had insufficient understanding of structural forces.

The evolution from simple trial and error to a more scientific approach was a gradual one. Francis Bacon gave us the "scientific method," an iterative technique of making a hypothesis (theory) and then testing and correcting that hypothesis with experimental results. Newton introduced a unifying theory of gravitation in 1674 and also taught us about the forces and accelerations that are the essence of classical mechanics. This classical era was brought to a close with Einstein's special theory of relativity, which established the famous relationship between mass and energy, $E = mc^2$, and provided the philosophical impetus to the development of the atomic bomb.

Finally, the early twentieth century brought with it a new philosophical idea: quantum mechanics. This dramatically different approach to the understanding of atomic behavior furnished the key to overcoming the classical constraints that had confused generations of physicists. The confusion was caused by attempts to understand things on an atomic or elec- tronic scale, with which humans have no direct experience. The new philosophical idea forced scientists to give up predicting exactly what would happen in a given circumstance and be satisfied with predicting the probability of different events. Although the path to understanding was illuminated by the quantum theory (that is, the equations were written down), meaningful applications to nuclear problems such as those found in weapons design became possible only with the introduction of modern computers (that is, when the equations could be solved).

The Manhattan Engineering District cost over $2,200,000,000 and the efforts of over 200,000 people to develop the first atomic bomb. The Manhattan Project was undertaken at a time when Western scientific thought had long been at the "theory and experiment" stage. Nevertheless, the inability to calculate solutions to complex problems hampered development and forced weapons designers to build in large margins against error (e.g., large amounts of high explosive, which increased weight to such an extent that some designers were uncertain the devices could actually be carried by existing aircraft). At the same time, physicists had no way of predicting the output of the implosion device; they had only marginal ability to predict it would explode.

Driven by complex weapons problems stemming from the Manhattan Project, John von Neumann in 1945 invented the first modern computer. Two years later the transistor was developed at Bell Laboratories by Bardeen, Brattain and Shockley. The integration of thousands of such transistors on a single tiny chip of silicon soon followed. The Atomic Energy Commission design laboratories were quick to understand the extreme importance of computers to their mission. Working closely with scientists in companies at the forefront of computing technology, they developed the world's largest computational facilities for science and engineering, driving computer technology itself in so doing.

To illustrate the capability and capacity of modern supercomputers, we turned to the supercomputers themselves. We asked a stress analyst to calculate the forces at all points in the structure of a medieval cathedral and hence to determine its maximum allowable height given a certain spacing of flying buttresses. The figure shows the stress distributions on the cross-sections of cathedrals 104 feet and 134 feet high, respectively.

Analysis of the height limitations of a cathedral can be accomplished in minutes on today's computers

This information is used to find the location and extent of the regions where failure is most likely to occur. Examination of the 104-foot-high cathedral reveals no failure. However, when the building is increased to 134 feet without any increase in wall strength, the roof of the highest vault collapses (see arrows). Examination of the full-color stress distribution, as seen on a computer terminal screen, clearly reveals the failure point.

The figure also provides, in the right frame, a representation of the displacements which the collection of cells comprising the cathedral walls experience under the added load. The displacements have been magnified for illustrative purposes. In actual fact, the walls would have come tumbling down long before the cathedral cross-section distorted this much. The tensile strength (the ability to resist being pulled apart) used in the calculation was chosen to represent medieval mortar, and the compressive strength (ability to resist being crushed) was that of granite. Our stress analyst was able to improve the calculation by including the effects of a 90 mile-per-hour wind on the cathedral. Such a load would destroy the cathedral even at 104 feet; hence, a closer spacing of flying buttresses would be necessary.

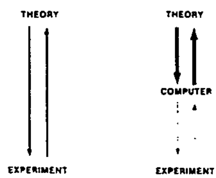
What could have been done in minutes on a supercomputer is to define the height limitations of a Gothic cathedral. This is an example of the *capability* of a modern supercomputer. The fact that a person could design another such cathedral the very next day illustrates the *capacity* of a supercomputer. Imagine the increase in productivity of the freemasons if they could have obtained such answers in minutes rather than by the trial-and-error process which took so many years!

A more relevant illustration of computational leverage is provided by replicating the Manhattan Project design. Again, the Cray supercomputer was employed. The device yield, which in 1945 could only be determined experimentally, was calculated in approximately 20 minutes on the Cray. It has been estimated that a team of scientists using the calculators of the 1940s would take five years to solve what it takes a Cray computer one second to perform. Adding more teams of scientists to the problem in 1940 would have increased the *capacity* of the project; what was so clearly needed was a dramatic increase in *capability*. It would be a great deal more complicated for the supercomputer to calculate the details of the output of the device: 60 hours on the Cray would be required, not only to duplicate Manhattan Project results, but to produce a level of understanding far beyond.

Computation—The Third Methodology

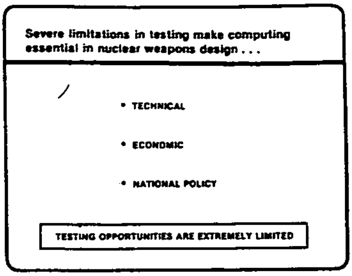
Returning to our historical illustration, we are now in a position to state the central point: A third methodology has emerged since about 1950 which has changed the way in which science is done today. Armed with the proper equations (theory), we can now design by solving these equations on large-scale supercomputers. Only when the design parameters have been optimized do we perform an experiment (test) to verify the product. The figure illustrates this process. The width of the connecting lines is meant to illustrate that we now perform a great many computer calculations before arriving at a design worthy of test. It is to be emphasized, however, that testing cannot be eliminated altogether; it can only be reduced and at the same time made more productive by computation.

Computation has been introduced in the pre-experimental phase . . .



The third methodology has increased both the capacity and capability of the nuclear weapons designer. Computation provides the weapons analyst with the ability to quickly evaluate new technologies and designs. Although testing is required, it cannot be thought of as an alternative. As the main body of this document attests to, without supercomputers, the nation's nuclear weapons program would be deprived of much of its vitality.

EVERE LIMITATIONS IN TESTING MAKE ·:OMPUTING ESSENTIAL



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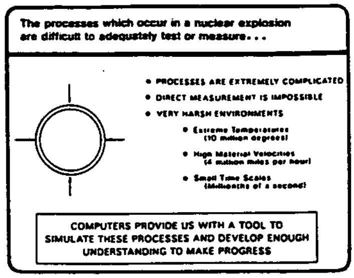
.Supercomputing has been driven ·lentlessly by the weapons program ecause of the unique severity of the mits of testing (Figures 4 and 5). The :chnical limitations are enormous: xtreme temperatures and material elocities, short time scales, and omplicated physical processes make irect measurement impossible. .dditionally, tests are performed deep nderground using data-collection istruments that must be protected om blast and radiation. This is one of ie most difficult instrumentation tasks ver performed and is severely limited ı the information it provides.

:onomic limitations are also severe. 'nderground nuclear tests are very ‹pensive in both the dollar cost to ıe program and in the scientific man- ɔwer that must be devoted to the 'eparation and execution of each st. Other testing, such as that on high explosives, hydrodynamics, and structures, is also expensive and difficult. Computation continues to be increasingly important as a tool to insure that we are devoting our resources to the most useful and cost-effective testing programs.

Of course, there are national policy limitations on testing as well. Consistent with that policy, it is our intent to meet the objectives of our mission (Figure 2) *with the minimum number of nuclear tests*. Supercomputing is essential to that goal in providing us with a tool to simulate the complex processes going on during a nuclear explosion.

It is possible that we may be faced with further reductions in nuclear testing activities. This will place still greater pressure on our computational capabilities.

WEAPON DESIGN IS A MOST COMPLICATED PROCESS



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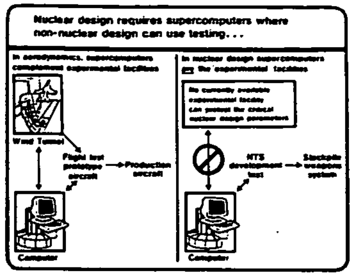
The design of a nuclear device is made most complicated by the difficulties involved in testing. Extreme temperatures, high velocities, and the short time scales on which the explosion proceeds make direct measurement of critical features impossible. Computers provide the necessary tool to simulate these processes.

COMPUTERS PROVIDE US WITH A TOOL TO SIMULATE THESE PROCESSES AND DEVELOP ENOUGH UNDERSTANDING TO MAKE PROGRESS

NUCLEAR DESIGN REQUIRES SUPERCOMPUTERS WHERE NON-NUCLEAR DESIGN CAN USE TESTING



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Our dependence upon supercom-
puting is illustrated graphically in igure 6. In the design of any other omplex device or machine (and for ertain limited parts of a nuclear veapon), experimental facilities can be et up to obtain data on the device efore actually producing a prototype. he aircraft industry, which is begin-ing to make heavy use of supercom-uters, is a case in point. There, wind unnel experiments can be performed n the computed design before the irplane is flight-tested.

However, there is no parallel to the wind tunnel in nuclear weapons design. No experimental facility exists which can pretest critical nuclear design parameters. Facilities exist for initial testing with high explosives, for testing certain structural engineering features, and for testing non-nuclear components. These tests which are of enormous value to the design still do not enable us to evaluate processes which only occur during the nuclear explosion itself (see Figure 5).

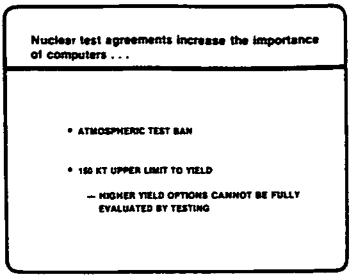
ODAY'S SUPERCOMPUTERS COST, IN CONSTANT DOLLARS, ABOUT THE SAME AS ESTERDAY'S, BUT ARE MUCH MORE CAPABLE

The term "supercomputer" has come to mean the most werful machine available for performing arithmetic operations a given point in time. While the cost of a supercomputer (in nstant 1985 dollars) has remained relatively stable, the pability of each new generation of machines has increased matically. In the accompanying figure, we see that, when ited in terms of Cray-1 equivalents, the cost of computer pability decreased by a factor of roughly 1000 from 1960 to 35 while, at the same time, an increase in capability per com-ter of greater than two orders of magnitude was occurring. e product of these two factors has resulted in relatively stable ercomputer costs. In contrast, the cost of consumer goods h as automobiles has gone up dramatically with only derate increase in capability (cars still move at about the ne speed, require the same fuel, etc.).

mputers are highly "leveraged"; they provide enormous reases in capability at relatively constant cost. There is a sound reason for this. Like all modern electronics, computer technology is based upon the large-scale integration of elec-tronic components on small chips of silicon (or, in the future, other materials such as gallium arsenide). Improvements in the speed and capability of electronic devices occur because manufacturers keep finding innovative ways to put more components on these little chips.

In the late 1970s a fundamental change in computer design known as vector processing was introduced. A vector machine is designed to operate efficiently on long lists of numbers such as those commonly found in scientific computations. The Cray-1 was the first commercially successful supercomputer to employ this technology. A similar approach has subsequently been used in the CDC Cyber 203, 205 series, and the Cray X-MP. Vector processing has made possible the continued growth of com-puting power at constant cost into the 1980s.

NUCLEAR TEST AGREEMENTS INCREASE THE IMPORTANCE OF COMPUTERS



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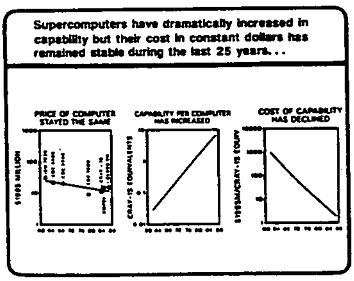
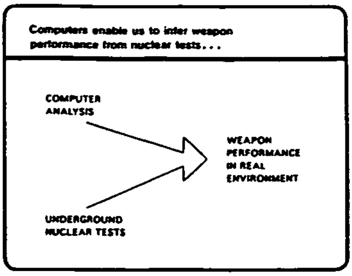
Computers are more important to nuclear weapons design when agreements limit testing. In support of the atmospheric test-ban treaty, we perform our nuclear tests underground. A weapon's performance in the mode for which it was designed, perhaps an above-ground burst, must be inferred from test data by extensive computer calculations. Such calculations take account of the "down-hole" environment, such as reflection from test-cavity walls which do not exist in the atmosphere. A second agreement, the threshold test ban, limits testing to weapons with yields of 150 kilotons or less. To design beyond this limit, computer extrapolations would be relied upon to verify the performance of the weapon.

Most people believe that computer technology has reached the point where serial processing is within a factor of 10 of the best it can do. This is chiefly due to the fundamental limitation of the speed of an electrical signal, i.e., the speed of light.

However, still another technology, parallel processing, is on the horizon which should enable the continuation of enormous growth in computer capability into the 1990s. A parallel machine is fundamentally different from a serial or von Neumann machine. Instead of processing information through one central unit, a number of processors are arranged to operate in parallel on different parts of the problem. Thus, for example, the stresses on the walls of our Gothic cathedral (see pages 10 and 11) would be obtained simultaneously with those on the roof.



COMPUTERS ENABLE US TO INFER WEAPON PERFORMANCE FROM NUCLEAR TESTS



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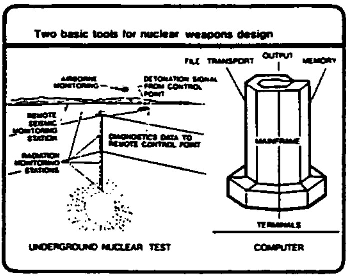
Computer analysis is our link between the underground test and the wartime situation. A vehicle containing a nuclear warhead might be expected to withstand very high accelerating forces and warhead surface temperatures, which are changing rapidly as the warhead reenters the atmosphere. In addition, upon detonation, warhead output will be affected by background environment which is radically different underground (e.g., neutron reflection). These conditions obviously do not exist, and cannot be easily created, underground. They must, therefore, be simulated by computer. Computers enable us to infer real-environment weapon performance from underground nuclear tests.

The battle environment itself can also have an important influence on the performance of this warhead. In a multiple-warhead attack, each reentry vehicle is to some extent exposed to the blast and the radiation effects of many of the other warheads in the salvo. To protect against this "fratricide," the designer must understand its effect on system performance. Since the true environment can only be produced in an actual attack, and practical constraints limit the extent to which the appropriate conditions can be produced underground or in above-ground experimental simulation facilities, the computer becomes absolutely essential in the evolution of a design that will survive the "fratricide" threat. A similar situation exists in the case of an attack on a reentering warhead by a hostile anti-ballistic missile (ABM) system. Here again, the computer is essential in designing a system whose vulnerability to an ABM attack is reduced to an acceptable level.

TWO BASIC TOOLS FOR NUCLEAR WEAPONS DESIGN



We use two basic tools for nuclear weapons design: underground nuclear tests and computers. Underground tests cannot be eliminated—they are still the "bottom line." We should be ever mindful of the enormous complexity of nuclear detonation processes and that we are not in a position to model many of the essential features: Ultimately, we must test our designs.

The computer is an essential tool in the evolution of a nuclear design concept. It enables the designer to "test" ideas before actually committing to hardware fabrication. In fact, it is not at all uncommon for the designer to complete several hundred design iterations on the computer before the concept can be considered for underground testing. Because of the large number of computer simulations involved in a successful design, if more than a day or two elapses before the computer can process a given design change, the designer will not make meaningful progress. It is well established at the design laboratories that, although occasional 100-hour runs are made on a one-time basis, it is impossible to design under such conditions.

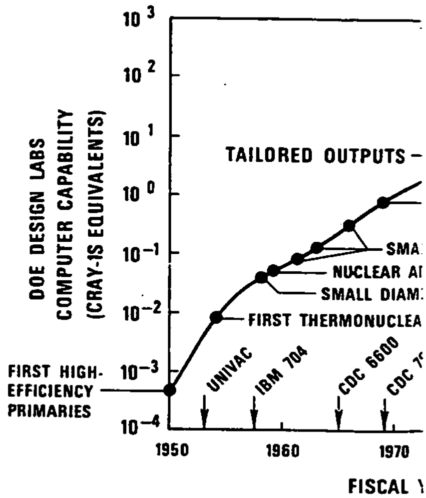
A designer needs to have the results of a parameter variation in at most an overnight timeframe, i.e., about a ten-hour run. A reasonable estimate of total computer time for a design is 8000 hours, which means there are 800 to 1000 runs for the designer to keep track of in order to optimize the design.

In Figure 9, we have plotted the computer power, in Cray-1 equivalents, of the entire design laboratory complex as a function of fiscal year. State-of-the-art mainframe computer acquisitions are called out. The design complex has increased its computer capabilities on this scale by a factor of nearly 100,000 since 1950. The increase actually represents developments in computer tech-nology. Indeed, the needs of weapons :echnology have actually driven the development of supercomputers.

The data points on the curve in Figure) are specific examples of major advances in nuclear weapons echnology, those advances which ave made a significant impact on our uclear deterrent (not just refinements f older designs). These major dvances could not have been chieved without the enormous omputer resources brought to bear n them. *COMPUTING CAPABILITIES RE ABSOLUTELY CRITICAL TO ROGRESS IN NEW DESIGNS.*

he proof-of-principle of the first iermonuclear device (named MIKE") in 1952 was the result of ex-nsive calculations on the largest omputer of that day. Calculations for e first weaponized thermonuclear omb were done in the early 1950s on UNIVAC-1 at the factory in iiladelphia. When the Soviets troduced the first intercontinental illistic missile following their iormous success with Sputnik and eir long-term (since 1936) research rocket propulsion systems, our sponse was a small strategic irhead which could be launched by smaller rockets in the U.S. arsenal. is was no small achievement; it presented a new dimension in clear technology that could not ve been understood without the ensive computer resources of the)E. (As a matter of fact, it would e a rocket with a thrust of several . missiles to launch a warhead ghing as much as one MIKE ice.) In this way, the mission of DOE to adapt the stockpile to nging weapons systems uirements was achieved.

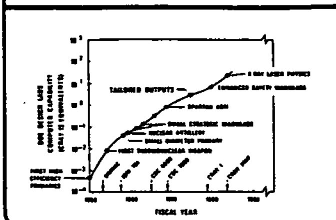
WEAPON DESIGN HAS REQU
COMPUTER C/

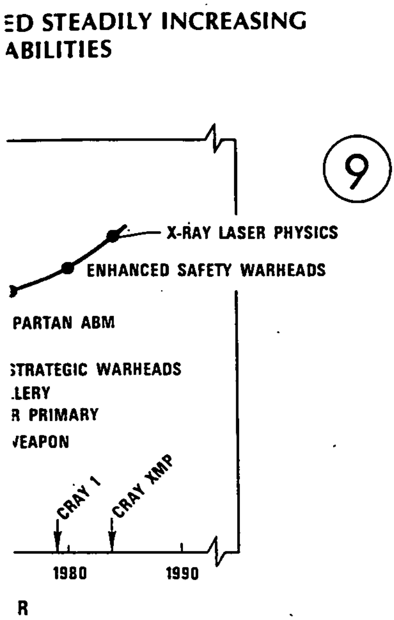


In the late 1960s, antiballistic missile systems (ABMs) were being developed before arms agreements were signed limiting the deployment of such systems. The Spartan ABM design represents another example of a technology that would have been unachievable without the DOE super-computing facilities. The details of this design, which derives its effectiveness from its large x-ray output, are exceedingly critical to its ultimate operation and required the most sophisticated physics calculations possible. This is because of the specialized x-ray output required of an antiballistic warhead to kill incoming warheads. It is estimated that the computational power of a CDC 7600 (the supercomputer of that day) running full-time for an entire year was required to design that system.

The early 1970s initiated the concept of tailored-output weapons. This concept made possible a credible

Weapon design has required steadily increasing computer capabilities





nuclear deterrent that uses the lowest possible yield. In fact, tailored-output weapons are designed to produce the least possible collateral damage which is consistent with military effectiveness. The first of these designs was made possible only by extensive use of CDC 7600 technology.

The tailored-output nuclear design is but one example of the general trend of the U.S. stockpile toward lower yield. As a matter of fact, *the total yield of our stockpile has diminished by 75% since 1960, largely due to the sophisticated designs made possible by supercomputer technology.*

A number of high-value strategic targets have been identified in recent years which can be most effectively neutralized with an earth-penetrating weapon. The effectiveness of such a weapon arises because of the much more efficient coupling of its nuclear blast to the target when it is used in the earth-penetrating rather than the air-burst mode. This coupling again allows military objectives to be satisfied with a much lower-yield weapon. The combination of penetrator impact velocities and ground-entry angles creates demands on the design which can only be satisfied with elaborate two-dimensional and often three-dimensional calculations. These calculations in turn can be accomplished only with additional computing power (see page 21).

Figure 9 also emphasizes the difference between *capability* and *capacity*, terms that were introduced in our historical perspective (see pages 10-11). With the computational capability of about 0.0005 Cray in the early 1950s, no number of machines of that day could have been used to design the small strategic warhead. The factor of 200 increase in computer power between 1950 and the early 1960s, when the small strategic warheads were designed, does not mean that 200 1950-type computers could produce the design. Such a conclusion would require that all 200 machines be able to work on the same problem at the same time, which was not the case. The 200 machines would certainly have increased the *capacity* of the laboratories to design more weapons but would not have provided the *capability* to design a new generation of nuclear weapons.

WEAPONS ENGINEERING HAS REQUIRED STEADILY

On the previous page, we have described how military requirements have driven the DOE design laboratories to steadily increase their computer capabilities. The resulting increase in complexity and sophistication of nuclear designs has placed new demands on DOE weapons engineering as well, and the response has been the same, i.e., to steadily increase computer capabilities. Engineering testing need not always be performed underground under adverse and enormously costly conditions as is the case for the nuclear design, but many engineering designs would require on the order of a hundred conventional tests, each taking three to four months to set up. At about $0.5M for each test, such a program is not economical; but, more importantly, it would take many years to complete. Most engineering designs are required in one or two years and are undertaken in parallel with the nuclear design, so that major changes can be made and are made, even in the final phases.

The conclusion is that supercomputers are vital to engineering design as well as to nuclear design, but for somewhat different reasons. Nuclear design cannot be accomplished in any other way, while engineering design would take too long and cost too much to be done in any other way. We follow with some specific examples.

Reentry Vehicle Impact Analysis

Ground impact is one of the required fusing modes on warheads for several strategic systems. Typical flight trajectories involve terminal impact velocities of several thousand feet per second. Successful nuclear detonation requires that all nuclear components survive long enough after initial ground contact to receive the fire signal from the fuse.

On a typical reentry vehicle, this means that the time between the initiation of the signal at impact and the arrival of the crushup wave must be no longer than a few tens of microseconds. At times after impact longer than this, the vehicle crushup wave that originates at the impact point will have traversed the vehicle and destroyed the nuclear package prior to its detonation.

Strategic reentry vehicles must withstand a high-velocity impact with the ground

The figure, from a recent engineering development program, shows the warhead impacting the ground at a specific angle and velocity. The designer must ensure that the signal from the impact fuse arrives at other components before they are destroyed by being crushed due to the impact. This must be ensured for all angles of impact, all velocities, and all ground conditions (rock, sand, ice, etc.). It is easy to see how over a hundred tests would be required in the absence of a computer: Testing ten velocities at ten different angles makes up 100 tests for even a single ground condition!

Instead, the approach that has been used generally involves a limited ground test program closely coupled to very extensive supercomputer calculations. (A typical ground test can achieve no more than 70% to 80% of the maximum impact velocity, however.) Flight testing is used only to provide overall confirmation of system performance.

The computational approach employed allows integrated system performance to be evaluated at maximum impact velocity with a three- to four-day turnaround between runs rather than the several months typical of the ground test program. Each run requires the entire memory of a Cray-1 computer and at present is limited primarily to two-dimensional calculations of ten hours each. The 100 runs comparable to the test program discussed earlier would therefore cost about the same as a single test (1,000 hours at $500 per hour).

Oblique impacts can produce three-dimensional deformations which must be evaluated. To date, only very coarse three-dimensional calculations are possible because of limitations on available computer memory (see page 24). Nevertheless, the weapons engineer is constantly striving to include three-dimensional aspects where possible.

ICREASING COMPUTER CAPABILITIES

Earth Penetrator

Recent preliminary design studies have shown a significant advantage of buried nuclear bursts over air bursts when targets such as underground command centers and silos are being attacked. These results have generated renewed interest in the design of earth penetrators that can be delivered from reentry vehicles and are capable of high yield. Such weapons, however, have the disadvantage of having to survive the extreme loads generated from impact into rock-like targets at velocities as high as several thousand feet per second. The development of strategic earth penetrators relies heavily upon a coordinated computational analysis and test program. Since the number of possible impact angles and velocities is so enormous, only through computation can we arrive at a design in which we have confidence.

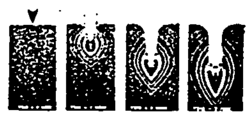
In the past, penetrator designs have largely been based on "rule of thumb" assumptions and simple hand calculations. The result has typically been either a heavy, inefficient design or one prone to failure. Penetrator development program failures were seldom predicted in advance or even adequately explained, largely because of the unavailability of tools (both hardware and software) for the calculation of lateral loads associated with oblique impact.

With the advent of the Cray-1 computer, it became possible to refine penetrator designs by using finite element analyses of vertical impacts (which generate no lateral loads). These two-dimensional (axisymmetric) analyses, invaluable in predicting axial decelerations for various targets and impact velocities, give more representative results than the previous calculations. We have thus been able to approach a minimum-weight, efficient design.

The figure depicts the analysis of a strategic earth penetrator impacting a medium-strength rock at a velocity of 1200 feet per second. The resultant penetration is shown at one-millisecond intervals. The fringes in the figure (which would be available in color to the analyst) display stresses in the penetrator case and lines of constant pressure in the target material. This analysis, at a relatively slow velocity, showed that the penetrator would not survive impact into this target if additional stresses due to lateral loads were included. Also, the depth of penetration predicted by the code would be insufficient for maximum underground energy coupling. A definite statement could not be made on the survivability because of the inadequate tools for lateral load prediction.

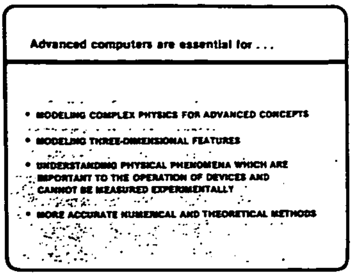
It has been established that software which can handle these loads will require a computer with a CPU speed many times faster than today's machines.

Computers enable us to satisfy otherwise impossible engineering design requirements



ADVANCED COMPUTERS ARE ESSENTIAL FOR...

- **MODELING COMPLEX PHYSICS FOR ADVANCED CONCEPTS**



(10)

Advanced concepts such as x-ray lasers require an understanding of complex physics. Modeling and simulation provide an essential means of learning about these physical processes; approximate models which may be appropriate for more conventional designs simply do not contain sufficient detail to predict real-world results.

For example, the opacity of materials (Figure 11) must be known (a) in order to better understand the device performance, and (b) to predict the interaction of x-ray output with the target (for example, a reenty vehicle), that is, to predict the lethality of a weapon as a function of target material. Reliable calculation of the energy released from the imploding nuclear materials in a weapon requires accurate knowledge of material opacities.

It turns out that the same level of calculation required to understand opacity is also required to understand the enormously complex electronic energy levels within atoms. This level of calculation is known as "detailed configuration accounting" (DCA), a relativistic quantum mechanical treatment of each individual energy level of the atom.

Today, weapon designers use an approximate theory of opacity known as "perturbation theory" in their design codes. This is because a single opacity calculation of a plasma at a single density and pressure takes approximately 50 hours of Cray-1 time using DCA theory, while the same calculation using the perturbation theory would take one milli-

RADIATION ABSORPTION AND TRANSMISSION CALCULATIONS

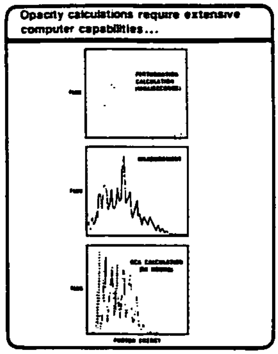
The extent to which different types of radiative energy, such as x-rays, are absorbed or pass through a given material is indicated by a property of the material known as opacity.

In the detonation process, a nuclear weapon releases a tremendous amount of radiative energy which may be absorbed by surrounding materials. In a conventional nuclear weapon, the later part of the overall detonation process, and hence the yield, can be significantly affected by the amount of energy absorbed. In a nuclear-driven directed energy weapon such as an x-ray laser, detailed knowledge of energy absorption by the lasing materials is also crucial, since it determines both the possibility and extent of lasing. Thus, accurate knowledge of opacity is an essential element in the design of both present- and future-generation nuclear weapons systems.

Since opacity measurements under the conditions of nuclear weapon detonation are both difficult and expensive, a computational approach is required. The following example of x-ray absorption illustrates the role of supercomputers.

X-rays and higher-energy photons (light rays) produced in nuclear weapons interact most strongly with the inner (core) electrons of those atoms which contain a great many electrons. These innermost electrons are traveling at relativistic velocities, that is, at very nearly the speed of light itself. If x-rays of a certain energy can get completely through a material, the material is said to be transparent to x-rays of that energy; if none of the x-rays can get through, the material is said to be opaque to x-rays of that energy. In the real world, neither extreme occurs; we speak of the "opacity" of the material: the degree to which the x-rays are unable to make it through.

In the figure to the right, we have sketched the basic idea of opacity. The large circles represent ionized atoms, and the small dots represent electrons comprising a "plasma." A plasma is a collection of electrons and protons, that is, atoms in highly ionized states formed at extremely high temperatures, such as those found during the operation of a nuclear weapon. The wiggly lines represent x-ray photons trying to get through the



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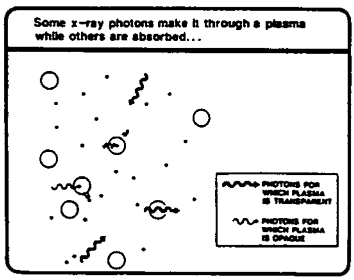
second, a factor of 2×10^8 in computer time. Considering that the density and temperature of the plasma may be changing rapidly, such a calculation would have to be performed hundreds or even thousands of times; that is, it must be performed "on-line." DCA calculations are now used to check a particular opacity data point; to actually design using DCA theory will require a computer approximately 2×10^8 faster than today's.

In Figure 11, a comparison is made between the results of a DCA and perturbation theory calculation. Perturbation theory evidently is not capable of identifying the location of any of the major peaks and, consequently, would be simply unacceptable as a design tool for advanced concepts. DCA theory, on the other hand, is able to reproduce the experimentally observed peaks from first principles. These peak structures are less critical to conventional nuclear designs because the uncertainties introduced can be resolved at additional time and expense through further underground testing.

plasma. The electrons reside in specific energy levels and can make transitions from one level to another by (a) absorbing one of the photons (blue circles) which excites an electron to a higher state, or (b) allowing the photon to pass through uninhibited (open circles). If the energy of an x-ray is near an electronic transition energy for one of the ionized atoms in the plasma, there is a high probability the x-ray will be absorbed. In the absence of such an electronic transition, the x-ray is most likely to be undisturbed and to continue on its way.

Which choice the atom makes depends upon the electronic energy levels, which can only be calculated using detailed configuration accounting (DCA) (see above). Such calculations require a computer two hundred million times faster than today's supercomputers.

The probability of absorption depends upon the density and temperature of the plasma because these factors influence the electronic transition energies in the plasma. Within a nuclear weapon, the density changes by a factor of ten thousand and the temperature by a factor of ten million.



ADVANCED COMPUTERS ARE ESSENTIAL FOR...

- MODELING THREE-DIMENSIONAL FEATURES

Advanced computers are essential for . . .

- MODELING COMPLEX PHYSICS FOR ADVANCED CONCEPTS
- MODELING THREE-DIMENSIONAL FEATURES
- UNDERSTANDING PHYSICAL PHENOMENA WHICH ARE IMPORTANT TO THE OPERATION OF DEVICES AND CANNOT BE MEASURED EXPERIMENTALLY
- MORE ACCURATE NUMERICAL AND THEORETICAL METHODS

Many of the complex physical features involved in a nuclear design are intrinsically three-dimensional. In the absence of sufficient computer capability, one- and two-dimensional approximations are employed which can give incomplete results. This dimensionality problem has been and continues to be an enormous force driving computer technology.

In some cases, it is the fundamental law of physics which is three-dimensional and hence not representable in one or two dimensions; in other cases, the geometry of the problem is deliberately simplified in order to become solvable on today's computers.

At the present stage of computer development, there are significant limitations placed upon weapons simulations. In a one-dimensional analysis (of what is really a three-dimensional problem), the object being analyzed is typically subdivided into 100 to 1000 smaller objects or elements which are then individually analyzed. By properly accounting in these individual analyses for the influence that neighboring elements have on each other, the behavior of the larger object can be calculated by combining the results from the series of smaller elements. Typically the subdivision into smaller elements is accomplished by superimposing a grid or mesh on the object and defining the smaller elements by the location of the intersecting meshlines which form their boundary. These points of intersection are known as "meshpoints." In general, numerical accuracy and spatial resolution is improved by increasing the number of meshpoints. Unfortunately, this also increases computing resource

MULTIDIMENSIONAL COMPUTATIONS INCREASE COMPUTING RESOURCE REQUIREMENTS

Adding a second or third dimension to a problem substantially increases the run time, even for a relatively simple problem. This is illustrated by the accompanying figure where the relative increase in run time for a typical nuclear weapon design problem is presented as a function of the number of meshpoints.

For the case of 100 meshes per dimension, run time increases by a factor of roughly 200 in going from one to two dimensions and by a factor of 33,000 in going from one to three dimensions. Thus, whereas run times on the order of tens of seconds to a few minutes are typical for one-dimensional problems on a Class VI computer, a three-dimensional calculation with the same mesh resolution would require thousands of hours. At this point it is worth remembering that the example discussed was for 100 meshpoints per dimension. Many problems will require additional resolution, say an increase by a factor of 10 per dimension. From the figure we see that attempting to include 1000 meshpoints per dimension for a three-dimensional calculation gives a run time which is off the chart (i.e., greater than 100,000 times the single-dimensional calculation).

Although the exact values vary from one problem to the next, the general message remains unchanged: Three-dimensional simulations of the type encountered in the nuclear weapons program will require substantial increases in computing power if such calculations are to become a useful part of the design process.

Memory requirements for multidimensional analyses

Number of Dimensions	Number of Meshpoints per Dimension	Total Number of Meshpoints	Number of Pieces of Information Required At Each Meshpoint	Required Memory (words)
1	100	100	10	1000
	1000	1000		10^4
2	100	10^4	19	19×10^4
	1000	10^6		19×10^6
3	100	10^6	27	27×10^6
	1000	10^9		27×10^9

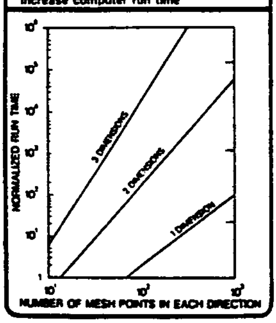
(12)

requirements. For illustrative purposes, we will assume 100 separate meshpoints are adequate. To solve the governing equations in one dimension, 10 separate pieces of information are typically required at each point. Thus, 1000 words of computer memory are required.

As a second or third dimension is added, each will also be divided into 100 meshpoints (although in practice the number of meshpoints chosen for each direction may be different, depending on the nature of the problem). Since it can be shown that the number of separate pieces of information required increases to 19 and 27, respectively, for the two- and three-dimensional problems, the increase in computer memory requirements can be estimated. This is done in Figure 12.

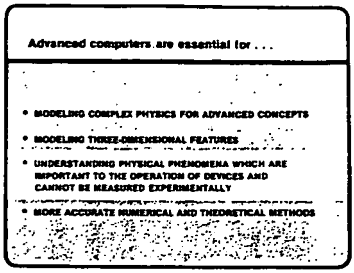
For comparison, a Class VI computer, such as the Cray-1, has a few million words of memory. (The Cray-2 computer will have 64 million words of memory when operational.) Clearly, Class VI computers can be used to calculate three-dimensional problems only if the designer is willing to tolerate very coarse spatial resolution. For certain parts of the preliminary design process, this may be quite acceptable. For problems where detailed 3-D resolution is required, Figure 12 shows memory requirements on the order of 10^9 to 10^{10} words. This will require a several-orders-of-magnitude increase in memory over that projected for any machine in the next five years.

Three-dimensional problems significantly increase computer run time



ADVANCED COMPUTERS ARE ESSENTIAL FOR...

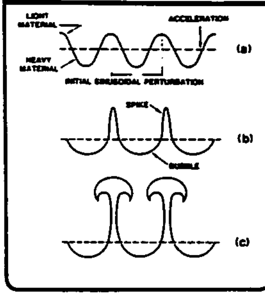
- **UNDERSTANDING PHYSICAL PHENOMENA WHICH ARE IMPORTANT TO THE OPERATION OF DEVICES AND CANNOT BE MEASURED EXPERIMENTALLY**



There are many physical phenomena involved in a nuclear explosion which may never lend themselves to proper measurement because the attempt at the measurement may perturb the result itself. Instabilities are in this category of important phenomena which only lend themselves to computation and for which the computer power of today is inadequate.

The interface between two materials is never exactly flat or perfect; imperfections always exist which can trigger an instability. Mathematicians like to simplify the description of such complicated problems. We see this in Figure 13(a) where a single sine wave is used to approximate an actual perturbation of the interface. When the amplitude of the perturbation becomes large, the interface begins to take the shape of bubbles and spikes as shown in Figure 13(b). Eventually, shearing instabilities occur as a result of the relative motion of the materials along the side of the spike. This forces the tips of the spikes to roll up (Figure 13(c)) and sometimes break off, leaving chunks of dense material in the lighter material.

Perturbations can grow into bubbles and spikes



13

Although illustrative of the phenomena, the single wavelength perturbation is not representative of the problems encountered in any real situation. Real interfaces are treated mathematically by including more sine waves of different wavelengths in the calculation. In the limit of including an infinite number of wavelengths, any complex interface could be exactly described. Calculations involving only a few wavelengths, capable of representing only nearly perfect surfaces in one or two dimensions, stress existing computing resources to their limit. Present computers do not allow any detailed calculation of multidimensional, multiwavelength phenomena.

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There are fundamentally two ways to improve weapons design calculations: more accurate numerical methods and improvements in the basic physics. Mathematical techniques can have an enormous effect on the accuracy of the calculation given a specific physics model. More physical detail in the calculation (e.g., including further equations to describe additional phenomena) will improve the theoretical method itself.

An example of an improved numerical method is the development of finite element meshes which change according to the solution (variable mesh gridding). That is, the greatest number of meshpoints are assigned by the computer to the most active regions as the computer iterates to a final solution. This has had a tremendous effect on accuracy of simulation.

In the future, numerical methods involving parallel processing hold the greatest hope and opportunity to achieve computational speeds of a thousand times or more than today's. These parallel numerical methods are the reason we feel confident of actually acquiring such a capability. Examples of using more accurate theoretical methods are found in the inset (this page); in our discussion of mixing accompanying Figure 13 (previous page); in our discussion of directed energy concepts, Figure 15 (page 30); and, most extensively in our treatment of opacity in the text accompanying Figure 11 and associated inset (page 22).

MODELING VS. SIMULATION

Although the terms are often used interchangeably, there is an essential difference between "modeling" and "simulation": On the one hand, modeling involves approximating the real problem so as to construct another problem (the model) which is solvable. On the other hand, a simulation is an attempt to put all that is known, both of the laws of nature and of the geometry, into the computer to actually calculate the result, as near to mimicking nature as the size of the computer will allow.

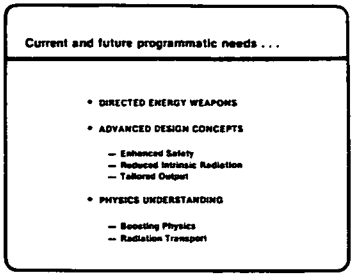
n the figure to the right, the "real world" at the center can be either "modeled" mathematically and physically, or "simulated."

he real-world problem will likely have a complex geometry; ne mathematical "model" of this geometry may be a sphere ight side) in order to allow the mathematician to solve the roblem. That is, the real problem is simplified to a spherical eometry so it can be solved. In computer simulation (left side), the real-world geometry is preserved by breaking the problem into small pieces.

The same concept holds for the physics. In a physics "model" of the real world, the electrons of, for example, a metal are assumed to reside in a "sea" of uniform positive background. This "Fermi gas" as it is known can then be solved with little resort to the computer. Really, however, a metal is a collection of closely spaced atoms whose outer electrons are more loosely bound to their centers (nuclei) than the inner electrons. This is sketched in the left side of the figure and is included in the simulation by actually calculating the electronic and atomic configurations on a supercomputer.

It is this simulation that is desired in the weapons program because the difficulties of testing preclude our gaining such understanding any other way.

CURRENT AND FUTURE PROGRAMMATIC NEEDS REQUIRE ADDITIONAL SUPERCOMPUTING POWER

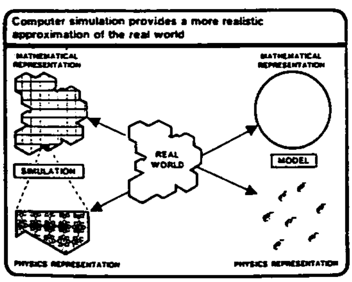


(14)

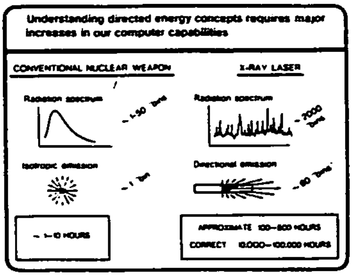
Most recently, the x-ray laser concept was put forth. This is a dramatically new directed energy concept that requires greater resources than are now at our disposal. Directed energy weapons head the list of current and future programmatic needs. They offer the hope of changing our posture from that of an offensive to a defensive strategic focus.

Several advanced design concepts, notably enhanced safety, are also being pursued. Such concepts involve the widespread use of insensitive high explosives to further minimize the risk of dispersing nuclear materials in the event of an accident. Safety concepts also include basically different designs of the nuclear warhead itself. Over the past 25 years, we have been able to reduce the total yield of our stockpile by 75% (a factor of four). To achieve military effectiveness with minimum possible nuclear damage, reduced intrinsic radiation warheads having reduced blast characteristics have been developed. Tailored output devices similarly enable lower yield warheads to be substituted for their higher damage counterparts. These weapons are far more complex and sophisticated in their design, however, and as such require ever increasing computer capabilities.

One of the most challenging future needs is in the area of basic physics understanding. We do not have an adequate understanding of boosting physics and fundamental instabilities. An adequate understanding of radiation transport is beyond the current generation of supercomputers.



UNDERSTANDING DIRECTED ENERGY CONCEPTS REQUIRES MAJOR INCREASES IN OUR COMPUTER CAPABILITIES



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A comparison of the computer capability which has been used for conventional nuclear design and for understanding the basic requirements for the x-ray laser is made in Figure 15. Here again we find that the smooth radiation spectrum (the "perturbation" approximation of Figure 11) has been used for the conventional weapon while the full spectrum, including peaks, is required for the directed energy weapon. Similarly, whereas the output of a conventional weapon is isotropic (the same in all directions), it is the directional aspects of the x-ray laser we wish to utilize. The number of bins of information necessary to be calculated and stored in a computer's memory gives one measure of the relative complexity of the calculations. Another such measure is the computer time required, which is given in the boxes of Figure 15.

Although we are able to have hope in the possibility of directed energy weapons, with current computer capabilities we are far from knowing if they are feasible. It is estimated that a computer with the computational power of 1000 Cray-1's will be required to obtain an adequate physics understanding of such a device.

Similar arguments hold for the present computer capability-versus-capacity discussion. With the power of several Cray-1's, we can only reach the "tip of the iceberg" in the evaluation of a directed energy weapon. Acquiring a thousand such machines (capacity) would not help. Instead, we require a single machine having the capability of a thousand Cray-1's. Since the history of supercomputing has shown that real costs have remained relatively constant through many generations of supercomputers (see page 14), this capability will not cost a thousand times that of a Cray-1 but about the same. Computers are greatly leveraged: As computing technology evolves, there is a tremendous increase in capability at only a moderate increase in cost.

TARGET ACQUISITION BY DIRECTED ENERGY WEAPONS

Research into directed energy weapons requires much more than just an understanding of the physics associated with the weapon itself. Even in the preliminary stages of study, it is important to carefully consider (1) the nature of the target that will be attacked with the weapon (in order to establish how much directed energy will be required to destroy it), and (2) the means by which the weapon system will locate and identify that target.

One of the primary threats a directed energy weapon would be required to defend against is an enemy launch of multiple-warhead strategic missiles. During the early phase of the trajectory of these missiles, their rocket motors are still burning, making them easier to detect. If it were possible to destroy the rocket during the early part of its flight, several warheads could be destroyed by a single DEW since they have not yet been separated from their booster rocket platform to follow separate paths to their individual targets.

Assessing the feasibility of a directed energy weapon system which can locate, track, and destroy a strategic missile within a few minutes of its launch is a formidable task. Supercomputers will be essential in achieving this goal. The target is only a few tens of feet in size and is several thousand miles away. Target acquisition becomes the military equivalent of searching for a needle in a haystack.

While difficult, the problem is not impossible. The exhaust gases from the rocket motor are extremely hot and are emitted in very large quantities, creating a very bright cloud known as a plume, which, because it is several hundred feet in size, can be seen from great distances. Once the plume is located, the problem reduces to tracking it and finding the rocket's location within it.

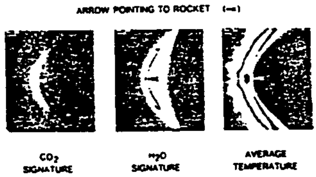
Because of the nature of the plumes of interest, traditional gas dynamic methods are not suitable for modeling their behavior. Instead, a technique known as the Monte Carlo approach is used. In this scheme, individual molecules are tracked as they collide with other molecules and their collisional histories recorded. After a sufficient number of these collisions have been simulated on the computer, it is possible to combine the collisional information in a way that describes the overall flowfield of interest—in this case, the rocket plume. In principle, the computational approach is rather straightforward. However, because of the numbers of molecules involved, even for relatively simple plumes, the capability of today's supercomputers is quickly exceeded.

The results, shown in the figure, are illustrative of a rocket at an altitude of 180 kilometers (110 miles) traveling at 5 kilometers per second (11,000 miles per hour). The pictures shown are calculations of what would be seen by a sensor which detected either average exhaust temperature, water vapor concentration, or CO_2 concentration. Close examination of each figure reveals an elongated black speck; this is the rocket. In principle, from accurate knowledge of the plume's structure, it should be possible to pinpoint the location of the rocket which produced that structure.

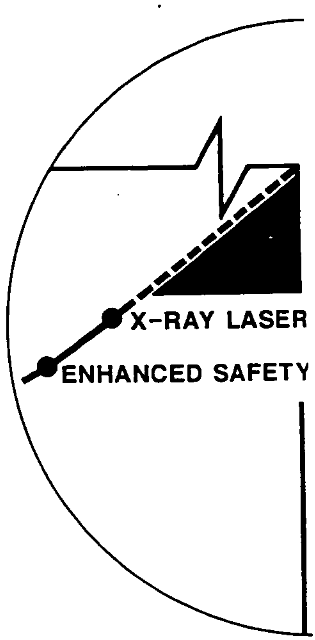
While the results are qualitatively correct, they do not contain nearly enough detail on plume chemistry and gas dynamics to make them useful. Each of these figures is a steady-state calculation at one point in time and requires in excess of ten hours of Cray-1 time. The real problem is transient in nature, since the entire plume structure changes as the rocket travels through space. Thus, tens to hundreds of such ten-hour calculations at different points in the trajectory would be required to develop even qualitative understanding of plume behavior for a single rocket trajectory.

Clearly, computational times of hundreds to thousands of hours for a single trajectory are unreasonable. However, if a multiprocessor machine were available, we anticipate that execution times could be reduced by about a factor of ten, since separate groups of molecules could be processed in parallel and their results combined at the conclusion of the parallel processing step. While not the final answer, such an improvement in computational power would have a significant impact.

Rocket exhaust plumes must be accurately modeled to evaluate DEW sensors and battle management systems



WEAPON DESIGN CONTINUES TO COMPUTER



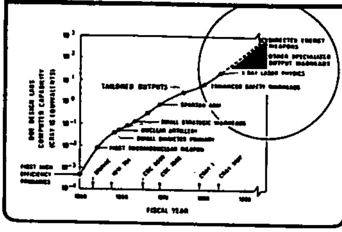
What does the future hold? What new advances do we anticipate will be the result of continuing our drive for greater computer resources? Will there ever be an end to our need to increase computer capabilities?

Our quest for a deeper understanding of weapons physics with which to design and improve our stockpile will continue, particularly when we know that computers are the key to that understanding. We cannot develop the required understanding empirically.

As long as nuclear deterrence is an element of our national policy, it is essential that a serious effort be made to understand those physics and engineering issues necessary to ensure the safety and reliability of the current stockpile. Enhancing the safety of the nuclear warheads in our stockpile from the point of view of accidental detonation or overrun in a foreign environment is a critical element of

:QUIRE STEADILY INCREASING
\PABILITIES

Weapon design continues to require steadily increasing capabilities



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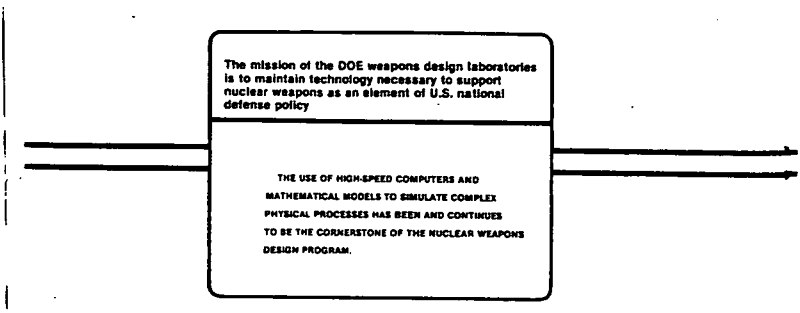
ɔur national policy. An additional key element is to understand the impact of echnological advances on weapon equirements and their influence on ne capability of our nuclear deterrent. ?esearch on the fundamental prin-iples of directed energy weapons may rovide the necessary insights which nay enable the shift from an offensive ɔ a defensive strategic focus.

As we have stated earlier (see text accompanying Figure 9, pages 18 and 19), the yield of the stockpile has been reduced by 75% since 1960. The future weapons design goals include specialized output warheads which will enable us to further reduce the yield of the stockpile while maintaining military effectiveness.

The intent of the laboratories to achieve the above goals with a minimum number of nuclear tests is consistent with national policy. The continued advance of supercomputer capability is an essential factor in our ability to meet our national goals.


The mission of the DOE weapons design laboratories is to maintain technology necessary to support nuclear weapons as an element of U.S. national defense policy
THE USE OF HIGH-SPEED COMPUTERS AND MATHEMATICAL MODELS TO SIMULATE COMPLEX PHYSICAL PROCESSES HAS BEEN AND CONTINUES TO BE THE CORNERSTONE OF THE NUCLEAR WEAPONS DESIGN PROGRAM.

17

TESTIMONY OF
WILLIAM A. REINSCH
UNDER SECRETARY FOR EXPORT ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
BEFORE THE
JOINT ECONOMIC COMMITTEE
APRIL 28, 1998

Mr. Chairman, members of the Committee, thank you for the opportunity to discuss the issue of China's access to dual-use and military technologies. This is an important issue which is central to the mission of my agency. Relations with China are in a period of transition, and this can create the potential for risks in technology transfer. Our job is to manage that potential risk so that the U.S. can reap the substantial benefits posed by China trade for our economy and for American foreign relations without adversely affecting our security. I want to describe how this is done.

First, we should consider the broad factors which shape technology transfer issues with China. These include:

-- U.S. Trade. China is a dynamic market, with high rates of growth and real opportunities for foreign firms. The U.S. has a significant advantage in the high value, high tech end of the market, but we have serious competition from the European Union and Japan. At the same time, U.S. demand for Chinese goods is high, and we have a significant bilateral trade deficit which we would do well to rectify. While technology transfer restrictions account for only a small portion of the trade deficit, in many cases they have a deterrent effect on trade expansion that goes beyond our national security needs.

-- The policies of other countries towards China. Before 1994, when COCOM ended, we and our major trade partners had a coordinated, multilateral approach to high tech trade with China. Since that time, we have found a growing difference in how we and our allies treat high tech exports to China. A number of our allies no longer appear to regard China as being of strategic concern and have dismantled export restrictions on a range of dual-use technologies. The result is that some U.S. controls have become increasingly unilateral and thus ineffective as restraints on China's ability to acquire advanced technology.

-- Security and Nonproliferation. Security and nonproliferation remain central to our dialogue with the Chinese, and have a profound effect in shaping high tech trade with China. We have serious differences with China on a variety of nonproliferation issues and have consistently engaged China to bring its practices into line with international norms. We have made notable progress in the nuclear area and are working to broaden this dialogue and to promote cooperation between the US and China on other security issues.

-- <u>The larger bilateral relationship.</u> China is in the midst of broad social, economic and political change. The Administration's goal of engaging China to influence its evolution to an open, market-oriented society shapes our technology transfer policies. A stable, prosperous and open China at peace with its neighbors is in the best interests of the entire world, including the United States, and appropriate transfers of civil technology can help achieve that goal.

Export controls are one of the principal tools we use to manage technology transfer. U.S. dual-use regulations allow for extensive review and denial of license applications in cases where a strategically sensitive item would make a "direct and significant" contribution to China's military capabilities. In addition, Tiananmen Square sanctions prohibit the export of arms, satellites and dual-use items used for crime control unless there is a Presidential waiver. U.S. policy since Tiananmen Square is to deny export of controlled dual-use technology to the Chinese military and police.

The Clinton Administration has significantly improved the dual-use export control process by, among other things, strengthening the role of other agencies in the review process. The source of this revitalized process is Executive Order 12981, issued in December 1995. E.O. 12981 gives the Departments to Defense, Energy, State and the Arms Control and Disarmament Agency the right to review any license of interest to them. It establishes a clear system for escalation and resolution of disputes, all the way to the President if necessary, and provides for an appropriate review of technology transfer cases by the intelligence community. As a result, dual-use license reviews are more thorough, more complete, and more carefully considered than at any time in the past.

In addition to E.O. 12981, the Commerce Department has taken a number of steps to reinforce our ability to enforce export regulations. We have increased the number of enforcement agents in the field and have ensured that they are well trained and better equipped to carry out their enforcement mission. The Congress could help us in this regard by passing a renewal of the Export Administration Act which would, at a minimum, raise the level of the penalties for export violations from those set almost a decade ago. Under current circumstances, financial penalties are little more than the cost of doing business for many companies.

Beyond these improvements, as part of the Administration's larger bilateral strategic and nonproliferation dialogue, we have engaged with the Chinese government on how to improve cooperation on export controls and have taken steps to help ensure that U.S. technology is properly safeguarded. The bilateral seminar on export controls held earlier this month in Washington was a good beginning to this process, and we hope to expand our dialogue with the Chinese to reach greater mutual understanding and cooperation in export controls and end use visits.

Satellite exports are an example of how effective dual-use export controls allow American exporters to compete and win without risk to our national security. Our controls on satellite exports to China are extensive and involve a number of measures to reduce the risk of unauthorized transfers of technology, including a bilateral technology safeguards agreement and the presence of Department of Defense monitors at Chinese launch sites. Also, sensitive military satellite technology remains on the U.S. Munitions List administered by the Department of State. Allowing China to launch U.S.-made satellites, under these safeguards, has been an important factor in helping U.S. companies dominate the satellite market. Most sales are to U.S. or third country firms who have chosen to purchase Chinese launch services.

The world satellite market was valued at more than $51 billion in 1997. The U.S. has the lion's share of this market. Satellite manufacturing alone employed 60,000 people in the U.S. and generated more than $8 billion in revenue for our country. Thirty-five commercial launches took place in 1997, by France, the United States, Russia and China, and we expect more in the years ahead. Commercial satellites are a key industry sector and vital to the health of the American economy as a whole. Our ability to maintain our leadership in this sector also has important implications for our military, which utilizes the same technology and depends on healthy American companies to meet its needs.

Jurisdiction for licensing exports of communications satellites was transferred from the State Department to Commerce in November, 1996. Since then, we have issued three licenses for satellites, with the concurrence of all agencies, to be launched in China. No satellite licenses for China are pending now at Commerce.

Another good example of the nexus between security and trade is high performance computers. High performance computers have attained a symbolic importance in our debates over technology transfer which their real utility may not warrant. It helps put the issue in perspective if you remember that some of the weapon systems found in the U.S. arsenal today were built with computers whose performance was below 1000 MTOPS -- in some cases with performance of 500 MTOPS. These were the supercomputers of the 1980's, but today you can find more capable machines on many office desktops. The U.S. currently dominates the high performance computer market, in part because of the computer export policy adopted by this administration in 1995. This sector is vital to the of the U.S. economy as a whole. Exports account for roughly half the revenues of U.S. computer companies. Ill-advised export legislation could put this vital sector at risk without a justifiable benefit to national security.

Satellites and computers are only one part of U.S. exports to China, which were valued at more than $12 billion in 1997. Commerce received 849 export licenses for China in 1997, valued at one billion dollars. Eighty percent of the licenses we received were given permission to export; export was not allowed for the remainder for a variety of reasons including a lack of sufficient information. This eighty-percent approval rate for China is lower than most other countries, including Russia. Applications for China usually take fifty-four days to process, sometimes because we must wait for sufficient information. The average for all licenses is twenty-nine days. These figures show that China licenses are subject to extensive scrutiny and review to ensure that U.S. interests are well protected. Our nonproliferation policy is fundamental to protecting U.S. national security, but it is not without real cost to the United States. These licensing statistics do not reflect the sales lost by U.S. firms in China because of export control policy or licensing delays. U.S. exporters face de facto unilateral controls on exports to China in several sectors where they have a demonstrated competitive advantage. For example, it has been reported that U.S. firms lost the contract for a three billion dollar semiconductor project to a Japanese firm largely because of Japan's apparent willingness to transfer advanced technology quickly and without extensive conditions.

China poses a difficult problem for U.S. export controls today, and the integration of China into a stable world order is one of the paramount challenges for American foreign policy. It is apparent that we are divided in thinking about how to meet that challenge, with some in the Congress and the media having apparently already decided that China is a committed adversary that we should treat the same way we treated the Soviet Union during the Cold War. Others, including the Administration, believe that the old Cold War controls aimed at the Soviet Union are not relevant to new and more complex situations like that of China, and that if we ignore the differences we risk producing the very result we wish to avoid. At the same time, as we pursue a policy of engagement, we clearly do it cautiously with our national security in mind. While the problems are not to be minimized, our relationship with China represents enormous opportunities for the United States if we can manage it well. And that is what we are committed to do.

United States General Accounting Office

GAO

Testimony

Before the Joint Economic Committee

For Release on Delivery
Expected at
10:00 a.m., EDT
Tuesday
April 28, 1998

CHINA

U.S. and European Union Arms Sales Since the 1989 Embargoes

Statement of Harold J. Johnson, Associate Director,
International Relations and Trade Issues, National Security and
International Affairs Division

GAO/T-NSIAD-98-171

Mr. Chairman and members of the Committee:

I am pleased to be here today to discuss the status of the arms embargoes imposed on China by the European Union (EU) and the United States following the 1989 massacre of demonstrators in Beijing's Tiananmen Square. Specifically, I will discuss (1) the terms of the EU and U.S. embargoes, (2) the extent of EU and U.S. sales of military items to China since 1989, and (3) the potential role that such items could play in addressing China's defense needs.

As you requested, we developed information regarding EU and U.S. arms sales to China; and did not assess China's military modernization efforts.[1] However, these efforts are the context for China's arms imports. In 1985 China adopted a military doctrine that emphasizes the use of modern naval and air power in joint operations against regional opponents. It later began buying foreign military hardware to support its new doctrine. The 1989 Tiananmen Square massacre ruptured China's growing defense relationships with the United States and the European Union. Since then, China has relied heavily on other nations, such as Russia, for its military hardware imports--although it is impossible to know the extent to which China's import patterns would have been different had the Tiananmen massacre not occurred.

[1]For a fuller discussion of China's military, see our report entitled National Security: Impact of China's Military Modernization in the Pacific Region (GAO/NSIAD-95-84, June 6, 1995).

Before I begin, I should emphasize that we focused on military items--that is to say, items that would be included on the U.S. Munitions List. As you know, this list includes both lethal items (such as missiles) and nonlethal items (such as military radars) that cannot be exported without a license. We did not address exports of items with both civil and military applications because the embargoes do not bar the sale of such "dual-use" items to China, although experts believe that dual-use imports are an important source of high technology for the Chinese military. Also, I should note that the information presented in this statement was developed from open data sources and, therefore, its completeness and accuracy may be subject to some degree of uncertainty.

SUMMARY

The EU embargo consists of a 1989 political declaration that EU members will embargo the "trade in arms" with China. Each EU member may interpret and implement the embargo's scope for itself. We found no instances of EU members entering into new agreements to sell China lethal military items after 1989, although some members delivered lethal and nonlethal military items to China during the 1990s--apparently in connection with pre-embargo agreements--and have more recently agreed to deliver additional nonlethal military items. According to experts, the embargo is not legally binding and any EU member could legally resume arms sales to China if it were willing to bear the political consequences of doing so. We noted that at least two EU members are presently reconsidering whether the EU embargo should be continued.

In contrast to the EU embargo, the U.S. embargo is enacted in U.S. law and bars the sale to China of all military items--lethal and nonlethal--on the U.S. Munitions List. The President may waive this ban if he believes that doing so is in the national interest. Since 1989, the President has issued waivers to (1) allow the delivery to China of military items valued at $36.3 million to close out the U.S. government's pre-1989 defense agreements with China and (2) license commercial military exports valued at over $312 million--primarily commercial satellite and encryption items.

The rather small amount of EU and U.S. sales of military items to China since 1989 could help address some aspects of China's defense needs; however, their importance to China's modernization goal may be relatively limited because Russia and the Middle East have provided almost 90 percent of China's imported military items during this period. According to experts with whom we spoke, China must overcome obstacles posed by its military's command and control, training, and maintenance processes before it can fully exploit such items.

Recent U.S. executive branch actions suggest that its view of China's human rights record--the basis for the embargo in the first place--may be changing. In light of the possible weakening of support for continuing the embargo by some European governments, the question facing the U.S. government appears to be how the United States should respond if the EU embargo were to erode significantly in the near future.

EU MILITARY EXPORTS TO CHINA HAVE BEEN LIMITED

In reaction to the Tiananmen Square massacre, the European Council--an EU decision-making body comprised of ministers from EU member countries--imposed several sanctions in June 1989, including "an embargo on trade in arms with China." However, according to experts, the Council's declaration was not legally binding. It also did not specify the embargo's scope. For example, it did not state whether the embargo covers all military articles, including weapons platforms, nonlethal military items, or components.

EU and other European officials told us that the European Union has left the interpretation and enforcement of the declaration to its individual member states[2] and that the members have interpreted the embargo's scope in different ways. Officials in some EU nations informed us that their nations have embargoed the sale of virtually all military items to China. In contrast, the United Kingdom's (UK) interpretation of the EU embargo does not bar exports of nonlethal military items, such as avionics and radars. The UK embargo is limited to lethal weapons (such as bombs and torpedoes), specially designed components

[2]EU officials informed us that this reliance on the EU members reflects the members' independence in defense matter.

of lethal weapons, ammunition, military aircraft and helicopters, warships, and equipment likely to be used for internal repression. European and EU officials told us that EU members tried during the early 1990s to develop a detailed EU-wide interpretation of the embargo's scope. These attempts apparently fell short and resulted only in the members' mutual recognition that they were not selling China lethal weapons.

According to EU and European officials, the EU embargo could be formally ended by unanimous consent or informally eroded by individual EU members' resumption of military trade with China. EU members, whose defense firms are faced with severe economic pressures, could move to modify their participation in the embargo if they believe China's human rights situation is improving. A recent EU report noted that human rights in China, while still far from meeting international standards, had improved over the past 20 years. There have been signs that some EU members have sought to increase arms sales to China. We found that at least two EU members are now reassessing whether the embargo should be continued.

EU Sales of Military Items to China Since 1989

As of today, no EU members appear to have concluded new agreements to sell lethal weapons to China since the imposition of the EU embargo. As shown in table 1, three EU members have delivered, or agreed to deliver, military items to China since 1989.

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Table 1: Selected Deliveries of EU Military Items to China, 1990-97

Country	System	Lethal	Agreement date
France	Castor-2B naval fire control radar	no	Pre-1989
	Crotale ship-to-air missiles and launcher	yes	Pre-1989
	TAVITAC naval combat automation system	no	Pre-1989
	Sea Tiger naval surveillance radar	no	Pre-1989
	AS-365N Dauphin-2 helicopter	no	Pre-1989
	SA-321 Super Frelon helicopter	no	Pre-1989
Italy	Aspide air-to-air missile	yes	1989[a]
	Electronic countermeasures for A-5M aircraft	no	Pre-1989
	Radar for F-7M and F-7MP fighters	no	1993
United Kingdom	Avionics for F-7M fighter	no	1989[b]
	Searchwater airborne early warning radar (no deliveries to date)	no	1996

[a]According to the source of the information, this agreement's exact date is unclear.
[b]This agreement appears to have been concluded prior to June 1989.

Sources: Stockholm International Peace Research Institute, various other public sources.

Two EU member states delivered lethal weapons to China after the embargo, according to publicly available sources of information. These deliveries of French Crotale ship-to-air missiles and Italian Aspide air-to-air missiles appear to have been made in connection with pre-embargo agreements. Similarly, French-licensed Chinese production of the Super Frelon and Dauphin helicopters, which continued into the 1990s, began prior to 1989. Also, the United Kingdom honored a pre-embargo agreement by providing China with radars, displays, and other avionics for its F-7M fighter aircraft.

During the 1990s Italy and the United Kingdom agreed to sell China nonlethal military items. Italy agreed to sell fire control radars for use on Chinese F-7M and F-7MP export fighters. The United Kingdom agreed to sell China the Searchwater airborne early warning radar system. UK officials informed us that the UK's decision to do so is consistent with its interpretation of the EU embargo because the Searchwater is not a lethal weapon or a weapons platform. (The appendix briefly describes these systems.)

WAIVERS HAVE ALLOWED EXPORTS OF SOME U.S. MILITARY ITEMS TO CHINA

On June 5, 1989, immediately after the massacre of pro-democracy demonstrators at Tiananmen Square, the President announced sanctions on China to protest its actions. In February 1990, Congress codified the sanctions' prohibition on weapon sales in Public Law 101-246. The law suspended export licenses for items on the U.S. Munitions List and specifically barred the export of U.S.-origin satellites for launch on Chinese launch vehicles. It exempted from this prohibition U.S. Munitions List items that are designed specifically for use in civil products (such as internal navigation equipment for commercial airliners) unless the President determines the end user would be the Chinese military. Because the U.S. Munitions List includes nonlethal military equipment (for example, radios and radars) in addition to lethal equipment (such as missiles), the U.S. prohibition on arms sales to China covers a broader range of items than the EU embargo, as implemented.[3]

Under the law, Munitions List items can be exported to China if the President reports to Congress that it is in the national interest to allow the export.[4] Presidents Bush and Clinton exercised this option and issued waivers for the export of Munitions List and satellite equipment to China based on determinations that it was in the national interest to do so.[5]

U.S.-China relations have slowly improved since the 1989 massacre. According to press reports, the executive branch is now considering easing restrictions on commercial satellite projects in China--in part through the use of blanket waivers. Moreover, for the first time in several years, the United States recently decided against sponsoring a United Nations resolution condemning China's human rights.

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[3]The Munitions List can also include dual-use items if they are specifically designed, developed, configured, adapted, or modified for military application and have significant military or intelligence applicability such that controlling them as munitions is necessary.

[4]The law also allows the President to lift the sanctions if he reports to Congress that China has made progress on a program of political reform covering a range of issues, including human rights.

[5]Since 1990 many items once controlled on the Munitions List have been moved to Commerce Department control and are therefore no longer subject to U.S. sanctions barring their export to China. In 1992, many items were moved as part of a larger rationalization process.

Sales of Munitions List Items to China Since 1989

The United States has delivered or licensed for export to China almost $350 million in Munitions List equipment since 1990. These exports were made through (1) government-to-government agreements managed by the Department of Defense (DOD) under the Foreign Military Sales Program; and (2) commercial exports licensed by the State Department, the majority of which were related to launches of U.S.-origin satellites in China. All were authorized under presidential waivers declaring the export to be in the national interest or were specifically exempted from the sanctions under the law.

Government-to-government sales

In December 1992 President Bush issued a waiver stating that it was in the national interest to allow the export of military equipment in order to close out four government-to-government military assistance programs that had been suspended by the sanctions. The waiver stated that these deliveries would not significantly contribute to China's military capability and closing these cases would improve the prospects for gaining further cooperation from China on nonproliferation issues. The total value of these exports, which are shown in table 2, was about $36.3 million.

Table 2: U.S. Government Exports of Munitions Items to China, 1990-97

Dollars in millions

Program	Description	Deliveries
Peace Pearl - F-8 modernization	Provide modern avionics for China's F-8 fighters.	Two modified F-8 fuselages, four avionics kits, and related equipment.
MK 46 Mod 2 torpedoes	Provide 4 torpedoes for test and evaluation purposes with ultimate deployment on Chinese Navy ships and helicopters.	Four torpedoes including spares and related test and maintenance equipment.
Artillery locating radars	Provide 4 AN/TPQ-37 "Firefinder" counter-artillery radar systems.	Two AN/TPQ-37 radars, including parts and support equipment. Two of these radars had been shipped before the sanctions.
Large-caliber artillery plant	Provide production capability for large-caliber artillery munitions.	Miscellaneous components. Major equipment was shipped prior to the sanctions.

These programs were in various states of completion when U.S. sanctions prohibited further assistance or deliveries. No new government-to-government agreements have been opened since 1990. There are now no open or unfulfilled agreements pending between the U.S. government and China under the Foreign Military Sales Program.

The equipment ending these programs was delivered to China between 1993 and 1995. It included four MK-46 Mod 2 torpedoes, spare parts, maintenance, and test equipment. The Chinese Navy was to test the torpedoes for use on its ships and helicopters.

Commercial Exports of Munitions List items

The Department of State has approved for export to China about $313 million in Munitions List items since 1990.[6] As shown in table 3, about $237 million of these exports involved launches of U.S.-origin satellites from China.

Table 3: Approved U.S. Commercial Export License Applications for Munitions List Equipment to China, January 1990-April 1998

Dollars in millions

Waiver requirement	Munitions List Items	Value
Approved export licenses for Munitions List items requiring a presidential waiver for export to China	Satellites and related equipment	$236.9
	Encryption for civil applications or satellites	63.1
Approved export licenses for items not covered by U.S. sanctions	Munitions List equipment for inclusion in civil products (e.g., inertial navigation gear for civil airliners)	12.7
	Total	**$312.7**

Note: Values represent figures provided on the export applications, not the value of actual shipments. In practice, the value of actual exports is often less.

The President determined that allowing these exports was in the national interest. According to State officials, since 1990 11 presidential waivers have been issued

[6]State also denied, or returned without action, export license applications valued at over $1 billion.

removing export restrictions on 21 satellite projects. Presidential waivers were also granted to permit the export of encryption equipment controlled on the Munitions List.

Since 1990, over $12 million in export licenses have been approved for Munitions List equipment designed for inclusion in civil products. These exports are not prohibited under U.S. sanctions and therefore do not require a presidential waiver. The majority of these exports involve navigational electronics used in commercial airliners operated in China.

Between 1992 and 1996, control over exports of commercial encryption equipment and commercial satellites was moved from the Munitions List to the Commerce Department's Commodity Control List. Since U.S. sanctions restrict Munitions List exports and do not prohibit the export of dual-use items, commercial encryption equipment can now be exported to China without a presidential waiver. U.S.-origin commercial satellites, however, though no longer on the Munitions List, are covered by the law, and exports still require a presidential waiver.[7]

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[7]Other items that have moved from the Munitions List to Commerce's jurisdiction since 1990 include jet engine hot-section technology, commercial global positioning system equipment, and some night vision equipment. See our reports entitled Export Controls: Issues in Removing Militarily Sensitive Items From the Munitions List (GAO/NSIAD-93-67, May 31, 1993); and Export Controls: Change in Export Licensing Jurisdiction for Two Sensitive Dual-Use Items (GAO/NSIAD-97-24, Jan. 14, 1997.)

CHINA'S EU AND U.S. MILITARY IMPORTS COULD HELP ADDRESS SOME DEFENSE NEEDS

The small amount of EU and U.S. military item sales to China since 1989 could help address some of China's defense needs. However, their importance to China's modernization goal is overshadowed by the much larger amounts of military equipment provided by Russia and the Middle East. Moreover, before China can fully exploit such items, it must overcome obstacles in its military's command and control, training, and maintenance.

Chinese Use of EU and U.S. military items

China has used French helicopters to reinforce its weak antisubmarine warfare capabilities. According to open sources, China has imported or built under license between 65 and 105 modern French turbine-powered helicopters, including about 40 after 1989. The helicopters include the SA-321 Super Frelon (built as the Z-8) and the AS-365 Dauphin-2 (built as the Z-9). China's Navy has adapted 25 of these helicopters to serve as its antisubmarine warfare helicopter force and equipped some with antisubmarine torpedoes. Several Chinese naval vessels carry the Z-9 helicopter. China's Army has also tested the Z-9 helicopter with ground-attack equipment, including antitank missiles.

According to experts, China's only effective ship-to-air missile is the French Crotale missile system. China has deployed the Crotale on four ships, including its two most modern destroyers.[8] Also, China has reverse-engineered the Crotale--reducing China's dependence on foreign suppliers. Similarly, China has reportedly-reverse engineered the Italian Aspide air-to-air missile for use as a ship-to-air missile.

China's planned purchase of six to eight British Searchwater airborne radar systems would provide China with some degree of warning against low-flying air attacks as well as help it direct fighter aircraft, detect small vessels, and augment over-the-horizon targeting.[9] China is expected to mount the radars on converted Y-8 transport aircraft.

China could possibly use its four U.S. Mod 2 version MK-46 torpedoes to improve its copy of the Mod 1 version, which China has already deployed on its French helicopters. The early-1970s era Mod 2 has an improved computer that provides it with a re-attack capability. The MK-46 torpedo's range and speed exceed that of China's other western air launched, antisubmarine torpedo--the mid-1970s era Italian Whitehead 244S.[10]

It is unclear whether China has benefited from any of the U.S. commercial satellite transfers. State officials told us that U.S. export licenses for satellite projects in China

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[8]These ships, however, still lack long-range, ship-to-air missiles.

[9]The United Kingdom has been reported as offering its Argus airborne warning system to China, although China appears to have chosen an Israeli system.

[10]China acquired the Whitehead in the mid-1980s and has deployed it on helicopters.

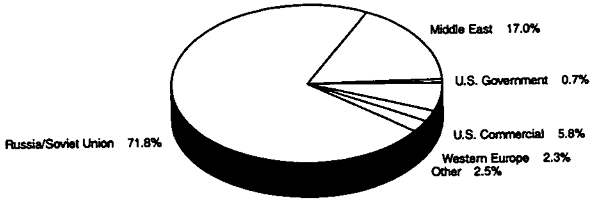
contain provisos intended to minimize the risk of any unauthorized transfer of sensitive technology. Recent press reports have asserted that, despite these controls, U.S. technology has been transferred to China that has improved the reliability of China's nuclear missiles. We have not examined the security guidelines and control procedures on satellite launches or how they are being implemented.

Russia and Middle East Provide Most of China's Modern Military Items

While these EU and U.S. military items could be used to address some modernization needs, they constitute only a small part of the range of military items that China has imported from foreign suppliers since 1989. As shown in figure 1, total EU and U.S. exports constituted less than 9 percent of the military items imported by China during the first 7 years of the embargoes. This share falls to less than 3.4 percent if U.S. exports of commercial satellites and encryption items are excluded.

Figure 1: Deliveries of Foreign Military Items to China, 1990-96

Total value: $5.3 billion (current-year dollars)



Note: The U.S. commercial share depicted above is based on the value of export licenses granted since 1990, rather than on the value of actual deliveries.

Sources: U.S. Arms Control and Disarmament Agency; the Departments of State and Defense.

Moreover, Russia and Israel have sold or agreed to sell China items that are far more lethal than those sold by EU members, as well as items similar to those obtained from EU members. For example, reported Russian arms agreements include

-- two Sovremenniy destroyers, which are more modern than China's domestically produced destroyers and which typically carry advanced supersonic antiship missiles, ship-to-air missiles with a much greater range than the Crotale, and antisubmarine helicopters that are considerably larger than the Z-9 helicopter;

-- about 50 Su-27 fighter aircraft--similar to U.S. F-15s--armed with potent air-to-air missiles, and assistance in producing more Su-27s in China;

-- about 25 Mi-17 transport assault helicopters; and

-- four Kilo diesel electric submarines (including two of a very quiet class that Russia has never before exported) and homing torpedoes.

Israel has helped China with its development of the F-10 fighter aircraft (similar to the U.S. F-16) by providing technology developed for the aborted Israeli Lavi fighter project--and of various missiles. It has also offered to sell to China its Phalcon airborne phased array surveillance radar which, if fitted to a Russian airframe, would provide China an airborne warning and command system.

China Faces Difficulties in Incorporating Modern Arms

According to experts, China will have to overcome several persistent problems before it can effectively use its imported arms to support its new military doctrine and help reinvigorate its domestic defense industry.

China lacks command and control capabilities needed to effectively integrate its armed forces in the fast-moving joint offensive operations called for by its new doctrine. China's Air Force units are hampered in their ability to communicate with air defense, naval, and ground units. China also lacks a reliable air defense intelligence system. While its future airborne early warning systems will help address this problem, China will still have to learn how to integrate such systems into its air defense system. Experts informed us that military systems integration remains a weakness for China.

China's acquisition of new and advanced military systems will also test its training and maintenance processes. China may have to significantly enhance the training, quality, and education level of its military personnel to use increasingly advanced equipment. Moreover, according to experts, China's Air Force has not yet considered the training implications of its new offensive joint operations doctrine. Chinese pilots fly fewer hours than their Western counterparts and tend to fly less demanding training missions that do not emphasize joint operations. Experts informed us that China's preference for buying relatively small numbers of foreign military systems and skimping on training and maintenance support packages reduces opportunities for its military personnel to become familiar with their new equipment and to augment China's weak maintenance efforts.

This practice of buying limited numbers of foreign systems may reflect China's interest in obtaining foreign arms for reverse-engineering purposes. China has long stressed its need to become self-sufficient in weapons development and less dependent on foreign suppliers. However, despite some successes, China has had a mixed record in reverse-engineering foreign systems. Its efforts to do so are hampered by an inefficient defense sector and by the increasing complexity of modern military systems.

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Mr. Chairman, and Members of the Committee, this concludes my prepared remarks. I. would be happy to answer any questions that you may have.

APPENDIX APPENDIX

DESCRIPTION OF SELECTED EUROPEAN UNION MILITARY ITEMS PROVIDED TO CHINA, 1990-97

According to various public sources, EU member states have delivered, or agreed to deliver, the following items to China since 1989.

-- Naval Systems for the Luhu destroyers. France has provided several systems for China's Luhu destroyers, including the Crotale missile system. France first installed the Crotale on its ships in the late 1970s. In 1982 it developed the Crotale variant later provided to China. According to public sources, the Crotale is a short-range (up to 13 kilometers), ship-to-air point defense missile. The system consists of the missile (which can travel at more than twice the speed of sound), a missile director, a missile launcher mounting, a fire control room with supporting electronics, and a console in a combat information center. The missile director uses a Castor radar, as well as infrared and television tracking systems.

Other French equipment on the Luhu destroyers includes the Sea Tiger naval surveillance radar, the Dauphin-2 (Z-9) helicopter (described later), and the TAVITAC combat data system (which is used to integrate the Luhus' various onboard systems).

-- Dauphin-2 (Z-9) Helicopter. In 1980 France agreed to allow China to build the AS-365 Dauphin-2 in China as the Z-9 helicopter. The Chinese Navy has equipped Dauphin-2s with sensors, torpedoes, and missiles for use aboard its vessels. The Dauphin-2 is a medium-weight multirole helicopter that is powered by two turbine engines. Capable of carrying 11 passengers and 2 pilots, the Dauphin-2 has a top speed of 140 nautical miles per hour and a range of 410 nautical miles. Composite materials are used in its main and rear rotor blades, and its tail rotor is built into the vertical fin.

-- Super Frelon (Z-8) Helicopter. France delivered the SA-321 Super Frelon helicopter to China in 1977 and 1978 and agreed to allow China to build the Super Frelon, under the designation of Z-8, in 1981. The Chinese Navy has used Super Frelons for anti-submarine missions and has equipped them with sensors, torpedoes, and anti-ship missiles. The Super Frelon is a heavy shipboard helicopter that is powered by two turbine engines. It has a top speed of 134 nautical miles per hour and a range of 440 nautical miles. The Super Frelon can carry 27 fully armed troops or 39 unequipped troops.

-- Aspide Missile. According to one public source, Italy developed the Aspide from the U.S. Sparrow air-to-air missile. Aspide production began in 1977. The semiactive radar-guided Aspide has a top speed of more than twice the speed of sound and a range of about 7 nautical miles.

-- Searchwater Airborne Early Warning Radar. The United Kingdom first deployed the Searchwater aboard its Nimrod aircraft in 1979 and adapted it for use aboard Sea King helicopters during its 1982 war with Argentina over the Falkland Islands. It later developed the Skymaster version of the Searchwater, which it subsequently incorporated into the Searchwater 2 system. According to a public source, the airborne Skymaster uses an I-band transmitter that can operate in (1) a pulse Doppler mode to provide look-down detection of airborne targets and (2) a frequency agile conventional mode to detect ships as well as aircraft flying above the Skymaster. When operating at 10,000 feet, it is capable of detecting (1) fighters and small boats below it at ranges of about 70 nautical miles, (2) bombers flying below it about 100 nautical miles away, and (3) larger vessels about 130 nautical miles away. The radar can store and update data on 100 airborne and 32 surface targets simultaneously.

-- F-7M/F-7MP Avionics. The United Kingdom and Italy have provided avionics for the F-7M and F-7MP fighter aircraft. The Soviet Union first authorized China to build the F-7--a variation of the MiG-21 fighter--in 1961. China later developed the F-7M and MP versions for export to other nations, including Pakistan. According to public sources, the United Kingdom provided China with heads-up displays, weapon-aiming computers, and fire control radars for the F-7M. Italy later provided a new fire control radar for the F-7M and F-7MP.

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Testimony of

Dr. Peter M. Leitner

before the Joint Economic Committee of the United States Congress

April 28, 1998 10:00 a.m.

Technology Decontrols: Striking at the Heart of U.S. National Security

Mr. Chairman, members of the committee, I am honored to appear before you today to discuss the issue of technology transfer and the release of so-called dual use technologies to potential military adversaries and countries engaged in nuclear, chemical, biological, and missile proliferation. I am obliged to point out that I am appearing today as a private citizen and not as a representative of the Department of Defense or the U.S. government.

As we meet today, the administration appears poised to announce yet another round of unilateral supercomputer decontrols. This time it is feared by many that administration excesses will extend well above the current unjustifiable 7,000 MTOP level. In 1995, "President Clinton [unilaterally] decontrolled computers up to 2,000 MTOPS [from the previous CoCom ceiling of 260 MTOPS] for all users and up to 7,000 MTOPS for civilian use in countries such as Russia"[1] and China. Providing access to even greater processing power will impart to potential adversaries and proliferators the ability to pursue design, modeling, prototyping, and development work across the entire spectrum of weapons of mass destruction. The weapons design establishments of Russia and the People's Republic of China stand to reap the greatest benefit from further decontrol.

There is growing speculation that the Clinton administration's furious push to decontrol supercomputers, widely seen as a payoff for generous campaign support and contributions,[2] was also intended to underwrite Comprehensive Test Ban Treaty (CTBT) signatures by providing an avenue for weapons testing, stockpile stewardship, and ongoing weapons development without the need for the physical initiation of a nuclear chain reaction.

On February 24, 1997, Russia's Ministry of Atomic Energy announced:

> The 1996 signature of the Comprehensive Test Ban Treaty (CTBT) has become an undoubted success in the struggle for nuclear disarmament. At the expert meetings in London in December 1995 and Vienna in May 1996, which preceded the CTBT signature, special attention was paid to the issue of maintaining security of the nuclear powers' respective arsenals under conditions of discontinued on-site testing. Nuclear arsenal security maintenance is impossible without simulation of physical processes and mathematical algorithms on high-performance parallel computers, which are currently produced in the United States and Japan. In the interests of

signing the CTBT in the shortest possible time, the U.S. and Russian experts mutually agreed on the necessity of selling modern high-performance computers to Russia.[3]

Going Virtual -- What Does It Mean?

Virtual testing, modeling, and simulation are essential to clandestinely maintain or advance nuclear weapons technology. As the planet shows no sign of nearing the point where nuclear weapons are banned, it is reasonable to assume that current or aspiring nuclear weapons states will vigorously attempt to acquire high-performance computers to advance their nuclear programs with a degree of covertness hitherto impossible to achieve.

The weapons-related research envisioned for the U.S. National Ignition Facility would rely on high-performance computers and test equipment to explore a range of activities potential adversaries may duplicate. These include:[4]

Radiation flow: In most thermonuclear devices X-radiation emitted by the primary supplies the energy to implode the secondary. Understanding the flow of this radiation is important for predicting the effects on weapon performance of changes that might arise over time.

Properties of matter: Two properties of matter that are important at the high-energy densities of a nuclear explosion are equation of state and opacity. The equation of state is the relationship among a material's pressure, density, and temperature expressed over wide ranges of these variables. Opacity is a fundamental property of how radiation is absorbed and emitted by a material. The correct equation of state is required to solve any compressible hydrodynamics problem accurately, including weapons design. Radiation opacities of very hot matter are critical to understanding the radiation flow in a nuclear weapon.

Mix and hydrodynamics: These experiments involve the actual testing of extremely low-yield fission devices (as low as the equivalent of several pounds of TNT) within a confined environment . . . to study the physics of the primary component of thermonuclear warheads by simulating, often with high explosives, the intense pressures and heat on weapons materials. (The behavior of weapons materials under these extreme conditions is termed 'hydrodynamic' because they seem to flow like incompressible liquids.) Hydrodynamic experiments are intended to closely simulate, using non-nuclear substitutes, the operation of the primary component of a nuclear weapon, which normally consists of high explosive and fissionable material (the plutonium pit). In hydrodynamic experiments, the properties of surrogate pits can be studied up to the point where an actual weapon releases fission energy. High explosives are used to implode a surrogate non-fissile material while special X-ray devices (dynamic radiography) monitor the behavior of the surrogate material under these hydrodynamic conditions.[5]

X-ray laser research: Supercomputer-based experiments could provide data for comparison with codes and could be used to further interpret the results of past underground experiments on nuclear-pumped X-ray lasers.

Computer codes: The development of nuclear weapons has depended heavily on complex computer codes and supercomputers. The codes encompass a broad range of physics including motion of material, transport of electromagnetic radiation, neutrons and charged particles, interaction of radiation and particles with matter, properties of materials, nuclear reactions, atomic and plasma physics, and more. In general, these processes are coupled together in complex ways applicable to the extreme conditions of temperature, pressure, and density in a nuclear weapon and to the very short time scales that characterize a nuclear explosion.

Weapons effects: Nuclear weapons effects used to be investigated by exposing various kinds of military and commercial hardware to the radiation from actual nuclear explosions. These tests were generally conducted in tunnels and were designed so that the hardware was exposed only to the radiation from the explosion and not the blast. The data were used to harden the equipment to reduce its vulnerability during nuclear conflict. Without nuclear testing, radiation must be simulated in above-ground facilities and by numerical calculations.

Verification Technologies Made Irrelevant

On a prima facie level most would instinctively argue that eliminating nuclear chain-reaction explosions from the planet is highly desirable and would help make the world a safer place. However, the reverse may actually be the case; that is, the elimination of physical tests and their migration to cyberspace may make the world a more dangerous place. Can such a counterintuitive proposition be true? Consider the trillions of dollars' worth of detection, monitoring, and early-warning infrastructure designed to identify and measure foreign nuclear weapons programs that would be rendered useless by virtual testing.

The term national technical means of verification (NTM) is often used to describe satellite-borne sensors, but it is more generally accepted as covering all (long-range) sensors with which the inspected country does not interfere or interact. Ships, submarines, aircraft, and satellites can all carry monitoring equipment employed without cooperation of the monitored country. Ground-based systems include over-the-horizon (OTH) radar and seismic monitors. Acoustic sensors will continue to provide the main underwater NTM for monitoring treaty compliance.

The first of the high-technology methods of treaty monitoring were the U.S. VELA satellites, designed in the 1960s to monitor the Limited Test Ban Treaty. Their task was to detect nuclear explosions in space and the atmosphere.[6]

> At precisely 0100 GMT on Sept. 22, 1979, an American satellite recorded an image that made intelligence analysts' blood run cold. Looking down over the Indian Ocean, sensors aboard a VELA satellite were momentarily overwhelmed by two closely spaced flashes of light. There was only one known explanation for this bizarre phenomenon. Someone had detonated a nuclear explosion. The list of suspects quickly narrowed to the only two countries at the time that had the materials, expertise, and motivation to build a nuclear weapon: South Africa and Israel. Both denied responsibility.[7]

This event was not confirmed until 1997, when Aziz Pahad, South African deputy foreign minister, stated "that his nation detonated a nuclear weapon in the atmosphere vindicating data from a then-aging Vela satellite."[8] Pahad's statements were confirmed by the U.S. Embassy in Pretoria, South Africa.

VELA's modern counterparts include the global positioning system (GPS) satellites. While these also have the function of providing navigational and positional data, their alternate role is to detect nuclear explosions, and to this end they mount both X-ray and optical sensors. However, "as nuclear detectors in orbit on Global Positioning System satellites age, the credibility of their data again could be challenged, and have subsequent adverse policy impacts."

> Without strong evidence of a nuclear test no Administration official is going to charge another nation with violating a test ban treaty, for example. Los Alamos and the U.S. Energy Dept. have

expended approximately $50 million to develop a new generation of space-based nuclear detection sensors, but they may never get into orbit. Pentagon budget woes could preclude inclusion of EMP sensors on next-generation GPS satellites, according to Los Alamos officials.

Researchers who developed the new sensors said it is ironic that funding constraints could force a decision to keep the detectors grounded. After all, had the old Vela satellite been equipped with a functioning EMP detector, it would have confirmed that the optical flash in September 1979 was a nuclear blast. The White House panel subsequently stated that, because nuclear detonations had such critical ramifications and possible consequences, it was imperative that systems capable of providing timely, reliable corroboration of an explosion be developed and deployed.[9]

The following types of verification technologies, among others, would be rendered ineffective or irrelevant by the migration of nuclear weapons testing to supercomputer-based simulation and modeling.

SPACED-BASED OPTICS AND SENSORS. Several satellites, such as GPS, Teal Ruby, Lacrosse, and the KH series, have telescopes and an array of detectors that are sensitive to various regions of the electromagnetic spectrum.

RADAR. Lightweight space-based radar aboard satellites such as Lacrosse or AFP-731 (KH-12), which are capable of penetrating heavy cloud layers and monitoring surface disturbances at suspected nuclear test sites.

LISTENING POSTS. Hydroacoustic stations located on Ascension, Wake, and Moresby Islands and off the western coasts of the United States and Canada and Infrasound arrays in the United States and Australia detect underwater and suboceanic events and distinguish between explosions in the water and earthquakes under the oceans. Some seismic stations located on islands or continental coastlines may be particularly useful since they will be able to detect the T phase--an underwater acoustic wave converted to a seismic wave at the edge of the landmass.

RADIONUCLIDE MONITORING NETWORK. A new effort is underway to detect Xenon-133 and Argon-37 seepage into the atmosphere days or weeks after a nuclear weapons test.[10] The inadvertent release of noble gases during clandestine nuclear tests, both above and below ground, represents an important verification technique. As nuclear explosions produce xenon isotopes, and xenon can be detected in the atmosphere, its concentration determined by noble-gas monitoring is very useful.[11]

SEISMIC DETECTORS. The United States has set up a worldwide network of seismic detectors, like those used to measure earthquakes, that can gauge the explosive force of large underground nuclear tests. Research programs funded by the Department of Defense improved monitoring methods for detecting and locating seismic events, for discriminating the seismic signals of explosions from those of earthquakes, and for estimating explosive yield based on seismic magnitude determinations.

A 1-kiloton nuclear explosion creates a seismic signal of 4.0. There are about 7,500 seismic events worldwide each year with magnitudes $\geq$ 4.0. At this magnitude, all such events in continental regions could be detected and identified with current or planned networks. If, however, a country were able to decouple successfully a 1-kiloton explosion in a large underground cavity, the muffled seismic signal generated by the explosion might be equivalent to 0.015 kilotons and have a seismic magnitude of 2.5. Although a detection threshold of 2.5 could be achieved, there are over 100,000 events worldwide each year with magnitudes $\geq$ 2.5. Even if event discrimination were 99% successful, many events would still not be identified by seismic means alone. Furthermore, at this level, one must distinguish possible nuclear tests not only from earthquakes but also from chemical explosions used for legitimate industrial purposes.[12]

Aiding and Abetting Proliferation

One of the lessons learned from the destruction of Saddam Hussein's nuclear weapons program was that a proliferant may be quite willing to settle for hydrodynamic testing of its prototype nuclear weapons as an uneasy certification for including them into its arsenal.

> The Iraqis were designing exclusively implosion-type nuclear weapons. Their apparent exclusive focus on U^{235} as a fuel is, therefore, puzzling because plutonium is the preferred fuel for an implosion weapon [as] . . . the mass of high explosives required to initiate the nuclear detonation can be far smaller. On the other hand, given enough U^{235} it is virtually impossible to design a nuclear device which will not detonate with a significant nuclear yield.[13]

> The Iraqi nuclear weapon design, which appeared to consist of a solid sphere of uranium, incorporated sufficient HEU to be very nearly one full critical mass in its normal state. The more nearly critical the mass in the pit, or core, the more likely the weapon will explode with a significant nuclear yield, even if the design of the explosive set is relatively unsophisticated. Furthermore, the majority of the weight involved in an early-design implosion-type nuclear weapon is consumed by the large quantity of high explosives needed to compress the metal of the pit; the more closely the pit approaches criticality, the less explosive is needed to compress the pit to supercritical densities and trigger the nuclear detonation, and thus the lighter, smaller, and more deliverable the weapon will be.[14]

Given the limited access to fissile materials facing most potential proliferants and the threat of a preemptive strike by a wary neighbor, as we saw in 1981 when Israel destroyed the Iraqi Osirak reactor, proliferants cannot readily engage in physical testing along the lines of the superpower model. U.S. actions to promote the availability of high-performance supercomputers will likely contribute to the proliferation problem by facilitating access to modeling and simulation, which will give clandestine bomb makers greater confidence in the functionality of their designs. This increased level of confidence may be all that a belligerent may require to make the decision to deploy a weapon. Sophisticated modeling and simulation will enable clandestine programs to advance closer to the design and development of true thermonuclear weapons.

From a historic perspective it is interesting to note that the concept of a comprehensive test ban was repeatedly forwarded by the Russians throughout the 1980s and consistently rejected by the United States. In the 1990s a strange reversal occurred with the United States advocating a CTBT and the Russians becoming reluctant to go along. This shift parallels the explosion in high-speed computing potential emanating from the United States and the relatively stagnant progress of Russian indigenous capabilities. There may be much truth in the statement of a MINATOM official that: "The United States has made much better provisions than Russia for giving up nuclear testing. Supercomputers used for virtual-reality modeling of the processes of nuclear explosions have played a decisive role in that."

If the Russian claim that the United States reneged on a promise of supercomputer technology in exchange for accession to the CTBT is accurate, then the very value of this treaty must be questioned. If, as a price for Russia's signature, the Clinton administration was willing to provide the means of circumventing both its spirit and explicit goals, then the treaty should be regarded as little more than a sham to be rejected by the U.S. Senate.

48-028 98 - 5

If high-performance computers were made available to the Russian nuclear weapons design bureaus the historical database accumulated from their previous nuclear tests will be the most significant factor in maintaining their stockpiles. In the absence of physical testing they would be able to simulate a wide range of nuclear weapons design alternatives including a variety of unboosted and boosted primaries, secondaries, and nuclear directed-energy designs.[15]

In addition, the modeling and simulation efforts will help them to maintain a knowledgeable scientific cadre and to continue to verify the validity of calculational methods and databases. Under a test ban, only computer calculations will be able to approximate the operation of an entire nuclear weapon. Other states would also recognize the value of advanced simulation research in helping to develop or maintain nuclear weapon programs. In addition, high-performance computers may make it possible for micro-physics regimes of directed-energy nuclear weapon concepts to be investigated as well.[16]

Few were happy when the United States helped the United Kingdom become a nuclear power. Even fewer were pleased when the United States helped the French develop an independent nuclear capability. Assisting the Russians in maintaining and further developing their nuclear arsenal is outrageous. Unfortunately, U.S. nuclear proliferation activities do not end there. If the persistent rumors are true that the United States is even considering providing aid to China to sustain its nuclear weapons modernization program in a CTBT environment, then alarm bells should be sounding on Capitol Hill on the unintended consequences of reckless disarmament.

Will the synergistic effect of the CTBT and the decontrol of supercomputers make the world a safer place or a more dangerous place? Our uncertainty anticipating the nuclear intentions of potential adversaries will increase as the result of an increasingly opaque window into their programs. As to whether this will translate into a quantifiable increase in the risk of nuclear war or terrorism intuitively the answer appears to be yes, but how much is uncertain.

U.S. willingness to trade supercomputer technology for treaty signatories and its own rush toward virtual testing make a farce of pretensions to high moral ground in criticizing others for rejecting the CTBT. "Pakistan or India . . . could be forgiven for suspecting that the five major nuclear powers, which asserted for years that testing was critical to maintaining deterrence, have now advanced beyond the need for nuclear tests. All the more reason, perhaps, for them to oppose the treaty."[17]

National Security vs. Market Share

The level of irresponsibility displayed by this administration toward our current national security and the legacy of physical security being left for our children are the most distressing developments of all. The blind pursuit of market share and the disregard of our national security were again demonstrated by the February 1998 U.S. proposal to the Wassenaar export control forum for the accelerated de-listing of virtually all telecommunications technology and equipment. If this proposal goes through it will result in free and open access by even the rogue states to state-of-the-art optical fibers, transmission equipment, switches, repeaters, high-speed computer network systems, advanced encryption, etc., which forms the backbone of military battle management, air defense, command and control, missile launch, and joint R&D development efforts.

As one of the architects of this so-called Wassenaar regime, the United States agreed to incorporate a series of "validity notes" in the text. Essentially, these notes are trap doors that are timed to spring open this fall and drop several key technologies from any form of international export control. The two principal technologies poised to fall out are telecommunications and machine tools.

To maintain these items on the export control lists requires unanimity from the member states. Unfortunately, as the organization's membership has expanded to include countries that were historically the target of export controls -- some of which still should be -- the likelihood of these controls surviving beyond this fall is very remote. Certainly, British proposals to maintain telecommunications as an item of control face great difficulty in overcoming U.S. calls for immediate pre-emptive decontrol. The weak U.S. position in seeking to extend machine tool controls beyond the fall deadline must be taken with a grain of salt as Wassenaar members that are also machine tool builders will demand decontrol at least equivalent to U.S. telecommunication proposals. After all, the United States continues to take the lead in scrapping national security controls in favor of market share.

As most Wassenaar member nations rely upon this list as the basis for their domestic export control systems, when a technology falls from that list it also disappears from their domestic systems as well. The result is the unrestrained export and re-export of commodities and technologies, which in the hands of potential adversaries will prove deadly.

To compound these problems in a most spectacular fashion is the pending administration decision to perpetrate another technological fiction known as the MD-17. Basically the MD-17 is the brand-new C-17 painted blue and white and incorporating some other minor cosmetic changes so that it may soon be termed a "civil" aircraft by the administration. This action appears to be motivated purely around attempts to lower the unit cost of this $170 million strategic airlifter so the U.S. military can afford to buy more of them. The game is to free this aircraft from the control of the ITAR (International Traffic in Arms Regulations) administered by the State Department and place it under the jurisdiction of the extraordinarily weak CCL (Commodity Control List) run by the Commerce Department. If the MD-17 is termed a civil airliner it will no longer be subject to sanctions such as those imposed upon the PRC after the Tiananman Square massacres. It will be free to be sold to China so long as a Department of Commerce export license is obtained. Unfortunately as the Commerce Department controls are extraordinarily non-specific when it comes to "non-military" transport craft, you can expect to see the PLAAF flying MD-17's in future military adventures.

The MD-17 will provide the PRC with the long-range military logistics support it currently lacks. This capability to deliver military supplies in any weather, over great distances, to even the most remote and austere ground locations will provide the missing link to PRC power projection needs. The lack of strategic and tactical airlift has been one of the principal factors limiting PRC expansionist ambitions. Once such aircraft are made available and incorporated into their military doctrine the critical mass may be reached for PRC decisionmakers for the military supported pursuit of historic territorial claims and the securing of vulnerable oil resources to their East, South, and West.

If experience is any guide we should also anticipate with a considerable degree of confidence that this "civil" aircraft will quickly become the target of PRC manufacturing ambitions as well. Considering the fact that the infamous Columbus, Ohio "Plant 85" where critical parts for the C-17 were manufactured was sold to the PRC the Chinese should be well positioned to begin manufacturing this aircraft locally. That transfer, and the subsequent diversion of some key equipment to a Chinese missile factory, is reportedly the subject of a federal grand jury investigation.

The critical mass issue is one of the greatest unknowns in predicting future events. One thing is certain however the continuing hemorrhage of U.S. and western "dual-use" technology will manifest itself in Chinese military capabilities. Where the "red-line" exists in the PRC's strategic calculus between capabilities, confidence, and mission requirements can only be inferred at this point. But what is certain is that the unique Chinese world outlook, practicality, military doctrine, national requirements, and geopolitical/military position will result in strategic surprise for the U.S. both in terms of where they will apply military force and the unique manner in which it will be applied.

Recent head-to-head competition between Russia and China to supply Iran with a nuclear reactor complex demonstrates the increasing willingness to collaborate with potential customers rather than cooperate with the West on proliferation issues. The current portrayal of the Chinese as being forthcoming on proliferation matters is a political fiction. Their backing away from Iranian nuclear cooperation was the result of losing out to the Russians on the reactor complex deal. Any appearance of a more judicious approach by the PRC is just that "appearance." It the Russians fail to deliver under their new contract then the PRC will certainly be first in line to offer the Iranians whatever they want.

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[1] Journal of Commerce (November 25, 1996):1A.
[2] Michael Waller, Vice President of the American Foreign Policy Council, Testimony before the House National Security Committee, Subcommittee on Military Research and Development (March 13, 1997).
[3] ITAR-TASS (February 26, 1997) Press Release, Information Department, Ministry of Atomic Energy of Russia, Presented by G.A. Kaurov, Department Head, February 24, 1997.
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[5] Michael Veiluva, John Burroughs, Jacqueline Caabasso, Andrew Liichterman. Laboratory Testing in a Test Ban/ Non-Proliferation Regime (Western States Legal Foundation, April 1995). http://www.chemistry.ucsc.edu/anderso/UC_CORP/testban.html.
[6] "Means to an End," International Defense Review Vol. 24; No. 5 (May 1, 1981):413.
[7] Jim Wilson. "Finding Hidden Nukes," Popular Mechanics (May 1997):48.

[8] William B. Scott. "Admission of 1979 Nuclear Test Finally Validates Vela Data," Aviation Week & Space Technology Vol. 147, No. 3 (July 21, 1997):33.
[9] Ibid
[10] Wilson, op. cit., 50.
[11] Prototype International Data Center, Report of the Radionuclide Export Group, www.cdidc.org:65120/librarybox/ExpertGroup/8dec95radio.html
[12] Prototype International Data Center, Contributing to Societal Needs, http://earth.agu.org/revgeophys/va..4.htnl.
[13] Peter D. Zimmerman, Iraq's Nuclear Achievements: Components, Sources, and Stature, U.S. Congressional Research Service Report #93-323F (February 18, 1993).
[14] Ibid.
[15] U.S. Department of Energy, The National Ignition Facility and the Issue of Nonproliferation www.doe.gov/html/doe/whatsnew/nif/nonpro2.html.
[16] Ibid.
[17] W. Wayt Gibbs. "Computer Bombs: Scientists Debate U.S. Plans For 'Virtual Testing' of Nuclear Weapons" Scientific American (March 1997): 16.

Multiplier Effect

The military value of high performance computers cannot be determined from their isolated characteristics but must be considered within the environment in which they will be used. They are essential to a host of military or nuclear programs which require computational complexity and extreme accuracy such as:

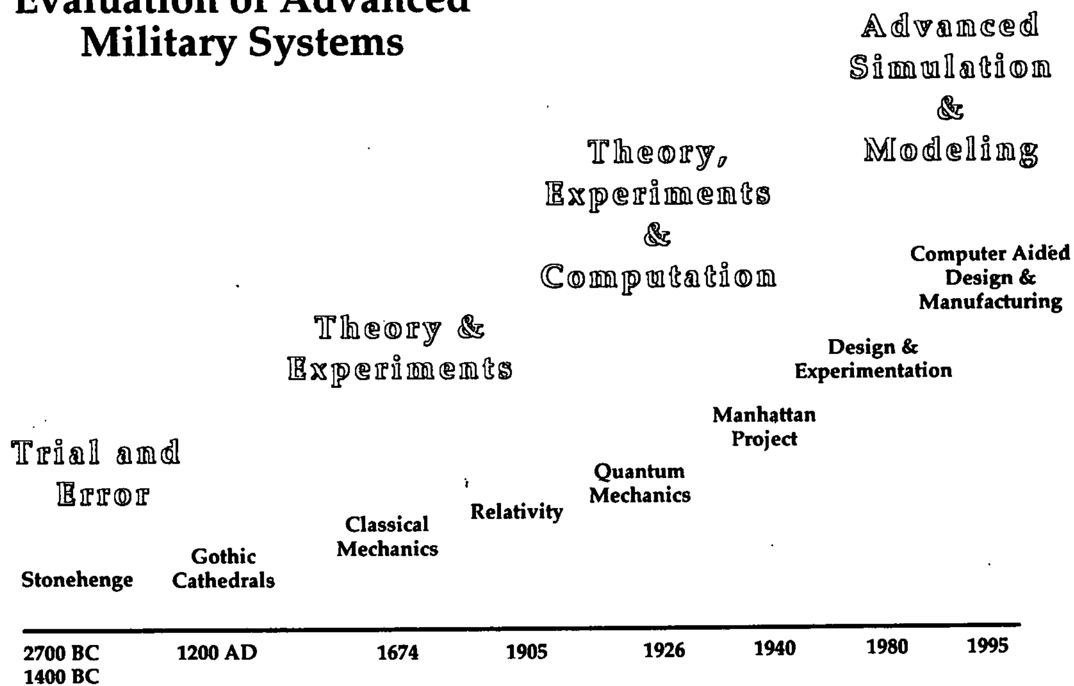
Simulation of missile, rocket and submarine performance.

Simulation of ablation and deformation of nuclear warheads during atmospheric reentry.

Simulation of nuclear weapons effects in lieu of atmospheric or underground testing.

Possession of high-performance computers will enable the design and testing of nuclear, chemical and biological weapons as well as missiles and aircraft in total secrecy. Traditional warning indicators of threatening activities such as large wind tunnels, instrumented test ranges, and seismic disturbances will no longer be available to intelligence analysts. This loss of strategic warning due to the "virtual" nature of future weapons development programs will drive the creation of a new multi-billion dollar per year "Information Warfare" program whose aims will include detection and disruption of clandestine weaponization activities.

High Speed Computers Crucial for Design, Test, and Evaluation of Advanced Military Systems



Testimony of

Dr. Peter M. Leitner

before the Committee on Governmental Affairs of the United States Senate

June 25, 1998
10:00 a.m.

Dual Use Technology Export Licensing Process: Wired to Fail

Mr. Chairman, members of the committee, I am honored to appear before you today to discuss the transfer of so-called dual-use technologies to potential military adversaries and countries engaged in nuclear, chemical, biological, and missile proliferation. I would like to state for the record that I am appearing here today in response to a subpoena and not as a spokesman for DoD or the U.S. government.

For the past 12 years I have been a senior strategic trade advisor within DoD's Defense Technology Security Administration. I have served as international negotiator for export controls over machine tools, controllers, robots, industrial equipment, software, and navigation and guidance equipment. I was also the chairman and head of the U.S. delegation to the Paris-based eight-country study group on Advanced Materials for Weapons Systems and the study group on Defense Production Technology and Equipment. In addition, I have been a licensing officer overseeing exports to various proscribed countries including China, Libya, Iraq, former Warsaw Pact countries, Iran, and India. Currently, I am DoD's representative to the Subcommittee on Nuclear Export Controls (SNEC). My tenure has given me the opportunity to witness the birth, development, maturity, and premature death of DoD's credible role as the guardian of U.S. technology security.

Let me state up front that over the past six years the formal process to control exports of dual-use items has failed its stated mission -- to safeguard the national security of the United States. On several levels, what passes for an export control system has been hijacked by longtime ideological opponents of the very concept of export controls. Six years ago, opponents of export controls were granted direct responsibility for managing the Defense Department's role in this important process. DoD has suffered the greatest damage. Unfortunately, the wrecking ball is still swinging, and on October 1, 1998, it will level the last vestiges of DoD's role in the process.

Through a tireless campaign, the opponents of export controls have managed to destroy the 16-nation Coordinating Committee on Export Controls (CoCom) and decontrol vast arrays of critical military technology, rewire the U.S. domestic export control process so that it is structurally unsound and unable to safeguard our security, and erect a series of ineffectual domestic regulations and international working groups designed to project a false impression of security, deliberation, and cooperation. This Potemkin Village has been constructed to deceive both the Congress and the American people and lull us all into a false sense of security while short-sighted business interests line their pockets at the expense of future generations of American soldiers and citizens alike.

Mr. Chairman, the single point of greatest failure in maintaining a credible export control system was the neutering of the Defense Department's traditional role as the conservative anchor. First, DoD's key staff were effectively removed from the chain of command and the decision-making process within DoD. DoD abandoned its traditional role and instructed DoD employees to side with the Commerce Department and isolate the State Department and the Arms Control and Disarmament Agency (ACDA) on many issues.

The campaign to isolate DTSA began in earnest with the arrival of David Tarbell as the director of DTSA. DTSA personnel were cut off from most technology security-related activities in the Defense Department. Whereas DTSA was once the linchpin for these issues within the department it was quickly marginalized by its own leadership. To clamp down this quarantine, DTSA management instructed the Pentagon to, in effect, prohibit DTSA personnel from receiving the USDP Daily Report, a summary of a broad range of issues important to DoD staff (see Attachment 1). This cut-off was both malicious and damaging to the organization's mission. It should be noted that the Daily Report, an E-mail distributed document, is available to hundreds of other OSD personnel, including interns.

As if these steps were not enough, as part of the campaign to marginalize —but maintain the illusion of an effective organization— DTSA management placed staffers with little to no experience or technical aptitude in key positions representing DoD in interagency meetings. DTSA representation has become the joke of the interagency process due to its putting its weakest foot forward. In addition, the revolving door of compliant military personnel being hired into DTSA civilian vacancies has helped to undermine the morale and competence of the entire organization. It should be noted that these practices were among the dozens of findings in a devastating 1992 DoD/IG report.

Shorting Out the Licensing Process

As the purpose of today's hearing is to review the licensing process, I would like to begin by describing the current process, how it has changed over time, and the impact of these changes upon our national security. The three charts in Attachment 2 are designed to illustrate these issues.

As shown in Chart 1, Pre-1992, a typical export license application followed a relatively straightforward path. The process began when an application was submitted to the Commerce Department. If Commerce deemed it appropriate the case was staffed to State, Defense, Energy, ACDA, or the NRC for review. Each agency provided its recommendation to approve, deny, or refer to one of the specialized interagency subcommittees on nuclear, missile, or chemical-biological warfare (CBW) issues. If agencies could not arrive at a consensus-based position, then the case would be escalated to the Operating Committee. If the WMD-focused subcommittees failed to agree, then the case would be escalated directly to the Advisory Committee on Export Controls (ACEP).

Chart 2 depicts the erection of the first of the firewalls that have come to dominate the process. This invisible barrier represents the unwillingness of DoD officials to escalate disputed cases beyond the ACEP. Unfortunately, in this process, failure to escalate and fight on behalf of a minority view means you lose. Commerce was quick to sense DoD's lack of resolve. Then the predictable took place. Commerce began pushing the envelope on virtually all issues and boldly overruled a weak and ineffectual DoD. It wasn't long before DTSA staff began receiving stunning instructions from their director to support DoC on a variety of issues. DoE and ACDA increasingly distanced themselves from DoD positions because of DoD's failure to protect its own mission areas. It should be noted that national security-minded staff in DoE were being similarly undermined.

Chart 3 shows the process calcifying with the promulgation in December 1995 of Executive Order 12981. This highly deceptive document purported to broaden DoD's role in export licensing by increasing the number of cases DoD would be permitted to review. But what the right hand giveth, the left hand taketh away. The Executive Order divorced the weapons of mass destruction (WMD) focused committees from the ACEP and elevated the Commerce-chaired Operating Committee to new heights of power and influence by breaking the peer relationship with its sister committees and making it the only committee to report to the ACEP. The Missile Technology Export Committee (MTEC), the Subcommittee on Nuclear Export Controls (SNEC), and the Shield (Chem/Bio issues) committee were all relegated to insignificant positions as they lost the ability to vote a case directly to the ACEP. Thus a second firewall was erected and serves as a barrier to prevent the most knowledgeable participants in the interagency process from being able to directly inform policymakers on the most profound technology transfer issues of the day.

As if these changes weren't enough, the Executive Order also shortened the time available for the USG to screen license applications. Combined with a further draconian shortening of the time allowed by DTSA management to review cases within DoD, the system is designed for failure. For example, when a case comes to DoD for review DTSA's internal engineering staff have approximately four hours to undertake a technical review of perhaps 20 to 30 cases each day. Approximately 70 percent of the cases are approved outright based upon the meager information contained in the license. The technical reviewer generally does not get a second look at the case. Agencies have only 10 days to ask questions. After that no questions are allowed.

As the charts in Attachment 3 reveal, at the same time that the December 1995 Executive Order was handed down, DTSA's role in the process was further diminished. DTSA in turn slashed the role played by the armed services, the Defense Intelligence Agency, and the National Security Agency by limiting the number of licenses referred for their review. These organizations, of course, possess the most credible and critical decision support information. DTSA's shutting them out cripples efforts to discern the national security implications of licensing decisions. In addition, DTSA management began arbitrarily dismissing valid intelligence information because "it was over one year old." Thus when faced with evidence that would have traditionally been termed "a smoking gun" the chain of command now capriciously rejects intelligence data and technical analysis when it suits them.

Matters are even worse in the case of supercomputer licensing.

A DoD That Won't Say No

The Defense Department was the leader in successful efforts to decontrol exports of supercomputers capable of processing vast quantities of complex information and supplied funding and other forms of assistance to contractors hired to justify preconceived policy initiatives in this regard. In a strategic context, such computer systems typically figure in weapons development laboratories, nuclear weapon simulation and modeling facilities, ICBM warhead design activities, and a host of other critical military applications. DoD's leadership harked right back to the role played by the new DoD chain of command in decades-long efforts to reform [read scrap] the export control system centered at the National Academy of Sciences.

Was it any wonder that DoD officials were unhappy when the Congress mandated, in Section 1211 (a) of the National Defense Authorization Act for Fiscal Year 1998, that Commerce was required to forward to the Defense Department all computer license applications for systems exceeding a certain level of performance? This new authority was an unwanted gift to some in DoD who led the charge to decontrol the very computers Congress addressed in the law. The White House immediately sought to neutralize this congressionally mandated requirement by requiring the signature of an under secretary in order to object to such an export (see Attachment 4). The Commerce Department narrowed the window even more by refusing to recognize the right of DoD officials to delegate authority internally.

As we meet today, the administration appears poised to announce yet another round of unilateral supercomputer decontrols. This time many fear that administration excesses will extend well above the current unjustifiable 7,000 MTOPS level. In 1995, "President Clinton [unilaterally] decontrolled computers up to 2,000 MTOPS [from the previous CoCom ceiling of 260 MTOPS] for all users and up to 7,000 MTOPS for civilian use in countries such as Russia" and China. This will enhance proliferators ability to pursue design, modeling, prototyping, and development work across the entire spectrum of weapons of mass destruction. The weapons design establishments of Russia and the People's Republic of China stand to reap the greatest benefit from further decontrol.

Just last year, DoD officials went along with a proposal from a minor DoE office director to decontrol oscilloscopes -- an item controlled for nuclear nonproliferation concerns. Remarkably, rather than opposing this reckless initiative, which was not coordinated with higher-level authorities, DoD counter-proliferation and DTSA officials supported it. DTSA officials even went so far as to bar its employees from addressing the vital nuclear weapons applications for oscilloscopes and limited position papers to the non-nuclear military uses of these instruments -- a weak argument at best, as they were controlled for nuclear non-proliferation reasons only.

A quick peek inside the instrumentation trailers and shacks set up around the Indian and Pakistani nuclear test sites would likely reveal scores, if not hundreds, of advanced oscilloscopes, reflectometers, computers, transducers, spectrometers, and other data-capture instruments whose export decontrol was championed by the administration. The United States developed and pushed decontrol both domestically and in the already ineffectual international regimes known as the Nuclear Suppliers Group and the Wassenaar dual-use technology regime. The oscilloscope decontrol took effect in 1997, just in time for India and Pakistan to freely procure as many oscilloscopes as they needed to install at their test sites. The Department of Defense became the incongruous champion of the wholesale decontrol of advanced computers while the Department of Energy promoted the decontrol of oscilloscopes despite the fact that they were originally invented to support DoE's nuclear test program. The main beneficiaries of these decontrols were intended to be the U.S. oscilloscope manufacturers and their Swiss affiliates which lobbied the Clinton administration in an effort to freely export their nuclear-proliferation sensitive products to India and China.

Nothing can more graphically illustrate how deeply embedded is the refusal to say no in DoD's current psyche than the DTSA internal routing sheet in attachment 5. This sheet is used to solicit and coordinate positions and recommendations on important issues including Memoranda of Understanding (MoU's), international agreements, data and exchange meetings, exemptions to Foreign Military Sales (FMS) policies, waivers and exemptions to established policies – including satellite launch policies. As you will notice, there are only two possible options given for DTSA analysts to return: Approval or Approval. The analyst who seeks to deny an export has no avenue to express an objection.

Waging a Scorched-Earth Campaign

On October 1, 1998, the final death knell will sound for DoD's role in the export control process. The pending merger of DTSA into the new Defense Threat Reduction Agency (DTRA) is a national security disaster in the making. This reorganization will result in the removal of DTSA from OSD Policy and place it within the Acquisition part of DoD.

First, historically, DTSA and Acquisition have been bitter adversaries over sanctions and export controls. Acquisition's primary interest naturally lies in lowering the unit cost of goods they procure for the military and in maintaining a healthy defense industrial base. Exports are seen as important profit centers, and overseas markets have long been viewed as a primary means of achieving economies of scale and lower unit costs. Export controls, sanctions, and embargoes appear, through Acquisition's lens, as running contrary to their mission.

Second, the merger will create a basic conflict of interest. DTSA is often asked to express an opinion/judgment on export license requests that Acquisition is sponsoring. This is true for both dual-use and ITAR items and involves several organizations. Placing DTSA under the command of parties that are net exporters raises the serious specter of conflicts.

Third, calling for the physical relocation of DTSA from its traditional Crystal City location and dropping it out at Dulles airport will be the coup degrace. DTSA personnel have been key players in interagency meetings and activities including SNEC, OC, MTEC, Shield, NEVWIG, missile launch arrangements, Wassanaar, etc. Personnel will no longer attend a great many meetings, planning sessions or crisis teams, which are essential if DoD is going to regain its former status as a credible player in the interagency process.

Fourth, the new director of DTRA is a Lawrence Livermore National Laboratory staffer who will occupy the position for a few years as an IPA fellow. This creates yet another conflict of interest as DoD staff often deny cases bound for DoE-financed programs within the former Soviet Union. Most of these programs are administered by DoE labs including Livermore. These denials have generated considerable anger throughout DoE in spite of the fact that DoE refuses to turn over evidence, repeatedly requested by DoD of a technology security plan for U.S. financed technology transfer programs. These programs alone are deserving of a major round of congressional oversight hearings.

Technology Security vs. Balance of Trade

For the Defense Department, both uniform and career civilian personnel, the philosophy of containment and technical superiority endures as an echoing mantra. The philosophy of the Department of Commerce, however, is one of economic engagement. This philosophy is generally agreed with, if not vigorously endorsed, by high level political appointees in all departments and agencies -- including DoD.

These philosophies are, of course, diametrically opposed. Technology sold to a potential adversary that can be used to close the technical gap between its military systems and ours diminishes our national security. Any short-term gain in our economy would, with this result, represent at best a Pyrrhic victory. The flip side to the argument is that by engagement our economy is improved. This provides incentives for increased R&D to maintain the technical gap. The biggest beneficiary in such a cycle would be the defense industry, which would be called upon to save us from our own trade policy.

The National Science and Technology Council Committee for National Security listed three conclusions in its Phase 1 Progress report briefing (28 April 1997):

1. Government controls over controlled technology are effective within legal and regulatory guidelines, but license decisions are generally made based on narrow evaluation factors and so do not include analysis of multidimensional and long-term effects.

2. The government does not have a comprehensive understanding of the effects on U.S. national security interests of the international flow of both controlled and uncontrolled technology.

3. Collecting and analyzing sufficient data to develop a comprehensive understanding of the international flow of both controlled and uncontrolled technology and its effects on U.S. national interests to determine if adjustments to policy are called for would be a major undertaking.

Controlled technology is being redefined as uncontrolled technology at an unprecedented rate and is being exported despite the fact that the government does not have a comprehensive understanding of the effects on national interests. While claims of "regulatory effectiveness" are made relative to controlled technology (again, which is being nearly defined out of existence), the government has no clue concerning multidimensional and long-term effects. Why? -- it would be a major undertaking and would almost certainly expose the recklessness of current export control policy.

The export control system works only when there is a strong degree of creative tension between agencies. This natural adversarial approach ensures full and open debate. In addition, it is vital that higher echelons be regular participants in the process, and this is only achieved through escalation of issues to their level. Pre-emptive surrender because one does not want to involve higher authorities or because one is afraid that escalation may be misinterpreted as a personal failure to resolve issues does a great disservice to the agency's mission, the process, and this nation's physical security. DoD's consistent pattern of weak or no opposition, capitulation, and failure to escalate issues is the single greatest factor in the loss of tension from the system and its consequent failure to execute its mission.

Who's Next?

Tragically, nowhere in this government are analyses being performed to assess the overall strategic and military impact of the technology decontrols I have described in my testimony before the Joint Economic Committee on June 17, 1997 and April 28, 1998. Nor are any analyses being performed on the impact of the day-to-day technology releases being made by the dysfunctional export licensing process. Yet it is precisely at the "big picture" level where the overall degradation of our national security will be revealed. Without such assessments the government will continue to blunder along endangering the lives of our citizens unnecessarily.

ATTACHMENT 1

USDP DAILY REPORT FOR 09 April 1997

SPECIAL OPS AND LOW INTENSITY CONFLICT

(U) FY 1996 REPORT TO CONGRESS PURSUANT TO 10 U.S.C. 2011, TRAINING OF SPECIAL OPERATIONS FORCES WITH FRIENDLY FOREIGN FORCES.

(U) PRESIDENT'S TRAVEL TO THE CARIBBEAN.

STRATEGY & REQUIREMENTS

(U) NDP DIRECTOR JEHN SPEAKS TO NORWEGIAN DELEGATION:

(U) PEACEKEEPING TRAINERS CONFERENCE:

(U) FAILED JUSTICE SYSTEMS:

INTERNATIONAL SECURITY AFFAIRS

(C) [ ]

(C) [ ]

(U) ZAIRE HEARING.

(C) [ ]

(C) [ ]

(C) [ ]

(U) POTUS CARIBBEAN SUMMIT COMMUNIQUÉ DRAFTING MEETING.

(S) [ ]

(U) HAITI/LABOR UNREST.

(U) MEETING WITH GUATEMALAN DATT.

(U) PANAMA.

(C) [ ]

INTERNATIONAL SECURITY POLICY

(U) CWC UPDATE.

48-028 98 - 6

3

(FOUO) NSC COMMENTS ON AIRBORNE LASER:

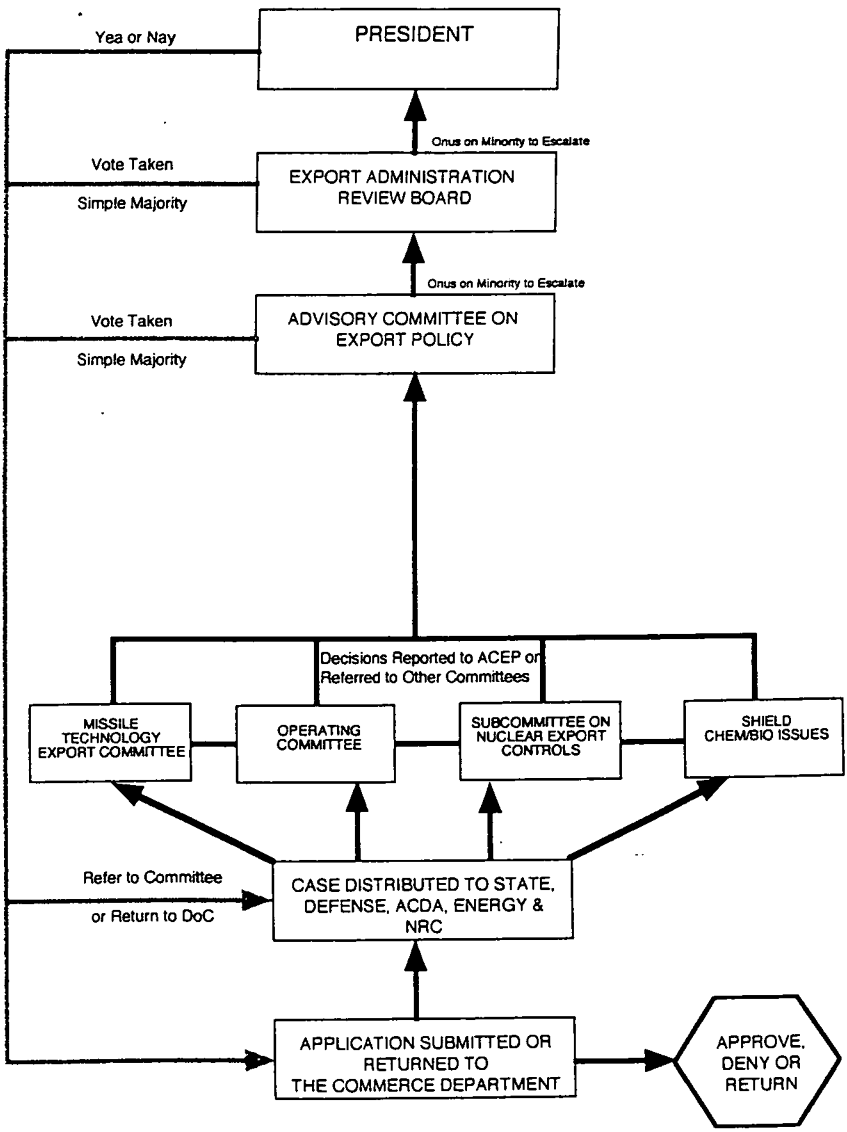
POLICY SUPPORT

(FOUO) ENCRYPTION.

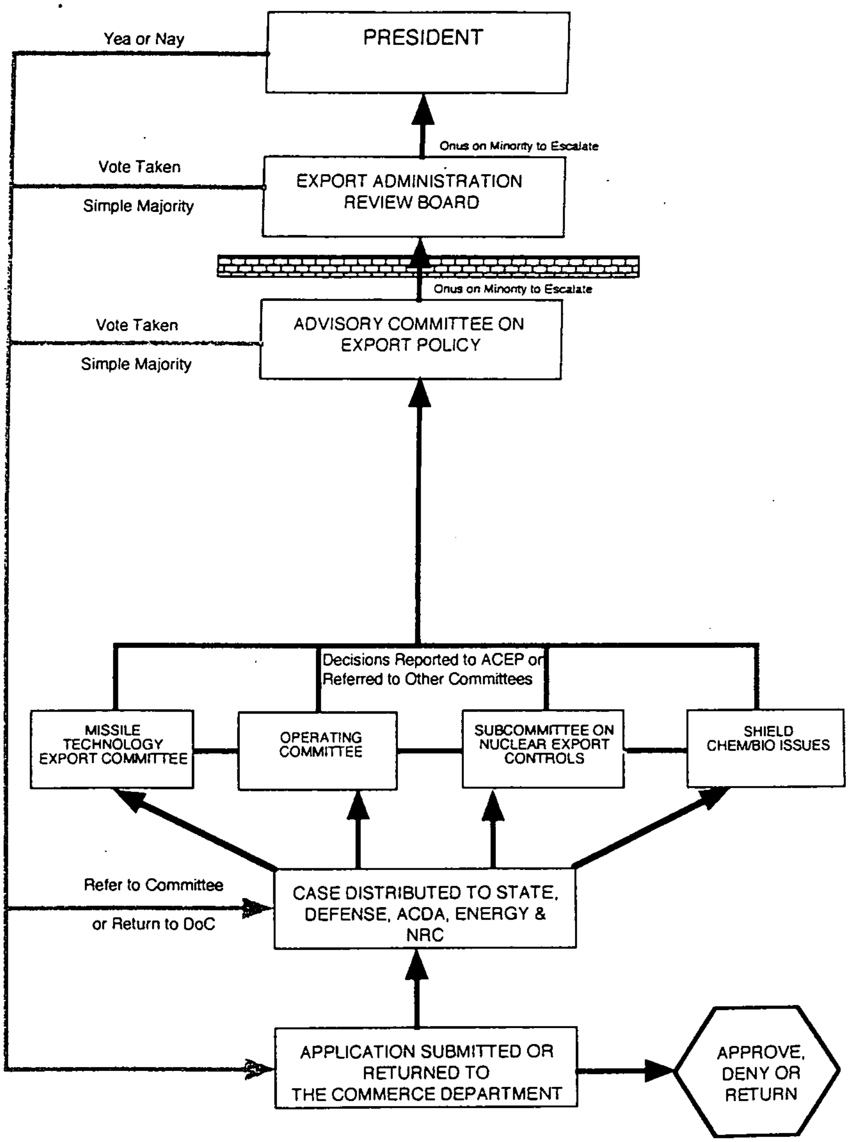
(U) USAF SPECIAL OPERATIONS SCHOOL.

ATTACHMENT 2

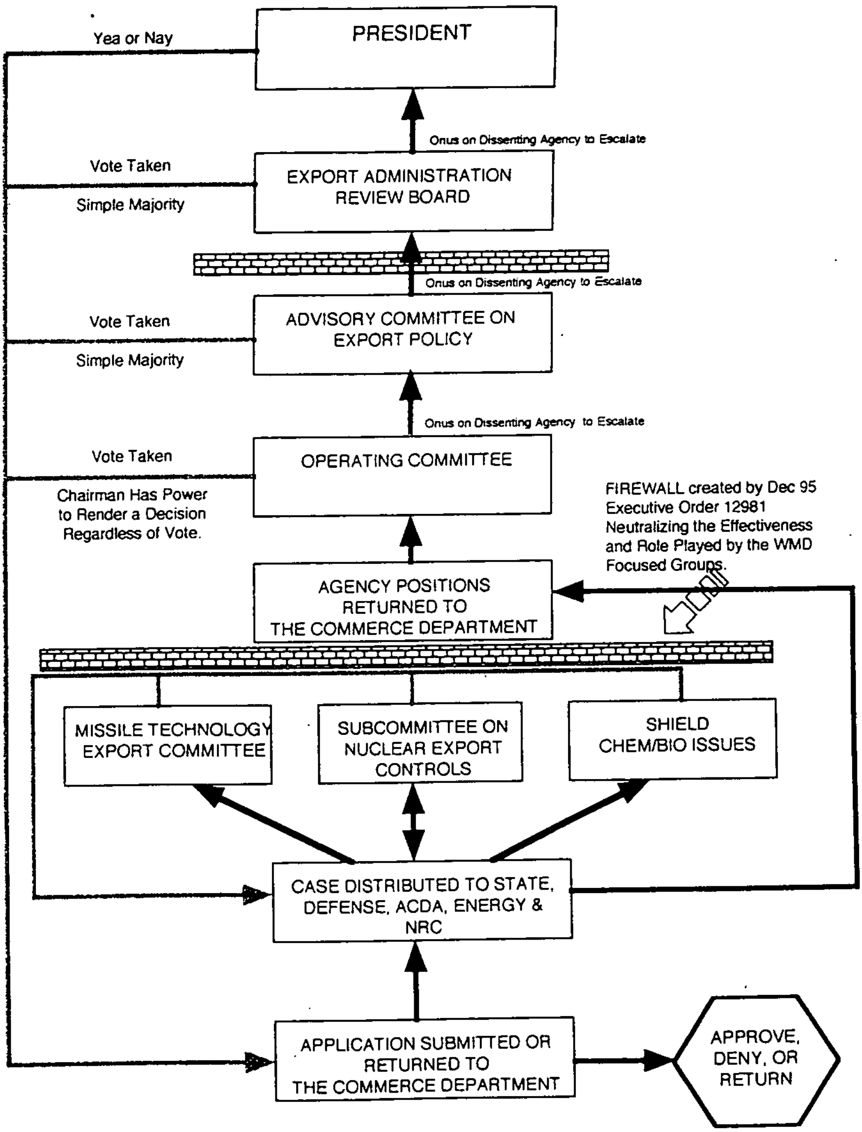
EXPORT LICENSING ESCALATION PROCESS
Pre- 1992



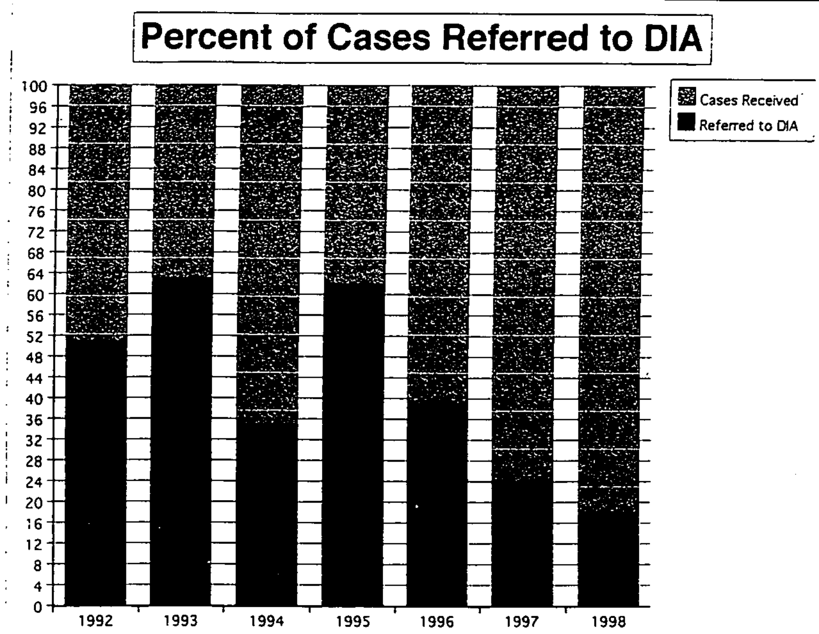
EXPORT LICENSING ESCALATION PROCESS 1992 -1996

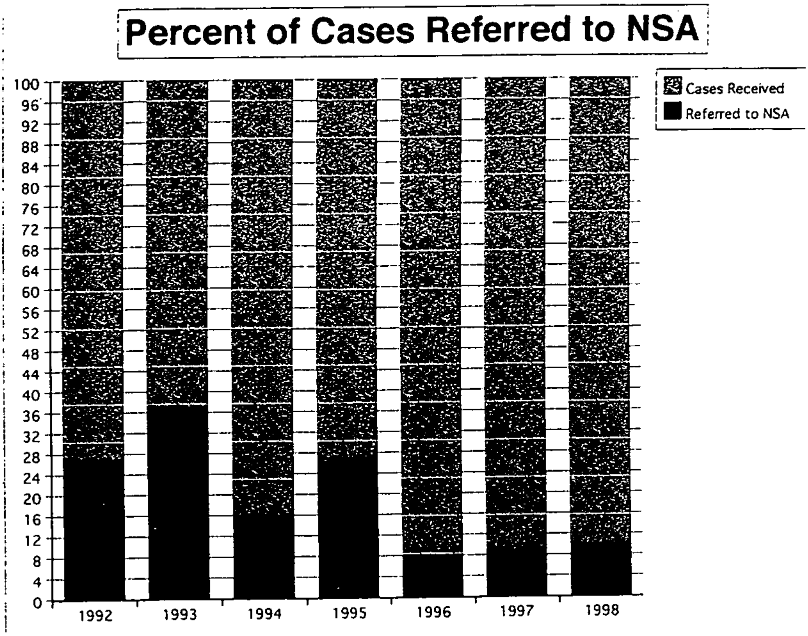


EXPORT LICENSING ESCALATION PROCESS 1996 - PRESENT



ATTACHMENT 3




Percent of Cases Referred to NSA
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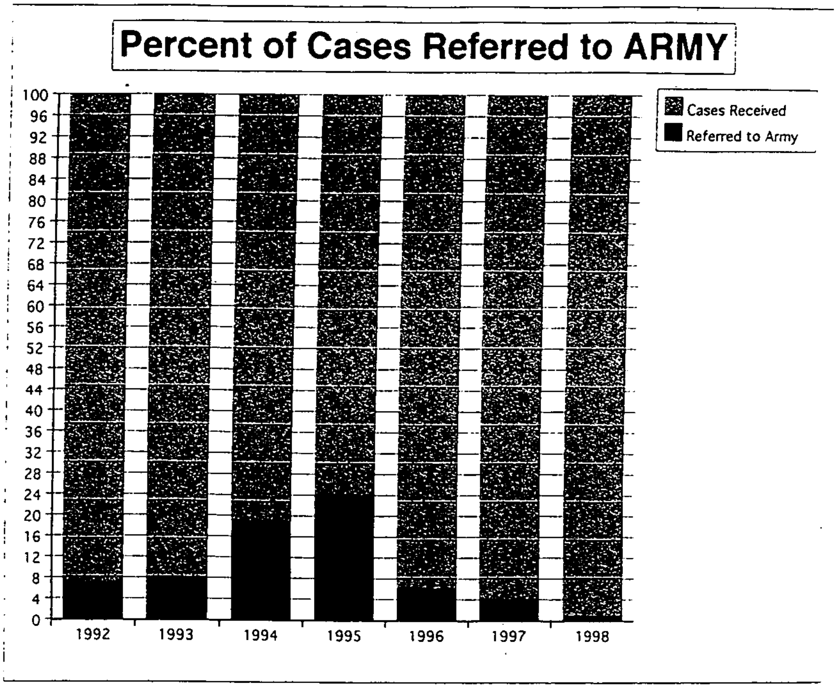
Percent of Cases Referred to ARMY
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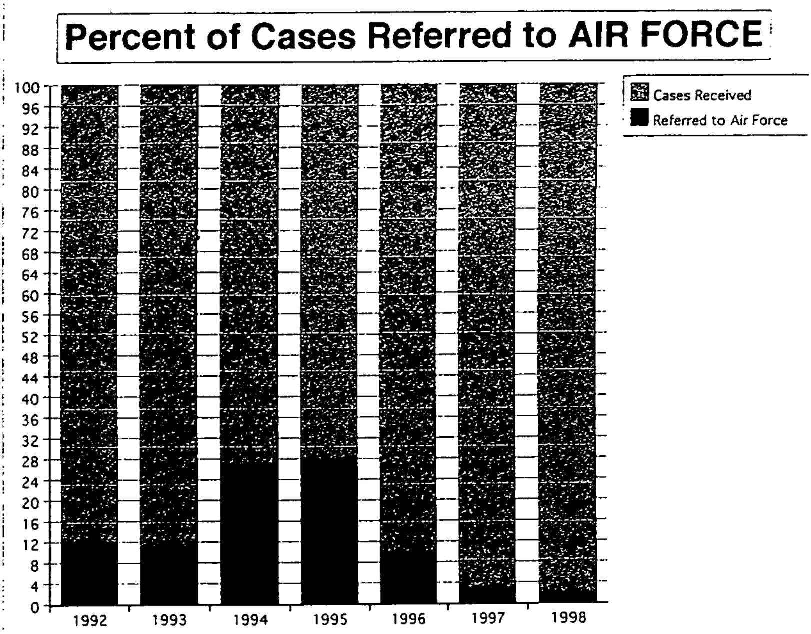
Cases Received
Referred to Army



Percent of Cases Referred to AIR FORCE
Cases Received
Referred to Air Force
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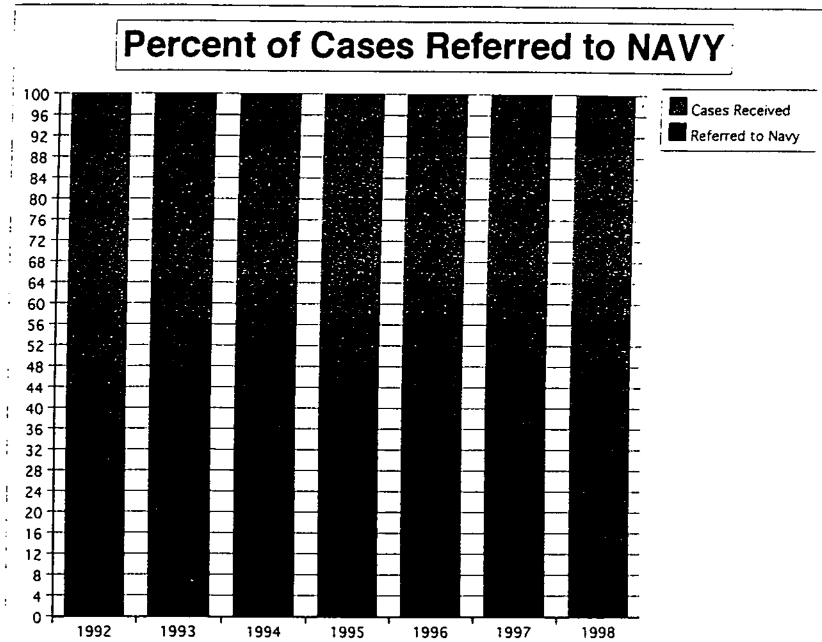
Percent of Cases Referred to NAVY
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Cases Received
Referred to Navy

ATTACHMENT 4

DISTRIBUTION: TD X TSO

SUBJECT: ____________________

SUSPENSE: ____________________

_____ 1. NO OBJECTION.

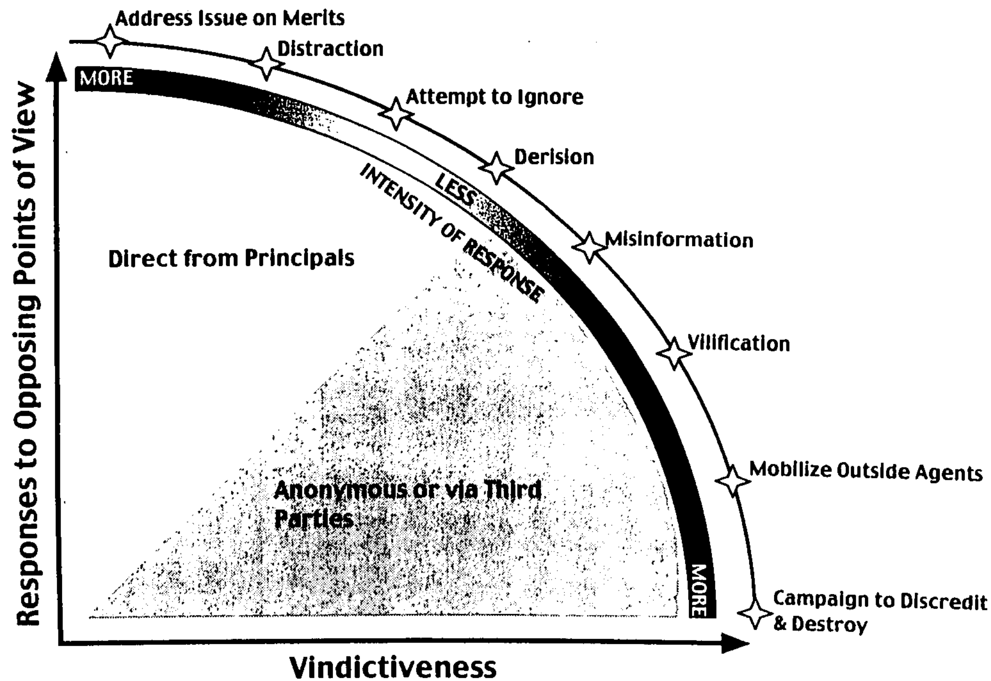
_____ 2. NO OBJECTION SUBJECT TO:

SIGNATURE OF ACTION OFFICER: ____________________ PHONE: ____________

DATE RETURNED TO PD/AC&PA: ____________

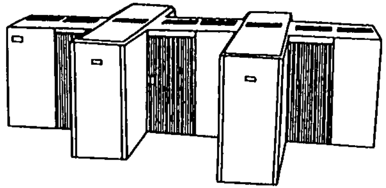
FOR ADDITIONAL INFORMATION, PLEASE CONTACT: ____________________

Shooting the Messenger



ATTACHMENT 6

HIGH PERFORMANCE COMPUTERS



The decontrol of all computers below the 500-CTP threshold would suddenly make available to any proliferant state-of-the- art CAD/CAM or signal-processing workstations that are more capable than anything in the US defense sector. An example of the strategic importance of such access can readily be seen in the aerospace/missile development field. High-speed, ultra-precise, and graphic-intensive workstations employing advanced (but recently decontrolled) software such as Computational Fluid Dynamics or Finite Element Analysis would obviate the need for expensive, thermally conditioned, wind tunnel facilities. The ability to rapidly model and alter size, shape, density and material characteristics in three dimensions and real time is what these workstations were designed for. A proliferant country could then totally conceal its R&D efforts for, say, ballistic or cruise missiles until it has developed a flyable prototype. Workstations at this level also play a pivotal role in the design and development of microprocessors, integrated circuits, dense memory, etc., thus providing the critical enabling technology for indigenous commercial and military devices.

A severe impact woild also occur in the areas of ASW, STEALTH, C3I, C4I, Tactical Weather Forecasting, Nuclear, Chemical, Biological weapons development as well as each of the 21 critical military technologies identified in the DoD Critical Technologies Plan (see below). This impact is directly related to the computational, memory, speed, storage, networkability, communications, and graphics performance of systems in the range decontrolled.

STRATEGIC IMPACT

An analysis of the technology embodied in the North American Aerospace Defense Command (NORAD) reveals that the continual erosion of export controls has resulted in the decontrol of virtually every system or sub-system at the heart of this nations strategic and ballistic missile defense capability. Examples include:

- Fiber Optic Communications systems and Cables
- Large format tactical displays
- Computers and Workstations
- Advanced communications and encryption devices
- Advanced Radars
- Advanced Signal Processing Systems

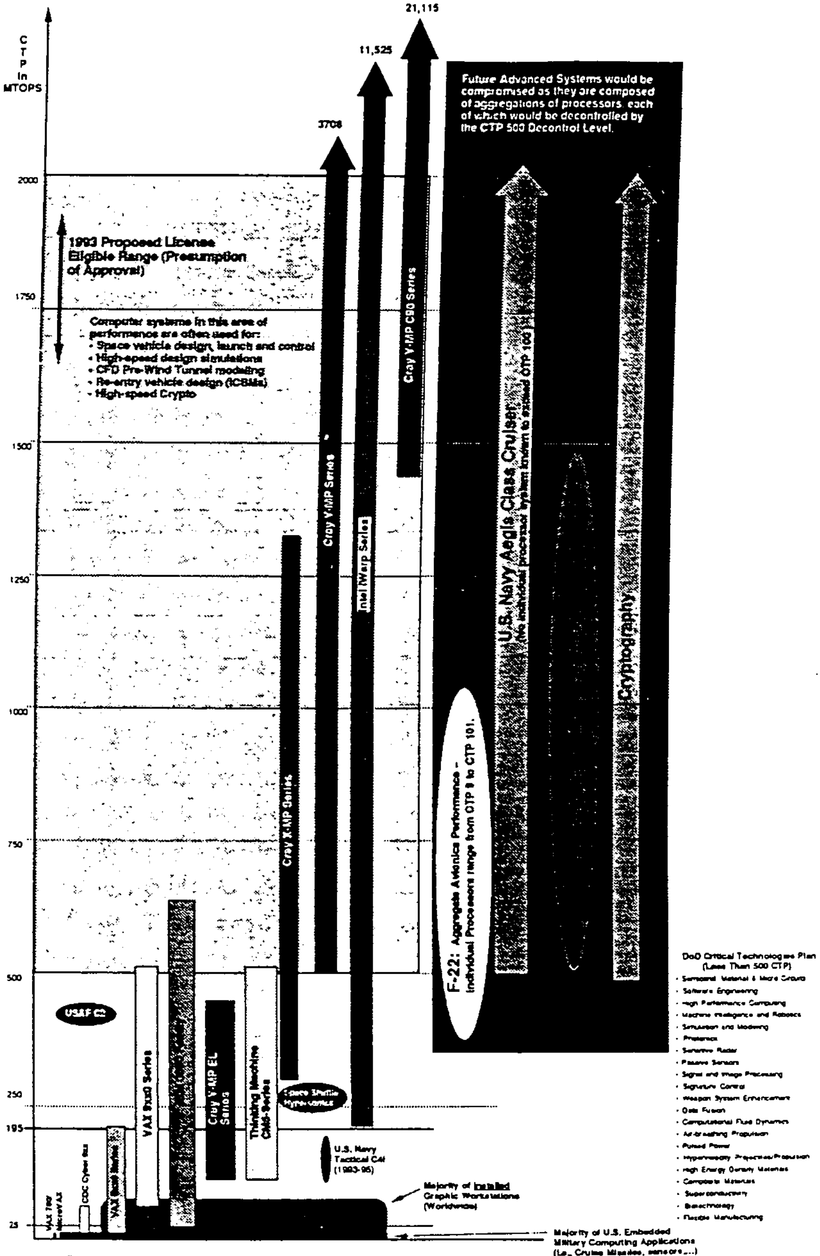
NORAD has just brought up to operational status an upgraded computer system to receive and integrate data from its region and sector operations control centers. This $10 million system consists of two types of Hewlett-Packard computers rated at 189 and 99 - 300 MTOPs respectively. This newly decontroled system is illustrative of the strategic applications which will quickly be made available to potential adversaries.

The decontrol of such powerful computing/analytical platforms obviates the need for large computing facilities or mainframe supercomputers such as a CRAY for weapons design, testing or command and control. Coupled with the recent and anticipated relaxations in the area of telecommunications, this makes rapidly relocatable and survivable C3I possible and testing of advanced weapons highly portable, concealable and inexpensive.

The 21 Critical Technology areas:

- Semiconductor Materials and Micro Circuits
- Software Engineering
- High Performance Computing
- Machine Intelligence and Robotics
- Simulation and Modeling
- Photonics
- Sensitive Radar
- Passive Sensors
- Signal and Image Processing
- Signature Control
- Weapon System Enhancement
- Data Fusion
- Computational Fluid Dynamics
- Air-breathing Propulsion
- Pulsed Power
- Hypervelocity Projectiles and Propulsion
- High Energy Density Materials
- Composite Materials
- Superconductivity
- Biotechnology
- Flexible Manufacturing

ATTACHMENT 7



CTP Ranges of Computer Systems Used for High-end Computing Applications (1976-1992) Such as Computational Fluid Dynamics, Weather, Sound Analysis, High-performance Jet Engine Design, etc. and Some Advanced Military Weapons Systems

IMPACT OF HOT SECTION DECONTROL

Decontrol by metaphor will yield the greatest results. Terms such as "Hot section" have no intrinsic meaning and can be defined to fit a particular audience. In addition, use of the term carries a certain rhetorical appeal as it can be argued that limited risks are being taken because it is only for one small part of an engine and will be limited to civil engines. This will effectively mask the equal utility of the underlying technology in military engines. Technologies, Materials, and components which will be become free from export restraints by decontrol of "civil" hot sections include:

Materials:
- Superalloys
- Ceramic Matrix Composites
- Metal Matrix Composites
- Organic Matrix Composites
- High Temperature Bearing Steels
- Intermetallics
- Powder Metallurgy
- Florinated Polymides
- High Modulus Organic Fibers
- Elastomers, Monoplasts, Phenolic Resins
- Carbon/Carbon Matrix
- Silicon Carbide Matrices

Coatings:
- Aluminides
- Platinum-Aluminides
- Silicides
- Carbides
- Refractory Metals

Coating Systems:
- Chemical Vapor Deposition (CVD)
- Physical Vapor Deposition (PVD)
- Thermal-Evaporation PVD (TE-PVD)
- Electron-Beam PVD (EB-PVD)
- PVD-Resistive Heating
- PVD-Cathodic Arc Discharge
- Pack-Cementation
- Plasma Spraying
- Slurry Deposition
- Sputter Deposition
- Ion Implantation
- Ion Plating
- Laser Hardening

Bearings:
- Solid Ball and Roller
- Gas-Lubricated Foil Bearings
- Hydrostatic Fluid Film Bearings
- Active Magnetic Bearings
- Shaberth & Adore CAD Programs

Software:
- Gas Turbine CGD s/w
- 2D or 3D Viscous s/w for Engine Flow Modeling

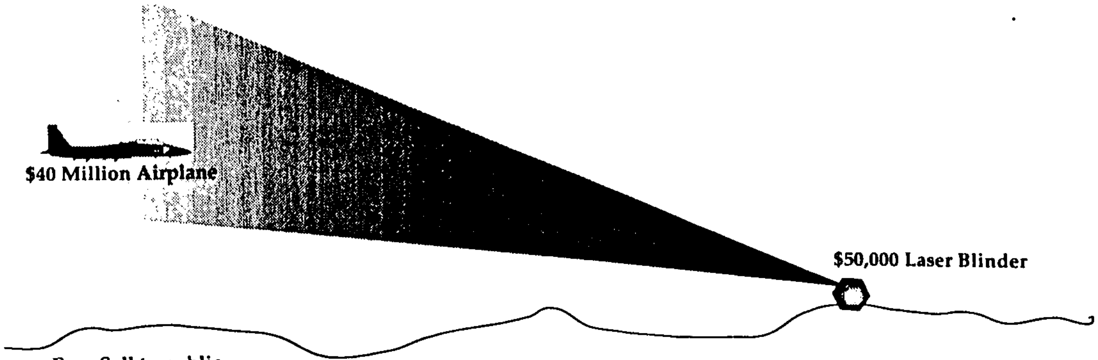
Technology:
- Thin Wall Cooling
- Hot Isostatic Presses
- Machine Tools
- Electro-discharge Machines
- Ceramic Core Manu. Equip.
- Ceramic Shell Wax Pattern Prep. Equip.
- Gas Turbine Brush Seal Manu. Equip.
- Tools, Dies, & Fixtures for Solid State Joining
- Precision Hole Drilling
- Single Crystal. Directionally Solidified Blade Manu. Equipment
- Precision Investment Casting
- Water Jet Machining
- Forging
- Diffusion Bonding
- Cooled & uncooled turbine blades
- Airfoil to disk techniques

Components:
- Heat Exchangers
- Single Crystal. Directionally Solidified Blades
- Ceramic Cores & Shells for Airfoils & Vanes
- Thermally Decoupled Combustion Liners
- Multi-domed Combustors
- Non-Metallic Liners

Synergistic Effect of Decontrolling Laser Technology

Solutions	Costs	Effectiveness
Sealed Cockpit: No windows or protective shell around pilot when entering high threat environment.	Tens of $ Billions	Most Effective. Technology does not yet exist. Current sensors are as vulnerable as human eye to laser exposure.
Brilliant stand-off weapons: Autonomous fire and forget, high precision, munitions carriers using multi spectral sensor arrays.	$ Billions	Poor Tactical Substitute. Extreme cost, small warheads, on-board sensors vulnerable.
Volumetric on-board defense system: Mini-lasers on aircraft project diffuse Laser pattern to polarize or ionize flight envelope as barrier to hostile Lasers.	$ Billions	Doubtful utility. Technology does not yet exist. Special sensors needed to "see through defense barrier, active barrier will increase electro-optical detectability of aircraft.
Countermeasures: Reflective, scattering, absorptive, material deployed between laser source and target.	Hundreds of $ Millions	Doubtful utility against fixed targets, ineffective against mobile targets.
Anti-Laser homing missiles: Detect and ride beam back to source and destroy it.	Hundreds of $ Millions	Minimally Effective, easy to counter.
Personal protective devices: Eyeglasses, shutters, visors, etc.	Tens of $ Millions	Least effective, narrow bandwidth

At 10,000 Meters Equivalent to Firing a 100 m Wide Bullet



- Easy Sell to public
- Very large pay-off for industrial base
- Use against civil avaition
- Use as assianation or terrorist weapon
- Humanitarian issue in U.N.
- Tactical weapon requires non-linear response
- More usable than Chem., Bio., or Nuclear weapons
- $40 Million plane w/$20 million laser protection against a $50,000 weapon to deliver $20,000 worth of explosives

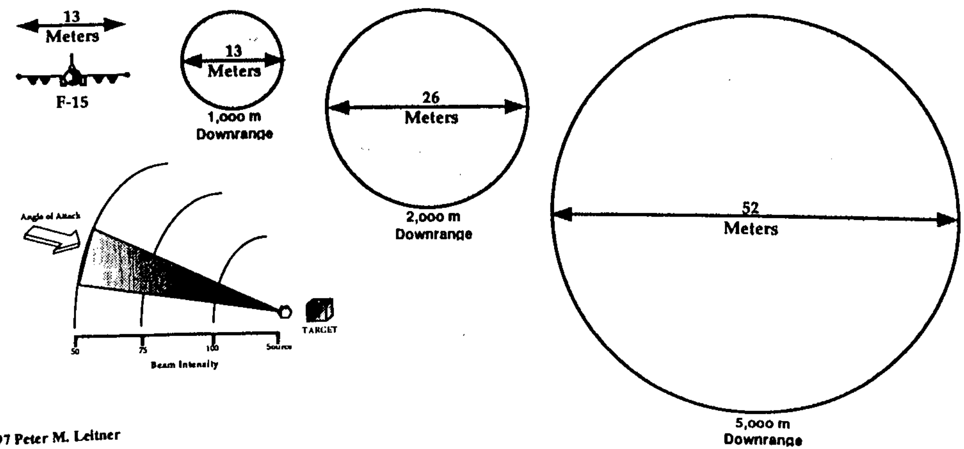
20 mrad Beam Divergence		
1,000 m	=	13 m Blinding Zone
2,500 m	=	33 m Blinding Zone
5,000 m	=	52 m Blinding Zone
10,000 m	=	104 m Blinding Zone

Once dazzled, a pilot has less than 28 seconds to regain sight before ejecting or losing control

Tactical Use of Laser Blinding Weapons

Range (Meters)	Relative Beam Intensity	Volume of Airspace Effected	Lethality Within Envelope	Mission Consequences
5,000	*100 %*	*3,536,109 m3*	*Hemorrhage. Permanent Blindness*	*Loss of Aircraft and Crew*
10,000	*75 %*	*28,288,872 m3*	*Retinal Damage, Cataracts Form, Permanent Damage*	*Loss of Aircraft and Crew*
15,000	*50 %*	*95,474,943 m3*	*Dazzling, One Second to Two Minutes Recovery Time*	*Reduced Effectiveness to Total Loss Depending Upon Pilot Reaction*

DOWNRANGE ILLUMINATION FIELD



FUTURE WEAPONS SYSTEMS: Technologies Required

★ ESSENTIAL
● IMPORTANT
○ HELPFUL

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Aerothermodynamics															●														
Bearingless Rotor																		●											
Burn Through Shroud																													
CAD/CAE/Simulation	★		●	★	●	★		★	★	●	★	●			★	★		★		★		●	★	★	★	●	★	●	★
Ceramics				★	●			★	●									★		★		●	★				★		
Cesium Clocks																													
Chemistry					●																								
Coatings																													
Compact Cryogenics	●																									★			
Composites	★			★	○			★	●							●		★		★		●	★	★	★		★		
Correlation Sonar																													
Crystal Growth																													
Displays																													
Elastomerics																		★											
Electronics, High-power																								●					
Encryption	○																												
Explosives Chemistry	●					○	●							●				★							●				★
Fiber Optics																													
Gas Bearings																													
Heat Lamp																													
High Power Battery	★																												
High Pressure Pumps																													
Hydraulic Press Design																		○											○
Hydraulics																						●							
Instrumentation			●																										
Know-how	★	●	●	★		★									●			●	★	●	★	○	★	●	●		★	●	
Laser Detector		●				●											●	●											
Laser																													
Machining	●	●	●	●	★			★	★		★			●	★			★				●	●	★			●	★	★
Magnetostrictive Devices			●																										
Manufacturing				●				★	★			★						●				●	●				●		
Materials	★		○	★		★		★	★			★	★		●	●		★		★	●	●	★	★		○	★		
Matrix Detector Production	★																												
Metals				★	○			★	●		★			●	●			★		★		●	★	★			★		★
Microelectronics	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Monomolecular Fluid																													
Optics	○			★		★						★						●									●		
Phase Shifters															●														
Piezoceramics			●																									●	
Power Source																													
Radar Sensor																													
Receiver																													
Sensors																													
Signal Processor																													
Software	★		●	●		★									★		●	★	★				●		●		●	★	
Spectroscopy																					●								
Superconductors											●													●					
Telecommunications																													

FUTURE WEAPONS SYSTEMS: Technologies Required

★ ESSENTIAL
● IMPORTANT
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Aerothermodynamics																													
Bearingless Rotor																													
Burn Through Shroud															O														
CAD/CAE/Simulation	O	★	★	★	★		●		●				★	★	O	●	●	●	O		★		●	●		●	★	●	●
Ceramics				★	●		●						O		O	★													●
Cesium Clocks											★			★															
Chemistry																													
Coatings																													
Compact Cryogenics			●			●						O															●		
Composites		★		★	●		●	★		★	★			★	O	●											★		●
Correlation Sonar														●										●					
Crystal Growth																													
Displays									★																				
Elastomerics																													
Electronics, High-power																										●	O		
Encryption																													
Explosives Chemistry	O	★	★				●						★	★	O	●		●											
Fiber Optics																	O												
Gas Bearings														●										●					
Heat Lamp													O																
High Power Battery																													
High Pressure Pumps		●												●															
Hydraulic Press Design			O										O																
Hydraulics																													
Instrumentation																													
Know-how							●		●			★		★			O		★				★		★			O	
Laser Detector														●								★	O	★	●			●	
Laser																													
Machining		●	★	★	★	●	●		O			●	★	★					★	●	★	★		●			●		★
Magnetostrictive Devices																													
Manufacturing		●		★	★	●	●							●										●			●		●
Materials	●		●	★	★	●	●		●			O	O	★	●	★						★	O		★		●	●	●
Matrix Detector Production																													
Metals			★	★	●		●						★			●				●									●
Microelectronics	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	★	★
Nanomolecular Fluid														●										●					
Optics																						★			★				
Phase Shifters									●										O										
Photoceramics																													
Power Source																													
Radar Sensor														★															
Receiver								●		●	●																		
Sensors							●																						
Signal Processor								●		●	●																		
Software	●			●		O	●		★		●	★		★	★	★	●		★			★	●	●	★	●	★	●	
Spectroscopy																													
Superconductors																													
Telecommunications									★						●									●		●			

FUTURE WEAPONS SYSTEMS: Technologies Required

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Aerothermodynamics																				
Bearingless Rotor																				
Burn Through Shroud	○																			
CAD/CAE/Simulation		●	●	★		★	★	★	★	★	★	★	●	★	★	★	★	★	★	
Ceramics	○						●	●	●						●		★	●		
Cesium Clocks									★	★	●									
Chemistry																			★	
Coatings		★																		
Compact Cryogenics																				
Composites	○			●		★	★	★	★	★		○	●	●				★	★	
Correlation Sonar											●									
Crystal Growth		★																		
Displays												●			★					
Elastomerics																		★		
Electronics, High-power						○								○					★	
Encryption																				
Explosives Chemistry	○			●			○	○	○	★		○	●		●	★	○		★	
Fiber Optics																				
Gas Bearings										●										
Heat Lamp																	○			
High Power Battery																				
High Pressure Pumps																				
Hydraulic Press Design																○				
Hydraulics																				
Instrumentation																				
Know-how			●							★		○		●	●		●		●	
Laser Detector										●		○					○			
Laser																	○			
Machining			★	●		○				★	★	●	○	★	●	★	★	●	★	
Magnetostrictive Devices																				
Manufacturing		★								●								●		
Materials	●	★		●		○		●	●	★		★		★	●		○	●	★	
Matrix Detector Production																				
Metals								●	●	●		★	○	●	●	★	★	●	★	
Microelectronics	★		★	★		●	★	●	●	★	★	●		★	★	●	★	★	★	
Monomolecular Fluid										●	★									
Optics		★																		
Phase Shifters			●																	
Piezoceramics																				
Power Source																	○			
Radar Sensor										★										
Receiver							●	●	●											
Sensors																				
Signal Processor							●	●	●											
Software	★		★	★	●	●			●	★	●	●	○		★		★	★		
Spectroscopy																				
Superconductors														○					★	
Telecommunications															★					

FUTURE WEAPONS SYSTEMS: Microelectronic Technologies Required

★ ESSENTIAL
● IMPORTANT
○ HELPFUL

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Automated Production	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
CAD Equipment	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Chemical Plasma Etchers	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Clean Room Design and Filters	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Czochralski Crystal Pullers	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
E-Beam Mask Makers	★		★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Epitaxial Growth (VPE, MBE)	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
High-Power Packaging Know-How	●			★							★				★		●	★	★	★		★	★				★	★	
High-Purity Polysilicon	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
High-Speed Gate Know-How	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Ion Implanters	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Ion Millers	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Know-How to Optimize for Military				★							★							●	★	★			★				★		
Low-Pressure CVD	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Magnetically-Enhanced Sputtering	●			★							★				★		●	★	★	★		★	★				★	★	
Materials Characterization	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Optimized Layout Know-How	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Parametric Testers	★	★	★	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Reactive Ion Etchers	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Scanning & Stepping Proj. Aligners	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
VLSI Circuit Testers	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Wafer Probe Testers	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
Wire Bonders	★		●	★	★	★					★		●		★	●	●	★	★	★	★	★	★	★	★	●	★	★	
100+ Pin Packaging Know-How	●			★							★				★		●	★	★	★	★		★	★			★	★	

FUTURE WEAPONS SYSTEMS: Microelectronic Technologies Required

★ ESSENTIAL
● IMPORTANT
○ HELPFUL

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Automated Production	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
CAD Equipment	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Chemical Plasma Etchers	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Clean Room Design and Filters	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
Czochralski Crystal Pullers	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
E-Beam Mask Makers	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Epitaxial Growth (VPE, MBE)	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
High-Power Packaging Know-How				★			★	★	★	★	★				★	★						●							
High-Purity Polysilicon	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
High-Speed Gate Know-How	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
Ion Implanters	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Ion Millers	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Know-How to Optimize for Military																													
Low-Pressure CVD	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	★	★	●	★	●	★
Magnetically-Enhanced Sputtering				★			★	★	★	★	★				★	★						●							
Materials Characterization	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
Optimized Layout Know-How	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
Parametric Testers	★	●	★	★		●	★	★	★	★	★	★	●	★	★	★	●		★		●	★	★	★	★	●	★	●	★
Reactive Ion Etchers	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Scanning & Stepping Proj. Aligners	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
VLSI Circuit Testers	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Wafer Probe Testers	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
Wire Bonders	★		★	★		●	★	★	★	★	★		●	★	★	★	●				●	★	★	●	★	●	★	●	★
100+ Pin Packaging Know-How	★			★			★	★	★	★	★				★	★						●							

FUTURE WEAPONS SYSTEMS: Microelectronic Technologies Required

★ ESSENTIAL
● IMPORTANT
○ HELPFUL

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Automated Production	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
CAD Equipment	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Chemical Plasma Etchers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Clean Room Design and Filters	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Czochralski Crystal Pullers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
E-Beam Mask Makers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Epitaxial Growth (VPE, MBE)	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
High-Power Packaging Know-How	★			●		●	●	●	●		★				★		○			★
High-Purity Polysilicon	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
High-Speed Gate Know-How	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Ion Implanters	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Ion Millers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Know-How to Optimize for Military																				
Low-Pressure CVD	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Magnetically-Enhanced Sputtering	★			●		●	●	●	●		★				★		○			★
Materials Characterization	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Optimized Layout Know-How	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Parametric Testers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Reactive Ion Etchers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Scanning & Stepping Proj. Aligners	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
VLSI Circuit Testers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Wafer Probe Testers	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
Wire Bonders	★		★	★		●	★	●	●	★	★	●	○	★	★	●	★	★	★	★
100+ Pin Packaging Know-How	★			●							★				★					★

ATTACHMENT 8

UNITED STATES OF AMERICA

Congress of the United States

SUBPOENA
000002

To Dr. Peter Leitner

Greetings:

Pursuant *to lawful authority, YOU ARE HEREBY COMMANDED to appear before the COMMITTEE ON GOVERNMENTAL AFFAIRS of the Senate of the United States, on* June 25 *, 1998, at* 10:00 *o'clock a.m., at its Committee Room,* 342 Dirksen Senate Office Building, Washington, D.C. 20510 *, then and there to testify what you may know relative to the subject matters under consideration by said Committee.*

Hereof fail not*, as you will answer your default under the pains and penalties in such cases made and provided.*

To ____________________________ to serve and return.

Given under my hand, by authority vested in me by the Committee, on this 17th *day of June, 1998.*

Chairman, Senate Committee on Governmental Affairs

Dr. Peter M. Leitner
2214 North Nottingham Street
Arlington, Virginia 22205
(703) 504-4784 (W) (703) 241-5579 (H) (703) 241-4153 Fax E-Mail: Pleit@erols.com

PROFESSIONAL EMPLOYMENT

February, 1998 to Present
CO-EDITOR IN CHIEF, JOURNAL OF POWER & ETHICS. New journal sponsored by the Southern Public Administration Educational Foundation dedicated to exploring the nexus of power and ethics in the formulation, administration, and implementation of a wide variety of public and private policy initiatives. The initial volume is scheduled to be released in 1999.

September, 1986 to Present
SENIOR STRATEGIC TRADE ADVISOR, DEFENSE DEPARTMENT. Principal Policy Analyst and international negotiator for all aspects of export controls over machine tools, controllers, robots, industrial equipment, software, navigation and guidance equipment. Former Chairman and Head of US delegation to Paris-based 8-country study groups on Advanced Materials For Weapons Systems and Defense Production Technology and Equipment. Licensing officer for US exports to: China, Libya, Iraq, former Warsaw Pact countries, Iran and India. Currently, DoD representative to the Subcommittee on Nuclear Export Controls (SNEC).

October, 1984 to September, 1986
COMPUTER SPECIALIST, US GENERAL SERVICES ADMIN. Managed reimbursable computer programming, maintenance and support program. Supervised team of specialists, systems analysts and programmers in the development of databases, E-mail, local area networks and security services.

May, 1984 to Present
ADJUNCT PROFESSOR OF INTERNATIONAL BUSINESS, GEORGE MASON UNIVERSITY (CURRENTLY), MOUNT VERNON COLLEGE (95-PRESENT) AND SOUTHEASTERN UNIVERSITY (84-88). Taught the following MBA level courses: Export/Import Management, Marketing Management, Information Resource Management, International Marketing, Intercultural Management, International Finance, International Relations and Developing Nations. Student populations are culturally diverse and largely international.

May, 1973 to October, 1984
CONTRACT AUDIT RESOLUTION SPECIALIST, US GENERAL SERVICES ADMIN. Responsible for overseeing conduct and follow-up of all audits performed by the Office of the Inspector General in the National Capital Area.

June, 1977 to May, 1973
GAO EVALUATOR, US GENERAL ACCOUNTING OFFICE. Team leader/member for a wide variety of multi-country reviews of U.S. military, foreign aid and represented GAO in several ongoing international negotiations. Supervised, coordinated, trained and directed audit staffs based in Panama, Bangkok, Frankfurt and Washington. Assignments included the following issues: Law of the Sea Treaty, host nation support for U.S. military forces, military assistance to Egypt, the Egyptian defense industry, the Sinai Field Mission, access to the Suez Canal for nuclear-powered ships, accounting education in the Third World, and maneuver damages caused in the FRG.

EDUCATION

1994	DPA,	Public Administration,	University of Southern California
1992	MPA,	Public Administration,	University of Southern California
1977	MA,	International Relations,	Northern Arizona University
1976	MA,	Science & Public Policy,	Washington University
1975	MA,	American History,	State University of New York
1974	BS,	Political Science/History,	State University of New York

MILITARY SERVICE

1970/71 U.S. Army, Army Security Agency. Honorable Discharge.

PERSONAL

Top Secret and SCI security clearances
Health: Excellent Married 4 Children
Professional Affiliations: Society of Manufacturing Engineers, American Political Science Association, Air Force Association, Disabled American Veterans, American Society for Public Administration.

Dr. Peter M. Leitner

Publications

Books:

Decontrolling Strategic Technology, 1990-1992: Creating the Military Threats of the 21st Century. (Lanham, Md: University Press of America, 1995).

Reforming the Law of the Sea Treaty: Opportunities Missed, Precedents Set, and U.S. Sovereignty Threatened. (Lanham, Md: University Press of America, 1996).

NANSHA: War in the South China Sea. (Forthcoming) [Fiction]

Handbook of Public Quality Management. (New York, N.Y.: Marcel Dekker Publishers, Inc., Fall 1998)
Co-edited volume under contract with publisher.

Fighting Nack: Waging Guerrilla Warfare Within Large Organizations. (In progress. Projected publication, Winter 1999)

Articles:

"Ethics, National Security and Bureaucratic Realities: North, Knight, and Designated Liars," American Review of Public Administration. Vol. 27 No. 1, March 1997: 61-75. Coauthored with Ronald Stupak.

"A Bad Treaty Returns: The Case Against the Law of the Sea Treaty" World Affairs. Vol. 160 No. 3, Winter 1998: 134-150.

"Feeding the Dragon: Technology Transfer and the Growing Chinese Threat," in Economic Espionage, Technology Transfers and National Security. U.S. Congress, Joint Economic Committee, June 17, 1997. S. HRG. 105-240: 62-118.

"Decontrolling Technology: Striking at the Heart of U.S. National Security" U.S. Congress, Joint Economic Committee, April 28, 1998, Senate hearing report forthcoming.

"Supercomputers, Test Ban Treaties, and the Virtual Bomb." World Affairs. Vol. 161 No. 2, Fall 1998.

"Japan's Post-war Economic Success: Deming, Quality, and Contextual Realities," Journal of Management History. Vol. 5 No.4. October 1999.

"Eyewitness to History: Methodological Suggestions, Public Servant Perspectives, and Professional Publications," International Journal of Theory and Behavior. (Forthcoming Fall 1998).

"Caspian Sea: Opportunities and Challenges for U.S. Policy" (Forthcoming)

Testimony & Interviews:

U.S. Congress, Joint Economic Committee. April 28, 1998, 10:00 a.m.

U.S. Congress, Joint Economic Committee. June 17, 1997, 10:00 a.m. Video Available.

Mary Matalin Show, CBS Radio Network, June 20, 1997. Interview concerning technology transfer and future chinese threats, Recording Available.

Blanquita Cullum Show, Radio Network America, July 22, 1997. Interview on supercomputer technology and possession by potential adversaries. Recording Available.

Blanquita Cullum Show, Radio Network America, September 11, 1997. Interview on the evolving Chinese military threat. Recording Available.

JEFF BINGAMAN (NM)
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MAURICE D. HINCHEY (NY)
CAROLYN B. MALONEY (NY)

Congress of the United States

JOINT ECONOMIC COMMITTEE — MINORITY

105TH CONGRESS

804 HART SENATE OFFICE BUILDING
WASHINGTON, DC 20510-6602
202-224-0372
FAX 202-224-5568

HOWARD ROSEN
STAFF DIRECTOR

June 23, 1998

Ms. Sandra Stuart
Assistant Secretary for Legislative Affairs
US Department of Defense
1300 Defense Pentagon
Washington, DC 20301-1300

Dear Ms. Stuart:

On April 28, 1998, the Joint Economic Committee held a hearing at which Dr. Peter Leithner appeared as a witness. Dr. Leithner, a Defense Department employee, appeared before the Committee in his capacity as a private citizen.

There was some confusion during Dr. Leithner's oral comments regarding the Defense Department's role in the February 1998 decision concerning the control of telecommunications technology and equipment. Dr. Leithner stated that, "the entire administration, including the Defense Department," acted irresponsibly in its handling of this decision. Yet, Dr. Leithner was unable to describe the Department's involvement in the decision. In order to clarify this apparent confusion, I would be grateful if you would provide me with a detailed description of the Defense Department's role in this February 1998 decision.

Please contact Howard Rosen, Minority Staff Director of the Joint Economic Committee, at 202-224-0372, if you have any questions concerning this request.

I look forward to your prompt responses to this request.

Sincerely,

Jeff Bingaman
US Senator

DEFENSE TECHNOLOGY SECURITY ADMINISTRATION
400 ARMY NAVY DRIVE, SUITE 300
ARLINGTON, VA 22202-2884

AUG 6 1998

Honorable Jeff Bingaman
United States Senate
Joint Economic Committee
804 Hart Senate Office Building
Washington, D.C. 20510-6602

Dear Senator Bingaman:

Thank you for your letter of June 23, 1998, regarding the Defense Department's role in a decision concerning control of telecommunications equipment and technology.

In December 1995, the multilateral export control organization known as the Wassenaar Arrangement (WA) agreed to remove from control certain telecommunications equipment and technology that is widely used in civil telephone systems. This decision will become effective on November 1, 1998, unless all WA members agree to modify it. This matter was reviewed by the interagency export control community with full participation by the Department of Defense (DoD), including NSA. DoD agreed with the U.S. Government's position in March 1998 that there is no national security basis to reconsider the WA agreement regarding the removal of this telecommunications equipment from the WA control list. Telecommunications items of continuing military significance, such as signal processing equipment and optical switches, will remain on the WA control list.

I trust this information will help to clarify the Defense Department's role in reviewing telecommunications export controls and safeguarding our national security interests. Please contact me at 703-604-5215, should you require any further information.

Sincerely,

Dave Tarbell
Director

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