NUCLEAR COOPERATION

CHALLENGES AND PROSPECTS

Edited by

Deepa Ollapally

S. Rajagopal

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PREFACE

In this era of globalisation and technology flows, the nuclear field continues to retain strong barriers to international collaboration. From nuclear energy to non-proliferation however, the potential for concerted action exists. The International and Strategic Studies Unit of the National Institute of Advanced Studies (NIAS) held a two day Seminar on November 21-22, 1996 exploring the challenges and prospects for achieving mutual cooperation between states relating to all aspects of nuclear technology. This volume is based on the proceedings of the Seminar.

The Seminar was attended by senior experts from the U.S., France, South Korea, Japan, India and the International Atomic Energy Agency. A major purpose of the Seminar was to approach the question of nuclear cooperation in a novel fashion by bringing international and security affairs analysts together with specialists in the areas of nuclear technology, monitoring and verification, and nuclear power. This unique gathering of scientists, technologists and defence experts was to allow consideration of both technical and political angles of nuclear cooperation. Such an approach is particularly compatible with the underlying philosophy of NIAS which is rooted in the multidisciplinary method of problem solving.

The broad themes that the Seminar considered included disarmament and the security link; implementation and verification of nonproliferation regimes; transfer of technology and nuclear energy. The Seminar culminated with a round table on confidence building. An important point of departure for the proceedings was the Indo-U.S. relationship and the need to place it on a stable course in the nuclear arena.

Explaining Indo-U.S. Relations

The episode of the Comprehensive Test Ban Treaty (CTBT) running through most of 1996, strained ties between India and the U.S. and had threatened to raise tensions to a new level. This was of course in stark contrast to the burgeoning links between the two countries underway since India's economic liberalisation experiment was launched in 1991. Despite their strategic relations not having taken off as was initially expected given the historically favorable conjunction of economic liberalisation and the end of the cold war, there seemed to be a period of low key and tacit acceptance of the complex relationship, which then came under severe tests with the unconditional indefinite extension of the Nuclear Nonproliferation Treaty in May 1995, the Hank Brown amendment and the tortuous CTBT negotiations.

Despite India's stand at the Conference on Disarmament at Geneva and the CTBT outcome, India's relations with the U.S. or any of the other countries for that matter seem to have not been appreciably affected, at least at the official level. This suggests that these relations are on fairly sound footing. Indeed, some evidence that a new sense of "realism" has begun to inform American thinking is found in the just released Council on Foreign Relations (CFR) report on U.S. policy towards India and Pakistan. The report calls for a fundamental change in U.S. approach towards this area and to "explore the formation of a real strategic partnership" with India. In the authors' view India has the potential to become a major power, with its strength contributing to stability across Asia.

On the nuclear question, the report points to the nuclear self restraint of India and Pakistan and urges the U.S. to "stop pressing for the Indian and Pakistani nuclear programmes to be rolled back completely, an outcome which is simply not in the cards for the foreseeable future." The authors go further and call for a change in the punitive approach and suggest lifting of existing embargoes on technology transfer, assisting India's civilian nuclear programme, and deepening military cooperation. What the prestigious CFR's report indicates is the lack of a monolithic perspective on India among U.S. policy experts and the possibility of a renewed Indo-U.S. dialogue encompassing even the nuclear field. For this to become a reality however, thinking on nuclear cooperation will have to be lifted to a different level.

Nuclear Paradigms

Recently, there have been suggestions that thinking on nuclear issues has come under increasing pressure in both India and the U.S., partly as a result of changed international circumstances and partly as a result of internal debates. While continuing its historical commitment to universal and nondiscriminatory disarmament, during the CTBT debate, the Indian government signalled that its own security consideration may become more prominent. In this reassessment, the persisting reluctance of nuclear weapons states to forgo their arsenal, and the nuclearisation of the region have been cited. Ultimately, policy will have to reflect India's security threats and strategic priorities.

According to some American experts, the U.S. nuclear paradigm is showing some cracks from its earlier consistent doctrine of deterrence. They argue that important voices in the United States are increasingly getting converted to the idea of the abolition of nuclear weapons. The "Generals" statement released in December 1996 by a large group of former senior military officials in the U.S., Russia and elsewhere, calling for the elimination of nuclear weapons, is seen as a case in point. One view is that this group (which included individuals who have been in charge of their country's nuclear arsenal at one time or other) is part of a larger movement in the U.S. seriously committed to abolition.

Of course, it remains to be seen how far this perspective can be sustained and to what extent it will influence U.S. and other nuclear weapon states' actual policy. The present official U.S. doctrine is solidly based on deterrence and nuclear weapons are viewed as useful among other reasons to deter use of chemical and biological weapons by so called rogue states, and to counter any nuclear armed regional power. In addition, given the vast U.S. superiority in conventional weapons as a result of its mastery of the so called the military technical revolution, there may be others among the nuclear weapon states who will resist giving up their nuclear advantage.

Dialogue at this level is not easy as conflicting "perceptions" among the participants of the Seminar demonstrated. But an important question is whether it is a matter of conflict of interest or conflict of perceptions, and for this to be explored, even more intensive dialogue is required.

Prospects

This Seminar was conceived in part with the assumption that while nuclear politics may continue to divide at least in the near future, technical cooperation in the nuclear area is still desirable and would be useful in moving relationships forward. With some imagination and will, this should not be an impossible task. Continuing embargoes and sanctions against India in nuclear trade will go against not only India's, but also the international community's energy, security and environmental interests. For example, India's nuclear capacity will no doubt have to be increased to meet its inevitably huge electric power needs in the near future to avoid the heavy utilisation of environmentally degrading fossil fuels. Environment and energy security are of course world class, and the problems in the power sector should be usefully delinked from proliferation problems. The U.S. responsiveness on this will be important for other countries' position vis-a-vis India and for joint bilateral or multilateral activities in this area.

Denial of leading edge technologies under dual use embargoes are unlikely to be successful in the long run against technically resilient states like India. Rather, it would be useful to look at this issue from a point of view of utilising technology to improve the quality of life in developing countries. Rethinking of existing embargoes need not be out of the question since the Nuclear Suppliers' Group operates only under "guidelines," and even the U.S. Nuclear Nonproliferation Act is open to reinterpretation. From India's perspective, there continues to be little, if any, acknowledgement of its self imposed restraint in the nuclear area, ranging from the question of deployment of weapons to export of sensitive material. A reassessment may be particularly timely in the current system of global interdependence in which India is increasingly getting linked through its economic and technological liberalisation.

From the perspective of the outcome of the Seminar, the next stage will be to identify interim steps and measures India and the U.S. could jointly pursue in the nuclear field and launch active work on them through nongovernmental agencies and unofficial channels. In the process, it is hoped that policymaking will be assisted positively in both countries.

We are indebted to the distinguished participants for sparing time from their extremely busy schedules to attend the Seminar and prepare papers as requested. Without their intensive and high quality effort, along with their willingness to engage in frank discussions on admittedly difficult topics, the Seminar could not have been a success. In translating the Seminar from an idea to reality, Dr. Raja Ramanna's vision, leadership, and encouragement were invaluable. In this connection, the keen interest and contributions of Dr. Thomas Graham from the Rockefeller Foundation, were indispensable, and we acknowledge the Foundation's assistance. We must also mention Dr. V.S. Arunachalam who has provided continuing support for the Unit.

Arvind Kumar, Research Associate in the Unit was tireless in taking care of many of the details of the Seminar as well as in preparing this volume. We must also thank the members of the NIAS staff who spared no effort in making sure that the Seminar proceeded smoothly, especially Gayathri Lokhande who provided outstanding secretarial assistance for the Seminar and the publication of this volume.

DEEPA OLLAPALLY
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January 1997

RECENT DEVELOPMENTS: AN INDIAN PERSPECTIVE

Raja Ramanna

Good morning to all of you, ladies and gentlemen. I am supposed to be the first speaker to talk about "Recent Developments: An Indian Perspective." My first duty is to welcome all of you, and express our appreciation that you are all able to be here for this discussion which we presume will have some impact on thinking in the world. I make a special reference to Thomas Graham of the Rockefeller Foundation because this meeting is held on the basis of a joint programme. I also express my thanks for the cooperation I received from my Indian friends.

One word about the passing of this century. It is a remarkable one, but I must say also a very unhappy one. From the scientific angle, the discoveries and progress that have been made are fantastic, but for those of us who have witnessed the great part of the century, it is with great sadness we see the use of modern technology and the world wars.

I would like to quickly summarise what makes India interested in nuclear energy and the consequent problem that it has, perhaps from an angle which may be different from other countries. But the very purpose of this Seminar is to expose these differences and see where we can find a common understanding so that it does not lead to unnecessary recrimination and unnecessary suspicion. One point to note is that the government for a long time has been convinced of the benefits of nuclear energy as a source of power. Unfortunately, our nuclear programme is going slower than before for various reasons which I am sure my colleagues will explain, but in this city of Bangalore itself, the state of power, and the number of cuts we get is a sign of how much we are suffering for want of a simple thing like power.

Once we use something like nuclear energy, we must also take note of other countries which are also engaged in similar activity. We have to protect and have some special considerations for national security and national sovereignty, especially in a situation of scarce resources. Now I have jumped from the necessity of nuclear energy or energy in general, to national security and national sovereignty because India is a country which has been during various periods of our history, dominated by some other power, which did not necessarily have a special attraction for our ways of living, our ways of thinking and this is something to be taken into account. We just cannot erase our cultural tendencies which go back to more than 3000 years. And that culture continues to be with us with its good points and its bad points and therefore, we are rather sensitive to national sovereignty and national security.

But how do we get over all these problems and I think I would like to go to my next part just by mentioning that we have a unique gathering of scientists and those interested in political affairs. Therefore, this gathering should be able to face the problems squarely and I request all of you to be as frank as possible. Our main problem is delinking: yes we need power, but nuclear energy is so connected with economics, safety, public opinion, political issues, and for all these, the base should be technical solutions. We have tried to be slightly different from other conferences and to give a technical bias to our meeting and therefore, I am grateful to the people who have given technical papers so that the solution which we are looking for, may lie simply with good technical approaches and reduce the political pressures that has been with us ever since 1945. In other words, I am saying treaties are necessary for taking certain actions, but they are not an end in themselves and therefore, the removal of suspicion, distrust should be looked at from a technological point of view as well.

I begin with the problem of resources itself which Dr. Chidambaram and the colleagues here from Atomic Energy will perhaps give us the latest information on. One thing we all agree is that we have so much thorium and if you are thinking not of the next century, but the century even after that, the conversion of thorium into fuel and the use of recycling of plutonium becomes essential, and in a sense we consider that the destruction of plutonium in a power reactor is a better way of getting rid of the material after having extracted all the energy that it contains. Be that as it may, we are told that essentially the Nonproliferation Treaty (NPT) and Comprehensive Test Ban Treaty (CTBT) are the way to make progress. This also includes the 93+2 proposal and we are grateful to the International Atomic Energy Agency for having sent a senior representative. These alone however are not a sufficient basis to go forward. Now, a certain amount of lateral thinking has to be done regarding the need for power, need for fuel, and the distribution of power which should be a common commodity all over the world in the next century.

What is happening now is not the example nor is it a happy situation because a lot of time is being spent on the technology of introducing embargoes. For the countries which have scarce material, that sounds more like punishment for no crime committed. But in the end, it is the people who suffer hardships as we are suffering through shortages now. And the moment people have hardship, internal acrimony will start with blame being put on others, which includes outsiders too. As a result, many misconceptions begin to arise. As I said, I do not want to speak too much on these issues but on embargoes I think Dr. Chidambaram is going to speak and I leave it to him. However, I saw something in today's newspaper which we supported a long time ago, and which we thought could prevent the misuse of atomic energy i.e. an agreement of no first use. We have agreed to "no first use" and I believe we can go down this path. If promises to the world mean anything, and someone says they will not use nuclear weapons first, then there can never be a beginning. Now, the whole problem comes down to the fact that there will always be "rogue countries," to use a common phrase. This is where the technical aspect comes in because whereas "no first use" sounds fine, we have to be able to detect unwelcome changes which might be brought on by some unexpected events.

This is a country of nearly a billion people, and democratic methods have to be used in convincing them regarding what is good. We have to compare this with the size of Europe itself. Many times, people say South Asia or Southeast Asia have very complex problems, and that India as a "country of countries" is a very difficult one for people to understand, even for the people who live here. And therefore, a country attempting democracy in these circumstances will always be criticised for the democracy that it does has.

It is not that people here want the weapon aspects of nuclear technology. Weapons of mass destruction are most unpleasant, but there is the question of bullying someone whether by saying "you do not do it" or by saying "we will look after you." There is an issue of being able to trust someone that is a part of the history of the world wars and part of our ancient battles here as well. For example on the question of no testing which came up during the CTBT, who can question India which has not tested since 1974 without signing any treaty. I agree that though we call 1974 a peaceful nuclear explosion, you cannot make a distinction between these things. It was an underground explosion first of its type. So I am sure that this country when it has not tested for more than 20 years, suddenly, it will not become interested in testing, unless there is a problem of security, unless new developments have arisen with respect to the political situation.

Because we are a new democracy, we do not like people being treated separately, one from the other. Yes, we agree that there could be rogue countries and non rogue countries if globally all countries are in agreement. But we cannot accept that five countries or six countries or a few others are highly intellectual and better than all of us, morally or mentally. This is the thing which used to worry us in the 1930s and the 1920s and something that used to demoralise us in the last century, if we look at the writings of that period. We would like to get rid of that. I am very glad that the IAEA is represented here. Perhaps, we have to look forward to some international organisation to remove suspicions.

I would like to end by saying that in the various presentations to come, we must have frank discussion at every point. Mine is essentially in the form of welcoming remarks and recent developments in the Indian perspective. I think people in charge in government like Dr. Chidambaram will say how important it is to increase our energy output from nuclear energy. Therefore, one would like to have assistance of getting on with the job quickly. I am sorry, but this is where I am very critical of the IAEA quietly sitting by while lists like the London Club list is made and the Zangger Committee is formed. They used to get a kick out of it by increasing the list without seeing the consequences in international trade and to other countries trying to develop. It helped us to a certain extent that a degree of self reliance came about, but we are such a big country that we could do it, but I think it harmed much smaller countries.

I do not know if it has helped in politics. Some of our industries rose to the occasion and could produce the required material, but sometimes it reached such a ridiculous stage by saying such things as "you will not be supplied nuclear magnetic resonance equipment for your hospital because it is nuclear material." I have seen that letter and that shows the arrogance which comes about by misinterpreting government rules (about which we know here). But when these things happen in the private sector, it shows a kind of contempt for other human beings. We would like to get rid of all that and our question is how do we do it. On dual use, certainly there are some good reasons for it, but simply signing things which other people want us to sign, certainly could upset the whole equilibrium of the world for the next century. This is a very bad situation, ladies and gentlemen, and I would like you to think about all these matters. That is all I have to say. I once again thank you for listening to me.

RECENT DEVELOPMENTS : AN AMERICAN PERSPECTIVE

Thomas W. Graham

This brief essay is being written to answer the question related to the continuing strains in Indo-U.S. relations, considered from a nongovernmental perspective. Many suggest that Indo-U.S. relations are strained primarily because of decades of nuclear controversies, the most recent of which was the Comprehensive Test Ban Treaty (CTBT). While clearly true, this answer also obscures more than it illuminates. A more complete answer relates to a series of changes in both the American foreign and military policy decision making systems and information gathering systems that have taken place after the end of the cold war. The basic problem is that the mainstream U.S. elite press such as the New York Times, Washington Post, and Wall Street Journal, has cut back on the quality and quantity of its foreign reporting at the same that other information sources including cable channels like CNN and the Internet have proliferated. Thus, the information gaps between what is in the minds of generalist decisionmakers, "functional" policy experts, and regional specialists have grown. Since U.S. government officials are also moving into an electronic environment, the problem is equally true for people whether they work for government or nongovernmental institutions.

The difficulty to get multiple audiences to learn the same lesson has increased, unless some dramatic event takes place. For better or worse, in terms of Indo-U.S. relations, in the last year this "dramatic event" has been India's blocking of the CTBT in Geneva and the nearly unanimous vote at the United Nations General Assembly. On the American side, this event has stimulated uneven learning. Some of the lessons that have been learned both by specialists and generalists may be wrong. Solving this problem will require a great deal of effort and changing some of our standard operating procedures.

Increasingly, in the United States, people who follow foreign affairs can be placed in one of three groups. While the name and composition of the groups differ depending on the issue being addressed, the basic structure is similar across issue areas. The most elite group consists of what may be termed as the "gate keepers" who are still (by virtue of their seniority) people who have spent the majority of their professional lives working on or near U.S.-Soviet issues and occupy most of the decisionmaking positions in government. In this regard, the Bush administration and the first Clinton administration are quite similar. For the first Clinton administration, Anthony Lake, (National Security Council), William Perry (Department of Defence), Warren Christopher (Department of State), John Deutch (Central

Intelligence Agency), Strobe Talbott (Department of State) were people who could make decisions on Russia related issues almost without the aid of briefing papers. This was not true of many other issues.

The second level team was equally dominated by people who have had little knowledge about Asia, Africa, Latin America or the emerging issues of drugs, terrorism, or even weapons of mass destruction (WMD) proliferation. The nongovernment sector is more diverse, but again the most senior experts tend to be people who have had extensive experience working in the executive branch, often on cold war issues. A good list of these experts may be found looking at the membership of the Council on Foreign Relations. Increasingly, these people are having to learn complex lessons concerning countries and issues about which they knew virtually nothing a few years ago.

Next comes "functional" policy specialists. These are people who are experts on issues such as arms control, human rights, economic policy and environmental policy. For any policy to be formulated and implemented successfully, their detailed knowledge must be understood by the gate keepers. While some of these experts in and out of government have developed significant knowledge about specific regions or countries, they often do not have extensive foreign language skills and have not lived outside the U.S. sufficiently to get a feel for non-European, OECD advanced industrial countries.

Finally, there are people who are traditionally characterized as "area studies" experts. Both in and out of government, most of these people have devoted their lives to learning about a particular region, and often one country. As mobility within government is the norm, many times regional experts outside of government have more knowledge of "their" region than do people on the foreign affairs, defence, treasury, and intelligence desks. However, until relatively recently, government area studies experts have had much more specific, time sensitive information than is available to scholars and nongovernment experts.

For purposes of this essay, the groups will be called the foreign and military policy gate keepers, arms control and nuclear specialists, and Southern Asia specialists. The term "Southern Asia" is not common. I use it here to include experts both on South Asia (traditionally defined) and China. I include China because in my view it is an integral part of both the security problem and the potential solution. However, most American experts on China share a traditional Chinese view that rejects such a close linkage with "South Asia". An important point which needs to be taken into account is the very existence of these groups in the U.S. and the lack of a monolithic perspective.

I will list in reverse chronological order short-hand notations for events that have been considered important to these different groups. The list is based on material that has crossed my desk in the last month and is by no means complete. I hope it will provide sufficient "data" so that participants at the conference can judge for themselves the validity, or lack of validity, of the propositions set out in this paper.

Foreign/Military Policy Gate Keepers

- The second Clinton administration has already met with opposition to its proposals to deploy additional U.S. troops in Bosnia and to deploy troops in Central Africa.
- The second Clinton administration will have a new foreign and military policy team with great uncertainty on the degree to which foreign affairs will be emphasized. During the last presidential debate which included questions from the public, the moderator asked at the end, "Does anybody have a foreign affairs question?"
  The failure of Bob Dole to make any headway on his "realist" foreign policy critique on Clinton demonstrates that voters really believe the cold war is over.
- A bipartisan group of gate keepers attempts to define U.S. national interests and sustain support for international affairs leadership in the face of decreased public interest. The Commission of America's National Interests produced a report in July 1996 which had as co-chairs, Robert Ellsworth, Andrew Goodpaster, and Rita Hauser; as executive directors Graham Allison (Harvard), Dimitri Simes (Nixon Center for Peace and Freedom), and James Thomson (RAND). Other members included Richard Armitage, David Gergen, Geoff Kemp, John McCain, Condi Rice, Robert Blackwill, Bob Graham, Arnold Kantor, Sam Nunn and Brent Scowcroft. The commission identified five "blue chip" vital U.S. national interests as the following: prevent, reduce and deter proliferation of WMD; prevent emergence of hostile hegemon in Europe or Asia; prevent the emergence of a hostile major power on the U.S. borders or in control of the seas; prevent catastrophic collapse of major global trade, financial, energy or environmental systems; ensure survival of U.S. allies. The report says that complete elimination of nuclear weapons should not be ruled out, but thought it was not practically possible at this point in time. With respect to South Asia, it said that an Indo-Pakistan nuclear war would not necessarily threaten a vital U.S. interest.
- A half dozen nongovernmental groups are trying to focus attention on

the sharp reduction in funding approved by the Congress for the 150 account which covers non-defence and non-intelligence aspects of U.S. foreign policy.

Arms Control and Nuclear Policy Specialists

- The intellectual debate over abolition of WMD has become more serious as demonstrated by the forthcoming (December 4, 1996) statement by senior retired U.S. military leaders, international military leaders, the Canberra Commission report and other policy papers. It may be noted that when this author first suggested that an intellectual movement was growing in the U.S. to support elimination of nuclear weapons at a meeting at NIAS in January 1994, many Indian participants were polite but skeptical. There are now at least a dozen policy reports that focus on the issue of deep cuts or elimination. Within the next three months several key documents will be released on this topic. A description of the range of thinking primarily in the U.S. on the abolition issue is summarized in a paper written by this author which can be made available to interested participants.
- President Clinton's speech at the U.N. on September 24, 1996 outlined his six point arms control agenda. Clinton's six points were: (1) Chemical Weapon Convention (CWC); (2) a fissile cutoff; (3) post Russian ratification of START II, continued nuclear reductions and limiting and monitoring nuclear warheads and materials to make deep reductions irreversible; (4) strengthening the NPT regime; (5) strengthening the Biological Weapons Convention; (6) ban on the use, stockpiling, production and transfer of antipersonnel land mines.
- Nongovernmental experts believe that severe challenges are ahead with respect to Russian ratification of START II, and U.S. ratification of the CWC and CTBT.
- The Republican platform, reports from key Republican members of Congress and other nongovernment policy experts reveal that a significant group of people oppose a zero yield CTBT and would like to continue to modernise the U.S. nuclear force. For example, the Chairman of the House National Security Committee, Floyd Spence, a Republican from South Carolina was extremely critical of the administration's efforts to reduce emphasis on nuclear weapons.

Southern Asia Specialists

- Japan was named over India to become the Asian non-permanent member of the United Nations Security Council.

- A parliamentary debate has begun in India over the effectiveness of its foreign policy.
- A sharp debate in India continues after the CTBT was approved by the UNGA on the desirability of India conducting another nuclear test. Participants include Raja Ramanna, K. Subrahmanyam, Brahma Chellaney, C. Raja Mohan.
- Support in India for total elimination of nuclear weapons is often mentioned, but few specifics are noted, especially with respect to steps India is willing to take.
- A public opinion survey conducted in Pakistan concluded that a consensus 62 percent supported keeping the nuclear option open, while 32 percent favored acquisition of nuclear weapons and six percent renouncing nuclear weapons. Virtually all saw the threat coming from India.
- Some South Asia experts support the United States having India balance China. Other South Asia specialists believe that no support for a balancing role will be found either in the United States or in Southeast Asia,
- Foreign Minister Gujral's July 15,1996 statement to Parliament included a subtle diplomatic hint that a compromise might be worked out on the CTBT issue: "What we are seeking is a commitment to engage in negotiations that will lead to the elimination of nuclear weapons within a time frame. Naturally, we have our own idea of what is a reasonable time frame but we are willing to negotiate this with other countries. We realize that such negotiations are not part of the CTBT, but we would like the CTBT to act as a catalyst for these negotiations. Without such a commitment reflected in the CTBT, we are convinced that this treaty will be an end in itself, rather than a first step on the road to nuclear disarmament. Unfortunately, the nuclear weapons states remain unwilling to make any meaningful commitment with regard to eliminating their nuclear arsenals." The speech also mentioned India's policy of unparalleled restraint for 22 years.
- In the summer of 1996, the Council on Foreign Relations convened a task force of specialists to attempt to outline a new U.S. policy approach towards South Asia. Press reports on China's assistance to Pakistan's nuclear weapons and missile programmes, repeated calls in the Indian press for nuclear weaponisation and testing, and the reduced quality of NGO interaction between American and Indian specialists all combined to keep this task force report from being completed.

CURRENT NUCLEAR PROLIFERATION REALITIES

NONPROLIFERATION, DISARMAMENT AND THE SECURITY LINK

C. Raja Mohan

India's decision to block the passage of the Comprehensive Test Ban Treaty (CTBT) at the Conference on Disarmament (CD) in Geneva and its vote against the Treaty at the United Nations this fall have deepened the nuclear divide between India and the United States--and the western powers in general. Although India and the United States have argued about the nuclear question for nearly three decades, their differences now look far more irreconcilable in the wake of their recent acrimony over the CTBT. After successful cooperation in the application of nuclear energy for peaceful purposes during the 1950s and early 1960s, India and the United States began to drift apart and argue on a number of issues. These included the role of nuclear weapons in international security, the management of the nuclear weapons dynamic in India's neighbourhood, the regulation of the global flows of civilian nuclear technology, the creation of a fire-break between civilian and military uses of nuclear technology, the question of technical choices for the future generation of nuclear power such as plutonium use, and on the priorities of global multilateral arms control. Since the 1980s, the differences have extended to the sphere of missile development, space technology and beyond to cover a broader gamut of strategic and dual use technologies.

A Rocky Relationship

Since the end of the cold war and the Gulf War, nonproliferation has become a major element of the Indo-U.S. dialogue, and tended to complicate the bilateral effort to build a new political relationship in the changed global context. For the United States, preventing the spread of weapons of mass destruction has emerged at the top of the American foreign and national security policy agenda in the 1990s. The Bush administration and the Clinton administration sought to promote a range of diplomatic initiatives--at the bilateral, regional and global levels with the objective of bringing India into the nonproliferation net. For an India that found itself in difficult political and economic circumstances at the end of the cold war, defending its nuclear option had become an important domestic political issue. India ducked and dodged most of the American arms control proposals, including the convening of a multilateral conference to develop a regional nonproliferation agenda for the Indian subcontinent.

Seeking to build a broader political and economic relationship, India and the United States made an attempt to narrow their nuclear differences and find some common ground on arms control. At their Washington meeting in May 1994, President Bill Clinton and Indian Prime Minister P.V. Narasimha Rao issued a joint statement in which they appeared to find a formula to finesse their nuclear divergence. The United States acknowledged the importance of total disarmament as a long term goal. India conceded the necessity of discussing nonproliferation in a regional and global context. Clinton and Rao also pledged that their governments would intensify their cooperative efforts to achieve a CTBT and a verifiable ban on the production of fissile materials.

Barely two years later, this approach towards bridging the nuclear divide between India and the United States lies in shambles. At the end of the drafting of the CTBT, India has declared that it will not sign the treaty, not now, not later. And the United States has managed to get a CTBT, that will not come into force without India's signature. The deepening nuclear divergence between India and the United States has also clouded the prospects for a fissile materials cut off treaty.

This paper argues that so long as India and the United States persist with their current normative approaches to the nuclear question, they will be unable to resolve their differences on nuclear weapons. The United States argues that nonproliferation has now become an international norm, with the unconditional and indefinite extension of the Nuclear Nonproliferation Treaty (NPT) and the overwhelming global endorsement of the CTBT. The U.S. believes that South Asia today remains the principal exception to the global nonproliferation norm. Gaining universal adherence to the nonproliferation norm must be expected to be one of the major priorities of American foreign policy in the coming years. India on the other hand argues that the elimination of all mass destruction weapons must be the norm that the world should work for. Having agreed to eliminate biological and chemical weapons, now it is necessary to move in a determined fashion towards the abolition of nuclear weapons. If India and the United States shed these rigid approaches and look at nuclear weapons as part of the larger balance of power system in the world, they may be in a better position to find cooperative solutions to their nuclear dilemmas.

India: A Step Towards Realism

The prolonged and vigorous recent Indian debate on the CTBT revealed one new trend: an emphasis on the security dimension as opposed to the traditional obcession with disarmament. For nearly half a century, normative considerations such as equity, fairness, and nondiscrimination have been at the heart of Indian nuclear policy. General and complete disarmament has been India's great goal. The elimination of nuclear weapons has been its principal objective. In an important shift during the CTBT debate, the officials of the Indian government and its negotiators at the CD have also cited national security considerations besides others in opposing an international arms control treaty. Pointing to the continued reliance on nuclear weapons by the great powers for their national security, and the nuclearisation of India's neighbourhood, New Delhi, probably for the first time, began to signal to the world that national security considerations may now have become a vital element in India's arms control decisionmaking.

For most countries of the world with a stake in nuclear issues, there was clarity about the relationship between national security and arms control. The latter was an extension of the former. Arms control diplomacy has always been an integral part of the national security policy of the traditional great powers of the international system. For the smaller powers or the defeated ones, national security through alliances has been far more important than fairness or equity in arms control arrangements. But for China and India, the two large nations with significant power potential that emerged at the end of the Second World War, managing the relationship between arms control and national security has not always been simple. They have been far too obsessed with independent foreign policy to become lesser partners in alliance systems with great powers. China found out that even ideological affinity would not cement its alliance with the Soviet Union in the 1950s. Both China and India discovered that they had no option but to rely on their own means for national security.

But the efforts by these emerging powers to realise their own power potential has often run headlong into the prevailing priorities of the arms control agenda established by the western powers which have dominated the international system. China's search for an independent nuclear deterrent in the 1960s was challenged by the Partial Test Ban Treaty (PTBT), that was widely seen as a "collective good" for the international community. While the whole world supported the PTBT, China had no option but to defy it. It was no surprise that China condemned the PTBT as a tool of superpower hegemony, and pressed ahead with atmospheric nuclear explosions until it could go underground like the other nuclear weapon powers.

India's own efforts to expand its strategic options had to confront a variety of international obstacles, including the NPT and the associated global nonproliferation regimes. Since the end of the cold war, the U.S. backed efforts to cap, reduce over a period of time, and eventually eliminate India's nuclear and missile capabilities acquired a new thrust. Like China in the earlier period, India today has had no option but to reject this post cold war arms control agenda of which the CTBT is only one element.

As they struggled to protect their strategic potential from being denuded by the international arms control regimes, both China and India had to justify their defiance in terms of higher ideological principles. Just as the west presented its own particular interests in nonproliferation as universal interests, China and India too had to articulate their defence in terms of a broader philosophy. China put its opposition to global arms control in the 1960s and 1970s in terms of left wing internationalism and resistance to superpower domination of the international order. India took recourse to principles of liberalism. At the bottom of it all, there was no question that both countries were seeking to preserve their own interests. But the similarity between India and China ends here.

China gate-crashed into the club of nuclear weapon powers, while India continues to agonize over its nuclear option. Once it became a nuclear weapon power, China has managed find a better balance between its national security interests and its disarmament diplomacy. Having gained formal recognition of its nuclear status, China's troubles with international arms control regime began to abate. India, which has danced around the threshold status, is now seen as the nation with the highest proliferation risk and invites the full wrath of the global nonproliferation regimes. For China, disarmament diplomacy has become an instrument to keep the international focus on the continuing arms race between the other great powers, to publicize its own restraint, and present its own nuclear weapons in a less threatening way. In that sense disarmament diplomacy has become a scaffolding to preserve the political utility of its nuclear deterrent.

In India, on the other hand, disarmament diplomacy has become an end in itself. It has tended to paralyse New Delhi's ability to take critical decisions on the nature and structure of its nuclear deterrent. The emphasis on normative principles and the focus on ethical questions that are so central to India's articulation of the goal of disarmament, have become the principal obstacles to clear and hard-headed thinking about nuclear weapons and its own security. The disarmament posture, to be sure, was useful in justifying India's rejection of international arms control that imposed unacceptable constraints on its nuclear programme. But it also has come in the way of taking tough decisions on its strategic programmes.

The new emphasis on national security in the Indian nuclear debate in the context of the CTBT has been long over due. But this new approach has not removed the traditional focus on disarmament. After all the absence of a linkage between the CTBT and a time bound framework for the elimination of nuclear weapons has been among the principal reasons for the Indian rejection of the CTBT. The broad political consensus in New Delhi against the CTBT was built around the traditional commitment to disarmament and not on the basis of an agreement on what to do with India's nuclear weapon option. This dominance of the disarmament view has left many questions unanswered. Would India have agreed to forego the right to conduct a test in the future in return for an agreement by the nuclear weapon powers to negotiate nuclear disarmament either within or outside the CTBT framework? Could India have accepted a time frame of, say, 50 years, to eliminate nuclear weapons? What about the possibility that nuclear weapons will be around for a long time to come? How would India deal with the nuclear threats in the interim, pending their elimination? Or even more importantly, has a compelling case been made to suggest that India would be more secure in a world without nuclear weapons? Or does the case for nuclear abolition rest on consequentialist and deontological arguments alone?

United States and Nuclear Abolition

Even as a realist strain begins to assert itself in the Indian thinking about nuclear weapons, there is a growing body of opinion in the United States that is beginning to look at the abolition of nuclear weapons in a serious way. Many former senior defence officials and retired generals have begun to argue that the utility of nuclear weapons has begun to decline. Many think tanks and groups in the United States are engaged in studies about the problems and challenges of nuclear abolition. Unlike in the past when the very notion of nuclear abolition was laughed out of court there is a strong view that the question now needs serious professional attention of the strategic community. At the global level the recent judgement of the International Court of Justice that the great powers have an obligation to negotiate the elimination of nuclear weapons has enthused disarmament activities worldwide. Earlier the Canberra Commission, a group of "wise men" from all over the world endorsed the objective of nuclear abolition, although without a definitive time frame to achieve it.

Does the new interest in nuclear disarmament provide an opportunity for resolving the Indo-U.S. nuclear differences, and for a cooperative endeavour towards nuclear abolition as envisaged in the Clinton-Rao declaration? The optimists argue that the Clinton administration has already conceded the objective of nuclear abolition, as an eventual goal not only in the Clinton-Rao statement but also in the declaration of principles and objectives issued at the end of the NPT extension conference in May 1995. It is pointed out that the difference between nuclear abolition as an "ultimate goal," accepted by the Clinton administration, and a "time-bound framework" demanded by India should not be impossible to bridge. Some pragmatists argue that rather than set time tables, India and the United States should work towards progress in all directions including regional nonproliferation, interim global steps such as a fissile materials cut off, further reduction of American and Russian nuclear arsenals, and the capture of China, Britain and France into the net of nuclear force reductions. The simultaneous progress on all fronts will eventually help reduce the reliance on nuclear weapons for national security and marginalise them. There is some expectation that President Clinton in his second term, with an eye on history and a new focus on foreign initiatives, will be in a position to give a decisive push towards the abolition of nuclear weapons. It is argued that this opportunity should not be missed.

It may be premature for New Delhi and Washington to build hopes for arms control cooperation on the basis of this scenario. A number of factors are at work that suggest the prospects for a significant movement towards nuclear abolition are not bright. Although the arms control community in the United States is today far more serious about nuclear abolition, there are strong forces that are opposed to the project. First, the strategic community in the United States has articulated a powerful set of reasons for the continuing relevance of nuclear weapons. The end of the cold war, it is argued, has not dissolved the importance of nuclear weapons and the doctrine of nuclear deterrence. Nuclear weapons are essential to preserve America's security commitments to its allies which are of prime importance in maintaining a stable world order. Without the benefit of America's extended nuclear deterrence, countries like Japan, Germany and Korea will be tempted to acquire national nuclear arsenals. Nuclear weapons are necessary to deter the use of chemical and biological weapons by the so called "rogue states." Maintaining a superior American nuclear force will help prevent local bullies from dominating their neighbours in regions of vital interest to the United States assuming that Washington will be deterred from intervention on behalf of the victims. These formulations have been fully endorsed by the Pentagon, and it will not be easy to overcome this new theology.

Second, even if the Pentagon can be rolled over, there is growing opposition to arms control in the United States Congress. Increasingly isolationist in its outlook and deeply suspicious of multilateralism, the Senate is unlikely to endorse the vision of a nuclear weapon free world. On the eve of the November 1996 elections, the Clinton administration was forced to withdraw the Chemical Weapons Convention from the Senate where it was believed there was enough opposition to prevent its ratification. Analysts in Washington are also suggesting that the CTBT too will face rough ride in the Senate, if and when the administration sends it for ratification. The Congress is also forcing the Administration to spend more on missile defences; this could undermine the ABM Treaty as well as prospects for further nuclear disarmament. In the United States there has always been a view that was strongly opposed to basing American security on international arms control agreements. This view emphasized the importance of Washington relying on its own military capabilities to ensure that cheaters of the treaties do not endanger American interests.

Even if President Clinton can persuade the Congress, the other nuclear weapon powers are unlikely to go along with the project on nuclear abolition. For Britain and France, nuclear weapons seem to remain an important source of international status and prestige. In a denuclearised world, the British and French could argue that there may be little to prevent them from being relegated to a secondary status; it could also diminish their political status vis-a-vis Germany. In Russia, there has been a dramatic transformation in the thinking about nuclear weapons during the 1990s. From actively campaigning for their elimination in the late 1980s and early 1990s, Russia has now returned to new dependence on nuclear weapons in its security strategy. Having weakened its conventional military power, Russia may have no other option. As the western powers debate the expansion of NATO closer towards Russian borders, Moscow appears to be debating the adoption of the doctrine that calls for reliance on tactical nuclear weapons to counter the conventional superiority of the west. As a rising power, and apprehensive of an American drift towards containment of China, Beijing is unlikely to forego its nuclear deterrent. Both Russia and China could argue that a world without nuclear weapons would work to the advantage of the United States, that has gone farthest down the road of a new military technical revolution based on information technologies. Recognising the impossibility of matching the United States in the new technological revolution, the lesser powers of the world may conclude that nuclear weapons may be essential to balance the American dominance.

Conclusion

From the preceding discussion it is obvious that nuclear weapons are here to stay for a long time to come. Many nation states are likely to operate on the premise that the combination of nuclear weapons and long range missiles provides an unrivalled source of power. The United States and India cannot hope to structure cooperation on the hope that nuclear weapons can be marginalised and eventually eliminated from the international calculus of power. Nor can they go by the premise that the existing structure of international power can be frozen through the strengthening of the current nonproliferation regime. Continued diffusion of power and the spread of technology as well as the political dynamics could break the current order. This bleak assessment does not however imply that there are no prospects for cooperation between India and the United States. If both the nations move towards a more realistic policy positions and locate their nuclear dialogue in a broader strategic context, it should not be impossible to develop areas of cooperation.

India can no longer postpone the crucial final decisions on the nature of its nuclear option. Its inability to be part of an alliance system and its determination to pursue an independent foreign policy will eventually force India to come to terms with its nuclear weapon capability. India's rhetoric on disarmament is a poor substitute for defining a nuclear posture. Clarity on its nuclear weapon capability will allow India to pursue more effectively an arms control diplomacy that will help stabilize the balance of power in the Indian Ocean/Asia-Pacific region.

The United States is unlikely to succeed in capping and rolling back India's nuclear and missile capability; nor can it hope to tie India down to a limited framework of South Asia. The challenge for the United States is in finding a way to accommodate India as a responsible partner in the management of the global nuclear order. Although the current thinking in Washington appears to have made nonproliferation an end in itself, the history of American policy reveals that nonproliferation and other normative goals have always been subordinated to the larger interests of balance of power. Once India and the United States begin to look at the importance of Asian security over the long term, they may be able to find ways to manage their nuclear divergence.

IS THERE A TECHNICAL SOLUTION TO PROLIFERATION?

Alfred Lecocq

Nuclear proliferation is presently a threat to all nations and there is a strong need to reduce the proliferation of weapons. At the same time, states should be able to increase nuclear energy supply safely with an attempt to avoid the production of weapon grade fissile material. The development of the thorium cycle is essential for achieving both these goals. The liquid fluoride technology finds its application with the Molten Salt Fission Reactors (MSR) and with the Accelerator Molten Salt Breeder (AMSB), initially proposed in Japan fifteen years ago. The liquid fluoride technology was studied at the Oak Ridge National Laboratory nearly thirty years ago but research was wound down in 1974. Therefore, a good question is the extent to which a technical solution, as opposed to a purely political one, may be found for proliferation.

Beyond Political Treaties

Global nonproliferation proposals have not been successful in the real sense of the term. The Conference on Disarmament (CD) for example which held discussions in Geneva on the Comprehensive Test Ban Treaty (CTBT) for two years, could not reach a consensus among the participants because India followed by a few other nations, has refused to sign the final proposal as long as the five nuclear powers consisting of China, France, Russia, U.K. and the U.S.A. have not agreed to define a specified framework of time for the elimination of their own oversized nuclear arsenals. To put it more bluntly, none of the five nuclear weapon nations seem willing to give up their nuclear weapon capability.

The main objectives of the Intermediate Range Nuclear Force (INF) and START treaties is to not only control further growth of nuclear weapons, but also reduce them. In addition, the fissile materials of nuclear weapons must be neutralized in order to eliminate the threat of nuclear war. However, until now, the problem of nuclear warhead elimination remains.

In addition to the nuclear threat, another important threat for mankind during the next century will be huge emissions of carbon dioxide which will induce an increased greenhouse effect, with consequences for the climate of the earth. As a counter to this prospect, the stabilization of greenhouse gases emissions at the 1990 level can be obtained if 3000 to 5000 large nuclear power reactors are constructed globally. But this could increase the risk of nuclear proliferation and thus negate another key objective.

Thus it appears that the reduction of nuclear proliferation must use technical solutions appropriate for the short term as well as the long term. Two questions are relevant. First, how to destroy existing nuclear weapons without producing new fissile materials. Secondly, how to produce a large amount of nuclear energy in the coming century without risking weapon grade material diversion.

Elimination of Existing Nuclear Weapons

The European International Working Association (EURIWA), a group consisting of independent nuclear technicians, has been working toward the reduction of nuclear proliferation and has proposed technical alternatives to eliminate nuclear weapons without producing any new fissile material usable to fabricate new nuclear weapons.

Neutralization of warheads made of Highly Enriched Uranium (HEU) is not a significant problem, since it is always possible to dilute this material in natural or depleted uranium until a convenient concentration (< 20 percent) is achieved which can be used later in classical fission reactors. A better solution would be to use it after an essential denaturation by the even isotopes of uranium (234U, 236U) to avoid plutonium production. Such fuels are the most convenient for small power research reactors, merchant ships, and isolated land surfaces (arctic, antarctic, deserts with untapped resources). The normal operation of these facilities could be easily checked by the International Atomic Energy Agency (IAEA) with satellites. Another option would be to use highly enriched uranium as seed for thorium, which has no natural fissile isotope, to allow its use as an easy energy source.

On the issue of burning military plutonium, various proposals have been made to destroy by fission the weapons grade plutonium in conventional reactors, Light Water Reactor (LWR), VVER, CANDU, or Fast Breeder Reactor (FBR). Inert matrixes can be utilized to contain the Pu compound (generally oxide). This process of weapon destruction necessitates the simultaneous use of burnable or removable absorbers, which deteriorate the neutron economy. Besides, the energy production is strictly limited to about 90 percent of the fissile content. The residual product might be buried in deep repositories. Classical fertile matrixes (MOX) can be irradiated with thermalized or fast neutrons in the present operating nuclear power stations. In this case, the neutron economy is better but the use of uranium based matrix leads automatically to the production of fresh plutonium which would further delay elimination measures.

Thorium Utilization

There are several lessons of the past for the fission nuclear industry. This industry is based on the use of uranium which was necessary for fission energy development. However, the uranium-plutonium fuel cycle was the starting point of nuclear proliferation. Historically, it could not be otherwise, but more precise possibilities offered by another fertile material, thorium, is now available for power production. The advantages of thorium include the following:

- Thorium is four times as abundant as uranium, and supplies 100 times more energy
- It breeds neither plutonium, nor long high-lived minor Actinides
- The amount of thorium waste is several orders of magnitude smaller than that of uranium
- The thorium cycle is self protected against proliferation by its U-232 contents.

Thorium's superiority is not in doubt but it does not have any fissile isotope. Until now, uranium was necessary for fission energy development and thorium cycle could not start without uranium. With the advent of accelerator spallators, this will not be the case.

The utilization of thorium results in the production of 233 U and thereby conserves the energy resources to a variable degree, depending on the nuclear characteristics of the industrial option. The danger of creating a new weapon grade material can be intrinsically avoided by tuning the generation of 233U towards significant contents of 232U, whose daughter products (212 Bi and 208 Tl) are high gamma energy emitters. While this contributes to proliferation resistance, it also leads to inconvenience in the subsequent utilization of this fissile material in the solid fuels of civilian classical applications. Many proposals for thorium utilization may be found in the literature. Some look at the use of HEU or plutonium as fissile; some others are devoted to classical reactors such as CANDU-Pressurised Heavy Water (PHW) reactors; still others to High Temperature Reactor cooled with helium; and to molten salt reactors.

The spallation process *which supplies 30-40 neutrons* by the blasting of each heavy nuclei with high energy proton, should be the most efficient way to produce 233 U from 232 Th. This route has been proposed within a global project called THORIMS-NES (Thorium Molten Salt Nuclear Energy Synergetics). This resulted after the Molten Salt Breeder Reactor (MSBR) studies pursued in the U.S. at the Oakridge laboratory was given up or stopped. The THORIMS-NES explores the whole process of energy production by fission, from the thorium element to waste elimination. The three principles of THORIMS-NES are *thorium utilization*, *liquid fuel* technology and separation of fissile producing facilities and power stations.

According to THORIMS-NES project, thorium releases its energy in thermalized reactors using liquid fluorides (Molten Salt Reactors:MSR), while the new fissile material, 233 U, is produced with spallation in Accelerators (Accelerators Molten Salt Breeders: AMSB). But presently, neither MSRs nor AMSBs are deployed, and nuclear weapons destruction is being postponed.

Proposal for CANDU-PHW Reactors

Before the development of these advanced devices, an intermediary step is available which helps in the recycling of warhead materials in CANDU reactors. Canadian studies have examined many scenarios for the use of fissile highly enriched uranium (HEU) or weapons plutonium (WPu), with a view of transmuting 232 Th into 233 U. The neutronic characteristics of CANDU-PHW allow to reach 30,000 Mwd/ton by mixing the fertile thorium with these fissiles.

The utilization of these new fissile resources, which need neither more enrichment facilities (to supply HEU), nor new reprocessing plants (for WPu production), would be an important economic trump, even if initially one works on Once Through Thorium cycle (OTT), i.e., without retreatment of irradiated thorium. With this management option, although not the optimal one, the irradiated materials are considered as mines of fissiles, to be exploited in the future.

During the eighties, many fuel cycle studies were conducted in India to reach a self sustained use of thorium with CANDU-PHW reactors. An assessment of the needs in basic materials (U and Pu), and in industrial capacity including fuel fabrication, reprocessing, and stor[illegible] spent fuel, to have a self-sustained management grounded on the thorium cycle, shows that the main difficulty is to have, initially, a highly concentrated fissile product. Its previous fabrication should tie up a large amount of money to build big industrial enrichment facilities (for 235U), or new reprocessing plants to extract plutonium which is originally produced from natural uranium in CANDU - PHW reactors. Thus, it appears that the lack of a necessary initial quantity of fissile material is a heavy handicap for India's development.

In an other study conducted at the Bhabha Atomic Research Centre, it was shown that a power increase, with a doubling time of about 14 years, could be easily obtained with CANDU-PHW near breeders, provided that there is a make-up of fissile. Therefore, the disposal of HEU or WPu from nuclear weapons could allow India, where sufficient expertise has been built up, to take up work in this field. India would be able to exploit sooner than later, the huge reserves (3,60,000 tons) of thorium it possesses.

NUCLEAR COOPERATION

In the coming years, it may be said without any doubt that the CANDU proposal is better than the MSR one. Several nations have chosen to undertake the CANDU route for their nuclear energy supply. Canada and India have wide experience with these reactors, but other nations (Argentina, Korea, Pakistan and Romania) will have the same knowledge. These nations which were never involved in the past nuclear weapon race, or have always denied having military projects (like India), could under the strict control of IAEA, technically start the reduction of the nuclear arms stockpiles.

In spite of the ending of Oak Ridge studies in 1974, several states have gained a good knowledge on molten salt reactor possibilities. Many calculations and experiments have been performed in Japan, Russia, France on breeders, converters and denatured MSR.

It can be concluded that for the present time, CANDU-PHW is the available way to destroy Pu nuclear weapons. It is also true to say that molten salt applications have the highest potentialities to fight against proliferation and terrorism. The threat of proliferation by laser enrichment of reactor grade plutonium can be eliminated by burning this plutonium in MSR or AMSB. The looming threat of energy shortage could become meaningless if states have the will to cooperate for the welfare of mankind.

In order to move now toward achieving this long term project several steps may be taken. For the destruction of weapon grade plutonium (WPu), CANDU reactors should be used with P_uO_2 -Th O_2 mixtures as fuel. For this, a short term cooperative plan of ten to twenty years needs to be formulated under the aegis of the International Atomic Energy Agency. Collaboration should be facilitated between nuclear weapon states and the nations which have a good knowledge of CANDU reactors and cannot be suspected of proliferation motivations. For the longer term plan, Molten Salt applications (MSR and AMSB) are proposed to relay the CANDUs, in order to achieve the treatment of nuclear waste and to supply the non proliferating fissile mixtures produced in highly safeguarded international centers. The expected second nuclear era could be on its way.

BEYOND NUCLEAR PROLIFERATION: IMPLEMENTING NONPROLIFERATION REGIMES

93+2 PROGRAMME PROPOSAL

David Sinden

In 1952, General Omar Bradley of the United States said that the only way to win an atomic war was to make certain that it is never started. Since those days, through nearly a lifetime of confrontation and negotiation on arms control, disarmament and the limitation of nuclear weapons proliferation, nations have come closer to collectively winning this war. As this Seminar explores the challenges and prospects for international nuclear cooperation, it is useful to recall that such cooperation has long been suspected of concealing nuclear arms proliferation in its shadow. Regimes of verification or safeguards designed to cast light into this shadow have thus become a cornerstone of peaceful international nuclear cooperation.

In this piece, I would like to describe some of the activities being pursued by the International Atomic Energy Agency (IAEA), through its Board of Governors, to strengthen the effectiveness and improve the efficiency of the Agency's safeguards system. I will first briefly put these activities into an historical perspective to illustrate the motivation and rationale of the measures under consideration.

A Historical Perspective

Nearly 40 years ago the statute of the IAEA came into force, thereby providing for the first international system of safeguards to verify that nuclear materials and facilities were not used to further any military purpose. Although the first systematic and documented IAEA safeguards system, approved in early 1961, was limited to small reactors, it was subsequently revised and expanded several times to take account of the full range of nuclear fuel cycle activities. In 1968, the Agency's Safeguards System, INFCIRC/66/Rev.2, was approved.

International safeguards were thereafter at the disposal of states to verify that nuclear materials and facilities were not being used to further any military purpose. Before this point, nuclear cooperation had largely taken place under bilateral cooperation agreements. If there were verification provisions in these agreements they were, for the most part, carried out bilaterally. INFCIRC/66 provided for the first time an internationally endorsed and administered system of safeguards measures. States entering into nuclear cooperation could and did take advantage of this system in connection with the nuclear trade between them. Dozens of such agreements were concluded, each usually covering a specific project or transfer of nuclear material, equipment or technology.

In March 1970, the Nuclear Nonproliferation Treaty (NPT) came into force and with it the need for an alternative system of safeguards to verify the more far reaching obligations undertaken by its parties. The NPT called for parties to enter into agreements with the Agency for the express purpose of verifying that nuclear material in peaceful use in the state was not diverted to the production of nuclear explosives. Safeguards agreements pursuant to the Treaty were comprehensive in nature, applicable to all nuclear material in the state at any time, present or future.

Within a year this new system of safeguards was developed and approved by the Board of Governors, formally the "Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Nonproliferation of Nuclear Weapons," otherwise and more simply known as "INFCIRC/153." This form of agreement came to be known as the Comprehensive Safeguards Agreement in light of its comprehensive application to all nuclear materials in present and future peaceful nuclear activities in the state.

In the ensuing years most of the INFCIRC/66 agreements administered by the Agency were superseded as more and more states became party to the NPT or other treaties requiring similar comprehensive safeguards, such as the Treaty of Tlatelolco in Latin America and the Caribbean. Today, safeguards agreements are in force in 125 states, most of these being comprehensive safeguards agreements. Active INFCIRC/66 agreements continue to be administered in only three states, i.e., nonnuclear weapon states with significant nuclear programmes. From the point of view of verification, there is a crucial distinction to be made between these two systems that is fundamental to understanding the conception and development of the Agency programme to make safeguards more effective and efficient.

Under the INFCIRC/66 system the items subject to verification are specifically identified in advance. For example, an agreement might apply only to one power reactor and to the nuclear material therein. Under the NPT the state party is obliged to declare all nuclear material in peaceful activities on its territory or under its jurisdiction or control anywhere. The Agency has at its disposal well established accounting, containment and surveillance measures that provide a high level of certainty that declared material has not been diverted. But there can be no absolute guarantee that all of the material that should have been declared has been declared. The inspector is thus faced with the challenge of determining, with an acceptable level of certainty, that the declaration is correct and complete and that no undeclared activities have been undertaken.

In the negotiations leading to the comprehensive safeguards system some nonnuclear weapon states expressed concern about the protection of their commercial and industrial secrets. Others thought that the cost of intrusive inspection would put them at a competitive disadvantage with the nuclear weapon states which, under the NPT, were not subject to safeguards inspection. The system which received international acceptance responded in some measure to these concerns. Inspectors would be required to focus on declared nuclear materials and there were few provisions for inspectors to look beyond so called strategic points. Thus, nuclear material or facilities not declared by the state could go undetected. The architects of the system were not blind to this limitation but, with cold war logic, it was presumed that significant undeclared activities would likely be detected by the sophisticated information gathering apparatus of the nuclear weapon states. In spite of this shortcoming, the NPT safeguards system brought greatly improved assurances and was to become instrumental in facilitating international nuclear cooperation.

If this shortcoming had faded from view with time, Iraq and its secret nuclear weapons programme brought it abruptly back into sharp focus. Iraq, a party to the NPT, had embarked upon a secret programme to develop a nuclear weapon in direct violation of its treaty obligations. The discovery shocked the international community and, consequently, jolted many intelligence agencies. If information was available at the time it certainly was not brought to the attention of the Agency. In the aftermath of the Gulf war, the UN Security Council gave the IAEA the mission to remove, destroy or render harmless the Iraqi nuclear weapons programme. To execute this mission the Agency was granted powers almost like those of a military occupation force. While the Agency's Iraq Action Team has been very successful in rooting out the details of the clandestine programme, it seems unlikely that such powers would ever be accorded voluntarily by a sovereign state. If the non-proliferation regime was to be strengthened it would have to be done through the collective agreement and action of a large number of states.

Programme 93+2 Proposal

Even before the revelations in Iraq, the IAEA had taken steps to strengthen the safeguards system. During 1992 and early 1993 the Board made decisions regarding the early provision to the Agency of nuclear facility design information. The Agency's right, under comprehensive safeguards agreements, to undertake special inspections to ensure all nuclear materials were under safeguards was confirmed. A voluntary reporting scheme on imports and exports of specified equipment and material was also approved. However, it was the discovery in Iraq that led the Agency to systematically reconsider the effectiveness of the NPT safeguards regime. In

June 1993 the Agency's Board of Governors requested the Director General to bring forward concrete proposals for strengthening safeguards and improving its cost effectiveness. The Director General's Standing Advisory Group on Safeguards Implementation (SAGSI) outlined a plan and in December 1993 the Director General proposed to the Board of Governors a two year programme to evaluate the technical, legal and financial aspects of new measures. This came to be known as Programme 93+2.

The fundamental problem facing the Agency was to increase the probability of detecting nuclear activities that had not been declared by the sate. Accounting for declared material could be done with suitable certainty. But no safeguards system, no matter how extensive the measures, can provide absolute assurance that there has been no diversion of nuclear material or that there are no undeclared nuclear activities in a state. The level of assurance depends upon a combination of elements including the extent to which related materials and activities are covered; the nature and intensity of safeguards measures; the extent of cooperation with state authorities and facility operators; and the nature of the fuel cycle and associated activities. The secretariat believed that improved assurances could be acquired through a higher level of cooperation with the state, increased use of advanced technology and access to more information and to more locations in the state.

The most far reaching proposal was to dramatically increase the inspectors' access to information about nuclear activities and nuclear related activities in the state and access to locations where these activities take place. Agency experience in Iraq had demonstrated the value of assembling the largest possible knowledge base about the nuclear programme under inspection. A nuclear weapons programme requires the bringing together of unique and sophisticated equipment, skills and development activities. The more that is known about nuclear activities in a state the more evident will be activities that do not fit with the declared programme and which should be investigated further.

In addition to information already routinely provided to the Agency under comprehensive safeguards agreements, it was proposed that states provide information on past nuclear activities to the extent necessary to enable the verification of the completeness and correctness of the state's declaration. Additional information would be sought regarding the nature and location of nuclear research and development activities and of facilities manufacturing major items of nuclear equipment. The proposal also foresaw the provision of additional information on the activities of nuclear sites and locations related to nuclear sites. Relevant imports and exports, uranium and thorium deposits and related mining activity would also be declared.

Information useful to the safeguards inspector can come from many sources; the state itself, trade journals, newspapers and industrial sources as well as importers from and exporters to a state. All of this adds detail to the picture of a state's nuclear programme. Any contradictions and inconsistencies in the information can be then be checked through physical access and inspection at the site. In retrospect, even the secret Iraqi programme left clues to its existence. For example, there were press reports of equipment procurement activity prior to the Gulf War which, if noted and followed up, may have led to earlier detection. The safeguards system then in place did not systematically seek out such information nor was there authority to investigate information received except in very specific circumstances. These new proposals would change that. In addition to demanding much more detailed information from the state itself, the secretariat would establish a comprehensive system for the collection and review of information from all sources.

The sampling of nuclear materials is an inspection measure used extensively in safeguards. It was such sampling that revealed that the Democratic People's Republic of Korea had separated more plutonium from spent reactor fuel than it had declared. It was proposed to complement this procedure by implementing a new and powerful tool for collecting evidence of nuclear activity through samples collected from the dust, soil, plants or water in the environment. Through sophisticated analysis techniques, traces of many past and present nuclear activities can be detected, sometimes at great distances. Environmental sampling is now used routinely in Iraq and Agency inspectors have begun applying it in states with comprehensive safeguards agreements. The Agency has built a special "clean laboratory" at its Seibersdorf Laboratories near Vienna to facilitate the analytical work.

Increased physical access was proposed to nuclear sites on which facilities exist, to sites with nuclear related manufacturing and research activities and to other locations where the Agency had identified an interest. Inconsistencies or questions arising from the information provided can sometimes be resolved only through unrestricted on-site inspection. To be most effective, access should be unannounced or on short notice, at least some of the time. Some states still insist on single entry visas for inspectors, frustrating any attempt to conduct such an inspection. Some states even limit the number or prescribe the nationality of inspectors they will accept, thus reducing the efficiency of personnel utilization.

Of course, the fullest possible cooperation of states is required to make safeguards effective and credible. A more detailed description of the activities undertaken by the state's system of accounting and control was suggested to identify areas where cooperation could allow a more efficient use of time and resources. The adoption of simplified inspector designation procedures and the issuing of multi-entry visas or eliminating the need for visas altogether was suggested to enhance effectiveness by facilitating unannounced or short notice inspections.

The proposal also considered optimizing the use of advances in technology. Unattended, remotely monitored equipment and remote transmission of data, including images was foreseen. Communications and information technology could be used to better advantage. Advanced non-destructive analysis techniques could help meet the Agency's measurement needs. Even commercially available satellite imagery has possibilities for the safeguards system. Optimal use of technology would not only improve effectiveness but would reduce costs.

A parallel objective of Programme 93+2 was increasing the cost effectiveness of the safeguards system. The Board was particularly keen on quantifying savings that could be realized from each of the proposed measures. The work that has gone into analysing costs has shown that the new measures will initially add to the safeguards bill but that these costs will eventually be offset by savings resulting from efficiencies in the new measures. The programme is thus expected to be cost neutral eventually, while being more effective. One difficulty in making precise cost predictions arises from the interrelationships of the proposed measures and which measures will be accepted, rejected or modified by the Board. Many of the measures complement each other to the extent that the full benefit will be realized only if they are taken together.

Implications of Programme 93+2

In June 1995, the Board noted the secretariat's intention to proceed with the implementation of those proposed measures already authorised under existing safeguards agreements. However, in order to implement some of the proposed measures, it was considered necessary to obtain additional legal authority to complement that already provided by comprehensive safeguards agreements. It was agreed, therefore, that the implementation of Programme 93+2 would henceforth proceed in two parts: Part 1 being those measures for which the legal authority for implementation existed; and Part 2 being those for which complementary legal authority would have to be sought.

The implementation of Part 1 has proceeded over the past year. Additional information has been sought on nuclear programmes and related activities through a questionnaire sent to all states with operative comprehensive safeguards agreements. Information on certain closed down or decommissioned nuclear facilities and on nuclear facilities which were built but where nuclear material has not been introduced was sought as well.

Initially, evironmental sampling is being focused on enrichment and hot-cell facilities. Guidelines have been developed, facility-specific sampling objectives, plans and procedures are being developed and consultations with member states regarding implementation are well underway. Analytical equipment for the clean laboratory has been installed and has been in full operation since the summer.

A mechanism for reviewing the significantly increased volume of information foreseen has been put in place. A methodology for improved information review has been further developed and a number of software tools to aid implementation are installed. Pocedures for protecting confidential information have been reviewed and are being consolidated and updated. Particular attention is being paid to the means of controlling access to confidential information in computer files. A group of member state expert consultants has reviewed the secretariat's procedures for protecting the anonymity of samples and the confidentiality of results. The consultants agreed that the procedures meet the objectives of the Agency and of member states.

With respect to increased physical access, work is underway to identify how short notice inspections, particularly in combination with additional operational data and advanced technology, could lead to more effective and efficient safeguards for a number of facility types. Administrative procedures necessary to support short notice inspections as part of the routine implementation of safeguards have been developed.

A wide variety of advanced technology for remote monitoring and transmission, and unattended measurements with remote transmission is being examined and demonstrated. This includes digital surveillance systems, electronic seals as well as motion and radiation detectors, and remote data transmission by satellite and telephone lines. The objective is the development of new safeguards approaches for locations which combine the new technology with short notice inspections thereby permitting reductions in inspection frequency and effort. Applications of advanced technology are being demonstrated at facilities in the United States, South Africa and Switzerland. In all cases the demonstrations provide for the authentication requirements of the Agency and the encryption requirements of the state.

States' responses to a questionnaire about their regulatory, accounting and control systems has provided a mechanism for a systematic exploration of areas of increased cooperation which could benefit both the Agency and the state. There has been a concern in some states that increased cooperation will result in a transfer of costs from the Agency to the state.

However, experience in EURATOM and Programme 93+2 field trials has been that after an initial investment in consultations and training, both sides can save resources.

A number of training courses necessary for the implementation of Part 1 measures are in various stages of development, pilot testing and implementation. A training course on environmental sample collection and handling is in place and soon more than 100 inspectors will have received this training. Training courses on enhanced observation skills are being tested and other courses dealing with the conduct of short notice inspections and design verification of closed down and decommissioned facilities are under development as are courses for the training of state personnel.

As the implementation of Part 1 of the programme proceeds, Part 2 has been the subject of intense discussion in the Board of Governors. At its meetings in December 1995 and March 1996, the Board discussed and provided views and comments on the Part 2 measures. Taking account of these comments, the secretariat further developed the concepts, and in June this year tabled an updated proposal together with a draft legal text of a Protocol. In his recommendation to the Board, the Director General said that the measures proposed, together with the measures already adopted, would complete the envisaged package. They would provide the Agency with a more complete picture of the state's nuclear programme, would secure Agency access to corroborate this information should the need arise, and would enable the Agency to rely on the increased assurances provided by the new measures to manage the system in a more cost-efficient manner by foregoing some of the routine verification activities currently carried out.

The Director General pointed out the package of measures sought to strike a proper balance between the Agency's need for information and access and the state's need to protect its legitimate interests. It had been arrived at through an intensive process of consultation with member states and the conduct of field trials over the last two years. According to him, it was for member states to translate the measures into new rights and obligations through finalization of the draft protocol.

The Director General recommended that the Board, through an appropriate mechanism, finalize a legal instrument taking as a basis the secretariat's draft protocol and explanation of the measures. The mechanism the Board found appropriate was an open-ended committee, the Committee on Strengthening the Efffectiveness and Improving the Efficiency of the Safeguards System, known locally as Committee 24. Under the leadership of the Board Chairman, work has begun to draft a Protocol through which states party to comprehensive safeguards agreements could undertake obligations to enhance the safeguards system. The Committee completed a first reading of the secretariat's text in July of this year and a second reading in September. The current Board Chairman, Ambassador Peter Walker of Canada, has produced a "Rolling Text" based on the Committee debate and his own consultations. The Committee meets again in January 1997 for a third reading based on this Rolling Text.

Contending Issues

In the committee debate a number of issues have crystallized that will have to be resolved before wide agreement is likely. One of these is the issue of so called "universality." Although the term has been used loosely it reflects two concerns. First, many states advocate the universal application of any new measures to states with non-comprehensive safeguards agreements, both the INFCIRC/66 agreements and the voluntary offer agreements entered into by the nuclear weapon states. In some respects this point is more political than practical since the measures have been developed as a package explicitly to complement comprehensive safeguards and many are simply not relevant under these agreements. This said, some of the measures, like simplification of inspector designation and country entry procedures, for example, would be helpful and could be undertaken by such states. Reporting by these states of nuclear exports and imports would strengthen the safeguards applied in the states with comprehensive agreements.

Secondly, there is a view in some quarters that any additional safeguards measures applied in nonnuclear weapon states should be equally applied in the nuclear weapon states in the belief that there should be an equality of any inconvenience or costs that might result from the new safeguards measures. There is an associated concern that the measures may burden the nuclear industry in nonnuclear weapon states to the extent that competitors in the nuclear weapon tates will derive unearned advantage. However, as disarmament progresses, any inequality of burden should diminish. Already large numbers of warheads have been dismantled and this process is bound to continue. Both Russia and the United States have said that these materials will be placed under IAEA verification as endorsed by the NPT Review Conference in 1995 and the Moscow Nuclear Summit. Already the Agency is verifying that some nuclear materials removed from military use in the United States is not returned to nuclear weapons use. The Director General, the Russian Minister of Atomic Energy and the U.S. Secretary of Energy have convened a joint working group to explore the technical, legal and financial issues connected with such verification. The group will report its progress in June 1997.

A second issue is the confidentiality of information gathered by the

Agency, both commercial proprietary information and security information. While confidentiality was an issue in 1970 in the negotiations of INFCIRC/153, experience has shown that information held by the secretariat has been adequately protected. This neither lessens the validity of the concern nor justifies complacency. The secretariat is now consolidating and further documenting its information security policies and procedures and will update them as necessary to ensure acceptable protection.

A third issue is physical access. An important question is to which locations will access be guaranteed and what freedom will be given to inspectors to demand it. The most difficult aspect of this issue has been access to private property on which no nuclear material is located, for example, laboratories carrying out research and development work on uranium enrichment processes or equipment. In many states existing nuclear legislation does not grant regulators access unless there are radioactive or other specified materials present. While there is general agreement that some form of "due process" is appropriate, each impediment reduces the system's effectiveness. Some argue that the Special Inspection provisions now existing under INFCIRC/153 is a sufficiently powerful tool to gain access where essential. Others believe that the required involvement of the Board in the Special Inspection procedure risks unnecessarily dramatizing inspections that may be seeking only to resolve question which, in the end, are minor.

A related question is the notice and timing of complementary access. In some cases it is clear that the shorter the notice the more effective the inspection. The Secretariat has proposed two hours notice as meaningful and feasible for the most important "short-notice" inspections. Longer periods have been suggested by some states. Also, some states have proposed that notice should include the reason for access, activity to be performed and a justification of the complementary access. Such conditions could seriously limit the usefulness of the inspection.

A few states have indicated a preference for proceeding such that safeguards obligations would be subject to any limitations imposed by their national and constitutional law. This notion arose particularly in the context of complementary access to private property where there was no nuclear material located which is a legitimate concern. Nonetheless, the idea is clearly unworkable and would be unacceptable by any standard of international law. Alternative ways of dealing with access issues will have to be found.

In the end it will be a decision of the Board of Governors that determines how effective and efficient the safeguards system will become. These measures will not only influence the activities now performed under existing safeguards agreements but will set a standard and expectation for verification to be performed under future agreements. As is the case for existing treaties, future disarmament and nonproliferation agreements will require credible verification and a high assurance that cheating will be detected. It is hoped that a broader and longer term view of the benefits to be derived from an effective non-proliferation verification scheme, such as that now under discussion in Vienna, will be carefully considered by all member states, and that there will be sufficient political will to reach consensus on an effective package of improvements. When this is realised, we will have moved one step closer to winning General Bradley's atomic war.

INTERNATIONAL MONITORING SYSTEM: A STATE OF THE ART

S. Sadasivan

The recently concluded Comprehensive Test Ban Treaty (CTBT) envisages four monitoring techniques, namely, seismic, hydroacoustic, infrasound (microbarographic), and radionuclide as one of the requirements for compliance verification. Under Article IV of the CTBT, these four systems form part of the International Monitoring System (IMS). The verification tasks associated with the CTBT are technologically the most advanced and go further than any other existing treaty.

The technical specifications for the four monitoring systems will be described in the operation manuals which are yet to be issued. The IMS is described in Part I of the Protocol attached to the CTBT and changes of administrative or technical nature could be effected easily in the Protocol as well as the Treaty. Lists of network of stations where these monitoring facilities will be located are available. Expert groups on the monitoring technologies were established by the Conference on Disarmament (CD) and the groups met regularly in 1994 and 1995 at the CD. All four groups were asked to freeze the individual monitoring system specifications and then design a network for detecting & identifying a nuclear explosion of 1 kiloton (kT) yield conducted underground, underwater or in the atmosphere, either evasively or non-evasively in any part of the globe. The key parameters in network design were the number of ground based stations, the sampling and analyses methods, the reporting timeliness and the sensitivity and synergy with other techniques. Where possible, the stations were to be co-located with any other system that forms part of the IMS. The expert groups submitted their final recommendations to the ad hoc comittee on nuclear test ban in December 1995. Below, the four monitoring mechanisms are briefly described.

Seismic Monitoring

The Seismic monitoring network is on a two-tier basis, comprising 50 primary stations which will provide data on-line and 120 auxiliary stations which will on request transmit data immediately. For the primary network array element and one vertical component with short period sensors is specified. The equipment requirements include a seismometer noise of 10 decibel (dB) below the minimum local seismic noise over the passband, relative location of array elements known to within 1m, seismometer dynamic range of 96 dB with a linearity of 90 dB over the pass band and orientation better than 3 degrees. The data availability should be greater than 99 percent. The equipment at the auxiliary stations are required to be eventually similar and the data availability should be greater than 95 percent.

Some of these stations are to operate as backup for the primary network and as such should have the same characteristics. The installation (if need be), upgradation and operation and maintenance costs of the primary network stations are to be borne by the CTBT organisation whereas that of the auxiliary stations are expected to be borne by the member states. The data transmitting costs of both networks will be borne by the CTBT organisation. The seismic network is expected to detect explosions of 0.51 kT yield over most of the earth. The localisation of events of magnitude greater than 4 is expected to be with an uncertainty of 1000 sq.kms., or less. Coverage of some broad ocean areas in the southern hemisphere is by synergy with the hydroacoustic network.

Hydroacoustic Monitoring

The hydroacoustic network is to detect underwater and sub-oceanic events. The system is capable of detecting explosions below 1 kT yield, discriminating between explosions and sub-oceanic earthquakes and providing independent location of events if they are detected by a minimum of three stations. The system however, cannot differentiate between nuclear and conventional explosions. It can detect events in the low atmosphere (over water) which the seismic or infrasound systems may not detect. The hydroacoustic signal, which is a sound wave that propagates through ocean, can travel over large distances due to low attenuation and the SOFAR channel which acts as a waveguide. The axis of the SOFAR channel occurs at depths near 1 km in equatorial and mid-latitude waters and becomes shallower at high latitudes, reaching the surface in polar regions. The hydroacoustic sensors can detect sub-kiloton events at ranges exceeding 5000 kms. Hydro-phones of spherical shape, which are omnidirectional and made of robust ceramics are proposed. Single hydrophones properly decoupled from the suspension cable against flow induced vibrations are to be positioned at the SOFAR channel axis depth with an accuracy of 10 metres and a horizontal positioning accuracy of 30 metres.

The system requirements follow closely that of the seismic system where applicable. Acting on a suggestion by the Indian expert that underwater explosions can also be detected through the seismo-hydroacoustic signals by coastal/island seismic stations and after careful evaluation of available past data in this regard, the expert group recommended that the hydroacoustic network should comprise six hydrophone stations (fixed cable) and five island-seismic stations (T-phase stations), all of which would transmit data in real time. The network is expected to detect explosions of 1 kT and lower with a localisation capability of the order of 1000 sq.kms., in conjunction with some additional existing coastal seismic stations.

Infrasound Monitoring

This system is capable of detecting atmospheric explosions at altitudes ranging from sea level to about 100 kms. A network can detect the event in a few hours and can locate with an accuracy of 100 kms or better. The method can differentiate between an explosion and other atmospheric phenomena like lightning and volcanic eruptions, but not between nuclear and other explosions, just like hydroacoustic. The recommended infrasound sensor is a microbarograph with a flat frequency response from 0.02 to 5.0 Hz, with a resolution of 0.01 Pa at 1 Hz and a dynamic range of at least 80 db.

A station is to have a four element array with optimal spacing between the elements in the range of 1 to 3 kms. The digital data from the station would be transmitted on line to the international data centre (IDC), whose location has yet to be decided. The infrasound network will have 60 stations most of which are co-located with other proposed systems. The performance evaluation of the network by two study groups have been at variance. The detection yield is less than one kT worldwide with a location uncertainty of less than 50 km radius as per one algorithm. The same figures from another data processing algorithm are 1 to 5 kT (depending on the latitude) and 100 kms.

Radionuclide Monitoring

Radionuclide monitoring is the only technique that can provide unambiguous evidence of a nuclear explosion. For tests in the lower atmosphere up to tropopause, ground based stations may be able to detect the fresh radioactivity released by an explosion. The method can be used in combination with infrasound. The expert group recommended a network and system specifications for detection, with 90 percent probability, of a 1 kT explosion in the atmosphere by at least one station within about 14 days including a reporting period of three days.

The radioactivity monitoring system consists of sampling and analysis of both particulated and Xenon gas produced in the nuclear explosion. The recommended equipment specifications for particulate monitoring are an aerosol sampler which is capable of collecting particles of 0.1 to 5 KM at a flow rate of 500 cu. m/h through a low-pressure drop filter, suitable gamma analysis system with a HPGe of at least 40 percent or higher efficiency and the associated multichannel analyser. The sampling time should be typically one day, counting time of one day and a reporting time up to three days. The samples could be analysed in a laboratory if the sample could be transported in 24 hours. The station availability should be more than ninety five percent. These specifications, it was agreed could detect explosions of even 0.001 kT yield, depending on the location of the station and the source. The network that was recommended has 80 stations for particulate monitoring and initially 40 of these would be equipped with Xenon samplers too. The suggested (minimum) radionuclides to be analysed are Zr and Nb-95, Zr-97, Mo and Tc-99m, Ru-103, I-131, Te-132, I-133, Cs-134, 136 and 137, Ba-140 and Ce-143 with an analytical sensitivity in the range of 1-60 uBq/cu.m. The list of isotopes given above are perhaps only indicative and it is expected that the operation manual will specify more fission products to be analysed. The data, namely, gamma spectra data, will be transmitted to the IDC, as soon as they are ready for each sample.

The IMS is also expected to have the capability for Xe-131m, Xe-133 and Xe-133m sampling and analysis. The sampling rate is to be about 10Cu.m/day and the sensitivity envisaged is about 1 to 30 mBq/cu.m. Within the radionuclide system, there is a recommendation to establish certified laboratories which can ensure quality assurance and authenticate measurements in the stations nearby. These labs would also help in the routine analysis of samples sent to them. The expert groups provided cost estimates for these networks and also indicated systems as well networks which may need further development. These other systems are discussed below.

Costs, Timeliness and Detection Capability of Networks

The CTBT organisation will comprise of a technical secretariat which will oversee the IMS. The secretariat would establish, as necessary, new monitoring stations or upgrade the existing ones. The cost of establishing stations will be borne by the CTBTO, if necessary. The operations and maintenance (O&M) and data transmission costs will also be borne by the CTBTO. The monitoring stations will be owned and operated by the state parties. In the case of auxiliary seismic stations, it is expected that state parties will bear the cost of establishing the station and only the data transmission costs are to be charged to the CTBTO.

The expert groups provided approximate cost estimates for the four networks as well as the estimated detection capability vis-a-vis the original requirements. Some typical sensor and station requirements for the four monitoring systems are presented in Table 1.

Table 1
Examples of Sensor Specifications and Station Requirements

Sensor specifications	Station requirements
1. Seismic Monitoring System	
- Pass band 0.04 to 16 Hz or 0.04 to 1 Hz & 0.5 to 8 Hz - Noise 10 dB below the min. local noise over the pass band - Dynamic range 96 dB minimum - Linearity 90 dB over the pass band - Calibration within 5 percent in amp. and 5 degrees in phase - Op. temperature, resolution, sample rate.	- Array with one vertical comp. - Transmission delay less than 5 mins. - Data availability more than 99 percent (Alpha) and more than 95 percent (Beta) - Location and timing precision
2. Infrasound Monitoring System	
- Wideband microbarograph - Flat freq. resp. over 0.02 to 5 Hz - Dynamic range of 80 dB or better - Resolution of 0.01 Pa at 1 Hz	- Four elements array Spacing between 1 to 3 kms. - Approx. 0.25 sq. km. level terrain - Digital data to be sent on line
3. Hydroacoustic Monitoring System	
- Pass band 5 to 100 Hz - Calibration within 1 dB - Dynamic range 10 dB	- One active hydrophone - Station noise once/d, 10s only - Timing accuracy needed

4. Radionuclide Monitoring System	
Particulate Monitoring	
- Capable of detecting following elements at levels (uBq/cu.m)	- Air sampling rate 500 cu. m/hr with more than 80 percent eff. for 0.2um - Sampling time 24 hrs - Reporting time 3 days - Transport/decay time 24 hrs - HPGe detector with more than 40 percent eff. - Network down time less than 5 percent - Station down time less than 15 d/y total
Zr-95 3-10 25 Nb-95 5-15 5 Zr-97 20-60 3 Mo-99 20-60 3 Ru-103 3-10 3 I-131 5 > 5 Te-132 5-15 5 I-133 >30 5 Cs-134 3-10 10 Cs-136 3-10 5 Cs-137 3-10 25 Ba-140 10-30 10 Ce-143 15-50 3	
Rare Gas Monitoring	
HPGe or beta-gamma coinc. Capable of detecting at levels- (mBq/cu.m) Xe-131m 22 Xe-133m 5 Xe-133 2	- Air sampling rate 10 cu.m/d - Sampling time 6 hrs? - Sample processing time less than 24 hrs - Network down time less than 5 percent

The costs for establishing new stations have been worked out by various expert groups. For seismic primary, no establishment or installation costs are indicated, as most of them are on line under the Group of Scientific Experts on Technical Test-3 (GSETT-3). For the seismic auxiliary, the cost of establishing stations is estimated to be about 10 million U.S. dollars. The O&M and communication costs for the auxiliary seismic are estimated to be 6 to 12 million dollars. In the case of hydrophones, the cost for installation was estimated to be 14 to 22 *million dollars while the O&M costs was* expected to be less than 1 million dollars per year. The data transmission costs could be about 7 million dollars. For infrasound the installation and O&M costs were given as about 11 and 3.6 to 4.0 million dollars respectively. The installation of particulate monitoring stations for radionuclide technique was estimated as 12 to 16 million dollars while O&M costs was given as about 2.0 to 4.5 million dollars, depending on the type of (manual or automatic) air monitoring system to be used. The installation and O&M costs for rare gas monitoring is 12 million dollars each.

In the case of seismic primary, most of the stations (50) are already on line. About 80 percent of auxiliary seismic stations were likely to be ready by 1996 end. The calibration of these systems however is expected to take several years. The radionuclide and infra-sound monitoring stations are expected to be on line in 3 to 4 years time.

The detection capability of the networks were also analysed by the expert groups. Several member states presented their own assessment of the detection capability using different models. The seismic monitoring was expected to detect explosions in the yield range 0.5 to 1.0 kT with a localisation of less than 1000 to more than 20000 sqkm. For the infrasound monitoring system, U.S. models estimated that explosions in the range of 0.2 to 0.7 kT could be detected over most parts of the globe with a localisation of less than 50 km radius. The French results however showed that the detection capability would be in range of less than 0.1 to more than 10 kT depending on the test site. The localisation was expected to be much greater than 100 km radius over most of the globe. The hydroacoustic system was generally expected to detect less than 1 kT but the system would require supplementary data from additional 4 T-phase stations. The radioactivity (particulate) monitoring would give 60 to 70% detection probability 10 days after the event.

The probability for detection by rare gas monitoring was estimated to be 70 to 80% for 1 kT, provided 10% of the total inventory of xenon isotopes were released within the first 12 hours. If the venting is only of the order of 0.01%, the probability for detection would be very low, about 20 percent. The background xenon over Europe is about 20 mBq/cu.m and would substantially interfere with the rare gas monitoring system. Some other monitoring networks, example electro magnetic pulse (EMP) monitoring, satellite monitoring and aircraft monitoring were also discussed by the expert groups. The Chinese advocated a EMP monitoring network while Russia was particular about monitoring from air borne platforms. These methods however, did not find substantial support among the experts. However, as per the treaty, new technologies which will make the IMS more effective can always be introduced in the protocol. As per the treaty a country's position in the CTBTO, especially in the Apex Executive Council will also be determined by the number of monitoring stations the said country hosts.

India was to have had one station each for the seismic primary and auxiliary, infrasound and radionuclide monitoring. In addition, Bhaba Atomic Research Centre (BARC), Mumbai, was offered by India as a Radionuclide Certification Laboratory. The coordinates for these were also listed in the treaty text till July 1996. The text submitted and passed by UN General Assembly however does not contain any reference to the Indian stations and laboratory.

U.S. NUCLEAR WEAPONS STOCKPILE STEWARDSHIP AND MANAGEMENT

Christopher E. Paine

An analysis of current global nuclear stockpile growth, reduction and costs would be incomplete without an outline and explanation of the U.S. "science-based stockpile stewardship and management" program. An assessment is also required as to what can and cannot be achieved without recourse to nuclear explosive tests. Evidence shows that the U.S. nuclear weapon stockpile has already returned to the 1959 level. The U.S. nuclear weapon stockpile peaked in 1967 at 32,000 weapons, came down to 22,000 weapons in 1989 and is now at 10,400 operational weapons, and 13,100 intact weapons. The current retirement backlog of 2700 weapons will be dismantled by the year 2000.

Pending further reductions, the U.S. plans a stockpile of 10,000 intact weapons under START II. Out of the 10,000 intact weapons, 3500 are to be deployed as strategic and 2500 are nondeployed strategic "hedge." In addition, 550 spare warheads to replace warheads removed for disassembly inspections will be retained as well as 950 non strategic and 2500 "inactive reserve" weapons.

Nuclear Program Funding

Spending trends have made it clear that funds for nuclear weapons have dropped significantly. The overall level of spending on nuclear explosives research, development, testing and production has been cut in half. In constant fiscal year (FY) 96 dollars, it has been estimated that an average eight billion dollars per year has been reduced between 1983-1993. There is a projection for an average of dollars 4 billion dollars reduction per year between 1997-2002.

In contrast, spending on nuclear weapons research remains high. The level of expenditure on the stockpile stewardship and management (SSM) program will remain above the cold war annual average for directly comparable activities (nuclear weapons R&D, testing, production, and stockpile surveillance). On average, 3.6 billion dollars has been spent between 1948 and 1990. The SSM is funded at 3.9 billion dollars for FY 1997. In August 1995, President Clinton pledged dollars 40 billion dollars for 10 years to "close the deal" on the comprehensive test (CTB) ban with the Joint Chiefs of Staff and the National Laboratories.

There are a number of important technical tasks related to stockpile management including plutonium pit manufacture, tritium purification, nonnuclear parts manufacture, weapon assembly and disassembly, and plutonium processing and recovery. The tasks of science based stockpile stewardship are computer modeling, high explosives R&D, low energy implosion physics, and high energy density physics. More specifically, under computer modeling, functions would include hydrodynamic codes, neutronic codes, and radiation transport. To maintain computer modeling capabilities, the Accelerated Strategic Computing Initiative (ASCII) has been approved under which one billion dollars has been allocated for new weapons lab computing network, including three so called massively parallel processors. This initiative is to be implemented through three collaborations consisting of Livermore-IBM, Sandia-Intel and Los Alamos most likely to be paired with CRAY.

Nuclear Testing

High explosive research and testing are undertaken at Los Alamos and Lawrence Livermore labs and the Nevada test site. The functions of nuclear explosive testing are numerous. It is significant to obtain weapon physics data and calibrate design codes and to confirm or disprove designer's calculated performance predictions about the advanced development of new designs. It also confirms whether engineering design changes are needed for nuclear warhead integration and quantity production. It is also utilized for certifying nuclear performance of production-line version of device for stockpiling following simulated "stockpile-to-target-sequence" stress testing. It may confirm or disprove the existence of problems which possibly affect nuclear performance and certify fix. Other functions include investigating the effects of nuclear weapon effects on military/space systems and confirming designer predictions of one-point safety.

Given the above, it is necessary to raise the question as to why the U.S. has agreed to stop testing. The high levels of U.S. - Russian nuclear explosive testing were primarily driven by the military requirements of each side's nuclear deterrent strategy during the cold war, which escalated into an arms race. The "mad momentum" of this race was compounded and complicated by internal bureaucratic and institutional factors, which are still present in both the countries.

The cold war is over, and the nuclear arms race, if not terminated completely, has at least considerably abated. The U.S. defence establishment has no current, or currently foreseeable requirement for the production of new design nuclear weapons. For technical reasons, many nuclear weapon experts favoured a low-threshold CTB. To maintain stockpile confidence, many in the U.S. defence establishment would have preferred a test ban that excluded tests up to the level required to verify primary conditions required for boosting (300-500 tons.) However, this level would have still required extrapolation of the test results to certify the final yield in a physics regime of considerable scientific uncertainty (i.e., effects of instabilities, mixing, boost performance). Such low-yield tests did not represent a significant enough improvement over calculated results to justify abandoning objective of "zero yield" CTB. The utility of hydronuclear tests (up to four pounds) had likewise been rejected on similar grounds, i.e., technical benefits did not outweigh political costs.

In asssessing the United States' SSM program, it should be noted that it is still a work in progress. Numerous planned capabilities are yet to be demonstrated and may not operate successfully for many years. The purpose of improved computing and experimental capabilities is not to design and certify performance of new weapons, but to maintain the technical capability (including relevant scientific cadre) to do so in the future whether the test ban regime breaks down or new threats emerge.

In the meantime, enhanced capabilities will be used to evaluate, maintain, and modify components and delivery packages for proven nuclear weapon designs retained in the so-called "enduring stockpile." Two alternative interpretations may be made regarding the U.S. agreement to stop testing. One is that the U.S. and other nuclear weapon powers no longer require nuclear explosive tests to develop new weapons, so they agreed to ban nuclear explosions. Another more likely reason could be that the U.S. and other nuclear weapon powers no longer have a sufficiently compelling political-military requirement to test when balanced against other important concerns.

There is one indication that the U.S. has not freed itself from reliance on nuclear explosive tests to develop new weapons, which is the 200 million dollars per year program to maintain the "readiness" of the Nevada test site to resume testing. Assuming a continuing high level of investment in ever more powerful computing and experimental facilities, the more technically aggressive elements of the U.S. nuclear weapons complex envision that by the year 2010, the United States will succeed in integrating 3-D weapon design codes that accurately model all phases of a nuclear explosion with 3-D CAD/CAM product engineering codes. The objective is to produce a "seamless" computer based "virtual weapon" design and "production ready" prototyping capability.

In the final analysis, broad political and security factors will continue to exert the strongest influence on the emergence of a virtual weapon testing capability. Even if this approach might ultimately reach the stage of implementation with high confidence (which does not appear plausible at this point), if the CTB enters into force and nuclear weapon reductions continue on an asymptotic course toward zero, this vision will never be realised. Financial support will be cut in proportion to the nation's reduced political and military reliance on nuclear weapons. Political considerations will ultimately determine the outcome. For example, engineering development and production of subkiloton micronuke weapons, which could plausibly be designed and produced as pure fission weapons without testing are prohibited by legislative statute (the 1993 Furse Amendment).

The SSM program is far larger than it needs to be as a result of political and institutional considerations. As a politically centrist President striving to overcome a "weak" image on military issues, Bill Clinton essentially needed to buy the assent of the nuclear defence establishment to a CTB, rather than seek to defeat it in a headlong confrontation in the Congress over the nuclear weapons budget. In 1994, both houses of Congress came under Republican control, and control of the national security committees passed to senior Republicans with a long history of unquestioning support for the Department of Energy's nuclear weapons design and production complex, much of it located in their states.

Ultimately, the goals and scale of the SSM program are strongly linked to the outcome of fundamental reviews of the future role of nuclear weapons in U.S. and international security strategy. A different SSM program could emerge, depending on the outcome of such reviews.

SSM Capabilities and Nuclear Nonproliferation

A non-NPT weapon state or nuclear threshold state will be concerned about getting four things right: hydrodynamics, neutronics, timely initiation of the fission chain reaction and estimation of yield. Hydrodynamic behaviour of a device during the assembly phase can be predicted by well established computer modeling techniques and confirmed experimentally by hydrodynamic testing. The behaviour of implosion systems designs with fissile Pu-239 or highly enriched uranium (HEU) cores can be investigated at reduced scale to avoid criticality. The full scale implosion system designs can be tested with non-fissile cores made of U-238 or 80 percent Pu-242.

Neutronics during the assembly phase can be calculated using publicly available data and computer codes that are the same as, or similar to, codes used by the commercial nuclear industry. Neutronic calculations using weapon-applicable versions of these codes can be "benchmarked" against lab-scale experiments using pulsed reactors and fast critical assemblies. The computer modeling of hydrodynamic and neutronic behaviour during the disassembly phase is important for accurate yield prediction. Disassembly cannot be verified without nuclear testing, or access to historical test data or previously verified weapon codes.

Initiation is a process in which fission neutron production rate peaks at the time of maximum core compression. The first generation devices are likely to be internally (self) initiated, and hence susceptible to exploding before the point of average peak compression or maximum criticality has been reached. The use of an external neutron source to achieve initiation closer to optimal moment will increase yield from the same amount of material or allow the use of less material. Establishing best initiation time requires carefully diagnosed experiments and calculations to determine the time history of core compression.

Accurate yield predictions require verification of the accuracy of computational modeling for the disassembly phase of the weapon. It requires higher yield testing or access to historical test data and nuclear test calibrated codes. Full scale nuclear tests are needed to certify yield of fully engineered devices, improve predictive power of weapon design codes, and optimize designs with respect to yield-to-weight and yield-to-volume.

But the suboptimal fission weapon can be developed without nuclear explosive testing. Confidence in the ability to achieve substantial yields (several tens of kilotons) can be established through the use of straightforward theoretical approximations. These relate the fraction of material likely to be fissioned to the number of critical masses achieved through compression at the time explosive disassembly begins. Such approximations can narrow the yield uncertainty for unboosted devices to within a factor of two.

On the question of India's nuclear option, it may be said that the design, manufacture, and maintenance of optimized DT boosted, two-stage high yield thermonuclear weapons is technically demanding, hugely expensive, and requires some level of nuclear explosive testing to verify designer choices and the capabilities of predictive codes. The "need" of the U.S. for such weapons was nurtured in the mindless momentum of the U.S.-Soviet nuclear arms competition and they are not required if the goal is simply to deter nuclear weapon use against India by other states pending their eventual elimination. A sensible nuclear option for India would be to rely on a "threshold" stewardship program without nuclear explosive tests that would insure the option of producing an improved pure fission weapon should future events so dictate. In the meantime, India could sign and ratify the CTB and resume its historic place as a leader in the global efforts to reduce and ultimately eliminate nuclear arms.

TECHNOLOGY TRANSFER ISSUES

GLOBALISATION AND TECHNOLOGY SHARING

K. Kasturirangan

In modern times, the trend towards globalisation is evident in every field such as politics, economy, culture and the science and technology. In the political scenario, the end of the cold war has transformed global political maps and equations.

On the economic front, a radical transformation has been taking place. The result is the shift for several countries in policy from the policies of centralized control of production and allocation of resources through state planning to market economy. Many countries have been persuing economic liberalisation policies in order to integrate into the global economy. In the field of culture, development in modern means of communications have assisted in greater exchange of cultural activities among nations.

Finally, the developments in scientific research and the pervasiveness of the spirit of science, have been promoting a universal outlook. It seeks to spread knowledge for the general welfare of human society and for preserving the environment. This spirit promotes globalisation of science.

Advancement in Science and Technology

Developments in science and technology (S&T) particularly in the fields of transportation, telecommunications and the advent of information technology are making progress towards rapid globalisation. In the very early days of industrial revolution, we·find that all factors of production played a key role in determining wealth generation capacity. Transborder movement of men and materials were constrained by the local political set up and also by the means for transportation. In many cases, colonies were used to supply material resources and cheap labour.

As the industrial revolution succeeded and industrialisation became the engine for creation of wealth and its growth, technology became the key factor for economic progress. Capital started flowing across the borders. Exploration of markets beyond the domestic markets became a necessity for creation of economic wealth. Mastery over the technology and its management became more importnat factors for achieving economic progress. The outlook for globalisation of the economy has grown in pace with the scientific and technological advances in recent years.

The globalisation of economies has been in turn propelling the drive for globalisation of S&T. As diplomatic relations strengthen, international trade increases and cultural exchanges enhance, the thrust towards globalisation of S&T is also increasing.

However, the increasing competition in the economic front will increase the tendency for technological protectionism and the road for globalisation of S&T is going to be rougher. A further challenge is to ensure that such globalisation of S&T will contribute to the social well being and to improve quality of life of a large part of world population who are yet to advance industrially.

Prerequisities for Globalisation of S&T

Globalisation in S&T demands that the standards are made universally applicable. The products and processes should meet the requirements of the international market. Scientists and engineers should have freedom for international activities. All activities in the chain of innovation, namely the discovery, invention, engineering, design, manufacturing and marketing should be open to international dissemination under a transparent and fair set of regulations. Globalisation implies that all new knowledge, inventions and technologies will be available as soon as they are developed and they are disseminated beyond national boundaries and without regard to the difference in political ideologies. Promoting the general welfare of all human kind and their harmonious progress should become the key objectives for such a process.

In recent decades, more and more countries have placed emphasis on scientific and technological development and have achieved varying degrees of success in assimilation of technologies for their development and to create wealth. Newly industrialising economies of Asia (South Korea, Taiwan, China, Singapore, Malaysia, Thailand, India) and Latin America (Chile and Mexico) are some examples. Many countries, which had a latent policy to S&T realise that they will be isolated, and are adopting transparent policies.

As the rate of obsolescence of technologies is increasing due to rapid developments, the nations which develop new technologies are forced to look for quick paybacks. The greater scope offered by world markets encourages introduction of the technology into global markets even before it achieves maturity. For example, the lead times between scientific discoveries or inventions and the practical use are phenomenally low in case of several new technologies like bio-technology, computers, communications and new materials.

International cooperation in science and technology holds the promise of bringing down the costs. Large scale efforts like manned exploration, global change research, and development of thermonuclear fusion reactors, are some examples of shared efforts. The economic imperative of cooperation can be an important driver for globalisation of science and technology.

As multinational enterprises grow, and employ people of various countries, scope for globalisation increases through their interactions and working together. The increasing opportunities available for continuing education and the activities of international organisation and professional bodies encourage the globalisation of science and technology.

Challenges for Globalisation of S&T

The greatest challenge for globalisation of S&T is the continuing concentration of research and development (R&D) investments. Over the decades, we observe that in the industrialised countries, the growth of R&D expenditure was more than the growth rate of GDP. This was contributed by both private and public sectors. However, in global R&D, the share of developing countries account for only 6 percent. The remaining 94 percent are held by developed countries.

This concentration of R&D and the consequent ability to consolidate market position by a few corporations in addition to the growing levels of R&D costs, pose barriers of entry for many developing nations to successfully use technology for rapid economic growth. The R&D costs for bringing new innovations into the market are prohibitive in many cases. Only large firms have this ability. In the field of semiconductors, for example, generation of each new process calls for investments on the order of a billion U.S. dollars. Hence promoting proper focus for R&D efforts at a national level, taking due account of international scenarios, assumes great importance.

Phenomenal reductions in technological life cycles pose many challenges for globalisation of S&T. As product life cycles decrease, the need for technology transfer before maturity of technology is urgent. However, there has been less incentive for technology transfer (at early stage of life cycle) for fear of generating competitors and the fear of rapid substitution of products. The preferred mode of several technology generating firms is to undertake direct trade in other territories.

Another challenge facing globalisation of science and technology is the military use. Traditionally military use attracts engagement of advanced technologies as well as driving the developments of technologies. However, such uses have also resulted in growing restrictions on transfer of technologies, particularly those having dual use potential. Thus new technologies reached the markets for civilian use with considerable time lag. Recent reductions in government support for military programs has however encouraged early entry of advanced technologies into the market place.

The greatest challenge in the globalisation of S&T is to achieve fairness in the play of economic interests and to overcome the ill effects of concentration of market power by a few, which de facto leads to elimination of effective conditions for competition. The development of indigenous capabilities in all the participating countries, and cooperative outlook is sine qua non for overcoming narrow economic interests. International legal and institutional frameworks should continue to be further developed to overcome those problems which could damage the prospects for a stable and sustainable global economic order.

Globalisation Strategies for Developing States

The question of globalisation has to be approached by each nation with a systematic and long term view. For example, economic liberalisation should be addressed along with the questions of providing stability in prices, appropriate institutional support for legal and financial aspects, and also a sound social support system which addresses the removal of poverty and ill effects of the transition. The globalisation in science and technology requires that close cooperation exists among the universities, industry, research institutions and the government. The private sector should be provided with roles and incentives for undertaking and supporting research and development.

The scientists and technologists should be provided with opportunities to participate in the international efforts for economic links so that they can integrate S&T aspects. They should also be provided with greater opportunities for overseas experience which will help in better understanding of the market needs and cultural aspects. An important role is also played by the national educational systems in the globalisation. Hence the educational system has to be tuned to the needs of a globalised society. Greater focus has to be given for the conduct of surveys to identify target markets and the technological progress in different countries.

An efficient information network is a pre-requisite for taking advantage of the opportunities provided during the globalisation process. Increased level of participation in the activities of international organisations and appropriate professional bodies will assist in further development of human resources. The universities and research institutions should be encouraged and supported to have collaborative programs with their counterparts in other countries. Participation in international standardisation programs is essential for industries to develop products which are acceptable internationally. Finally, each country has to pursue multiple forms of cooperation including bilateral and multilateral forms, taking into account the specific needs and the benefits. All these strategies emphasise that there should be a multipronged approach to effectively participate and take advantage of globalisation process.

Importance of Technology Sharing in the Context of Globalisation

Globalisation implies competition at the international level. Technology is a key factor for maintaining or gaining competitive positions. Technology also plays an important role in the development process. Hence technology sharing and transfer at the international level assumes importance from the view points of technology suppliers and those who need technology. Political and economic factors have been playing a dominant role in technology sharing among the nations of the world.

Technology transfer takes various forms depending on the level of technological evolution in a recipient country. Typically, it is a step by step process which includes initiation and learning phase, internalisation and assimilation phase and technology generation phase. During the initiation phase, the needs are for acquiring a knowledge of operations (involving plant and machinery), and undertaking low level design activities. Hence the less formal modes of technology transfer such as acquisition of machinery, reverse engineering and technical assistance by original equipment manufacturers take precedence over more formal modes of transfer like foreign director investment (FDI). For large plants like steel or chemicals, turn-key agreements are preferred where technology is delivered in a bundled form.

During the phase of internalisation, the needs such as mastery of production technology, manufacturing equipment, plant engineering and high level design are common. Licencing and FDI are the preferred modes of technology transfer.

During the technology generation phase, demands arise for sophisticated technologies and even technologies which are yet to achieve maturity level, so that they could be subjected to further innovations and create greater market opportunities. In addition to FDI and licencing, new forms of technology transfer such as joint ventures and strategic alliances are resorted to. In the scenario of intense competition among a few strong parties, strategic alliance is an effective way of deriving benefits through synergy of cooperation and through sharing of efforts and benefits. This form of relationship is a response to the compelling technological and competitive challenges encountered in the modern era. The strategic alliance can be based on the strength and contribution of each party in one or more of several aspects such as technological assets, access to large markets, efficient manufacturing capacity, speed of delivery or possession of large cash reserves.

The other form of technological and business relationship is the joint venture. Although this is practiced extensively, the success depends on particular agreements. The mere equity participation of the technology holder has not implied success since in many cases such partners did not assume equal risks with the other partner. Although rare in the history of developing countries, another form of technology transfer is through acquisition of high-tech firms in an industrialised country by an enterprise in the developing country. Such an acquisition gives substantial opportunities for the recipient to upgrade its technological level.

With the heralding of an information era, and with the growing desire of technology holders to get quick returns and to capture new markets, the foreign direct investment mode has been increasingly adopted by the international community. This is increasingly facilitated by the policies of liberalisation adopted in many countries and also due to the reduction of sponsorship of R&D and procurement programmes by the defence sector in advanced countries in the post cold war environment. The annual growth rate of FDI in developing countries was 19 percent during the period 1985-1990. This rate was much higher than the growth rate in the capital goods import which was growing at 11 percent during the same period.

Regimes for Control of Technology and Product Exports

The political and ideological division which dominated the international setting after the second world war, along with the security perceptions, and the latent economic interests, gave birth to several regimes which controlled the export of various technologies and products. In the nuclear field, examples of such regimes are the Zangger Committee, the London Club, and the Nuclear Suppliers Group and the insistence on full scope safeguards. In the field of dual use technol _:es, the erstwhile Coordination Committee for Multilateral Export Controls (COCOM), the more recent Wassenaar arrangements, and the Missile Technology Control Regime (MTCR) are well known.

The MTCR, which was promulgated with the objective of restricting the spread of ballistic and cruise missiles has however, failed to distinguish the need to protect the purely civilian space launch programmes and has remained controversial. The undertone of economic interests in the activities of such a regime cannot be ruled out. Continuation of regimes with specific interest groups imply that there cannot be a global system or global solution for technology sharing. However, since the issues related to globalisation of economy and the technology sharing are closely linked, efforts should be continued to evolve certain common minimum globally applicable principles, which take into account the interests of all countries.

Globalisation and Emerging Aspects for Technology Transfer

In the wake of globalisation of economies, there are several emerging aspects for technology transfer, which need close attention of the international community. Firstly, the rapid technological developments have reduced the time lag between the scientific discoveries and their market application in several fields. Fear of compeitition and of loss of market position have generated greater barriers for rapid dissemination of new knowledge generated by science. With a significant and increasing role of private sector in the scientific and technological activities, the tendencies to restrain access to scientific knowledge and also to promote technological protectionism are natural. Appropirate regulatory frameworks to respond to such developments in the context of globalisation need to be worked out both at the national and international level in order to protect the interests of all, in the long and short run.

Conclusion

The world is changing rapidly towards establishing a globalised society on many dimensions. Of particular interest is the recent movement of a significant part of the world population to realise the globalisation of economic system with accent on free markets and increased global trade. In the context of globalisation of the economy and also in the context of the needs of technology for socio-economic development in a large number of countries, there has been increasing demands for technology sharing. There cannot be a single global solution to this complex issue, given the interplay of various interests and the systems that exist in relation to the generation of technology, its transfer and applications. However, at the international level, efforts should be continued to evolve appropriate regulatory and promotional systems, open for participation by all. These should take into account interests of all countries and correct any imbalances due to the overplay of particular interests of a few members.

EMBARGO REGIMES AND IMPACT

R. Chidambaram and V. Ashok

In history, the use of an embargo has always been associated with a state of war. This is also seen in the definition of the word itself, i.e., "official suspension of commerce or other activity." In the nuclear field however, embargoes have been in place during peacetime, and, interestingly, from almost the time when the destructive power of the atom was first unleashed in war.

As early as 1946, the U.S. brought in the U.S. Atomic Energy Act which sought control over the dissemination of restricted data and prohibited the exchange of any nuclear information with all states, including even its war allies, Britain and France. Yet no international agreement on trade controls emerged between major suppliers until the mid-1960s. Nuclear export control policy remained primarily a national affair, with the U.S. and other suppliers like Canada, Australia and France imposing unilateral export conditions for nuclear transfers based on their respective national policies. The Soviet Union, prior to its dissolution, also controlled its nuclear transfers to other Eastern European states. After 1958, the Soviet Union adopted a policy of supplying nuclear reactors and enriched fuel to these states on condition that spent fuel rods were returned. It also concluded nuclear cooperation agreements with other states, most notably in the 1950s with the People's Republic of China.

NPT and its Aftermath

Articles I and II of the Nuclear Non-Proliferation Treaty (NPT) of 1968, which entered into force in March 1970, contain pledges not to transfer, seek access to, or in any way assist, the spread of nuclear weapons. Article III outlines the International Atomic Energy Agency (IAEA) safeguards to be applied under the Treaty in non-nuclear weapon states, with Article III.2 covering safeguards on the transfer of fissile material to such states. The Statute of the IAEA states that the Agency "shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." Likewise, it stated unambiguously the "inalienable right of all Parties to the Treaty to develop, research, production and use of nuclear energy for peaceful purposes without discrimination" and that all Parties to the Treaty "undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information." Article IV adds that "Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other states or international organisations to the further development of the applications of nuclear energy for peaceful purposes, with due consideration to the needs of the developing areas of the world." Sadly, the NPT has been used far more to deny than to provide assistance to needy states. Of Article VI, which called for universal global nuclear disarmament, the less said the better. The final nail in the coffin of this clause was sealed with the indefinite extension of the NPT, perpetuating the existing discriminatory system between the haves and the have-nots.

The Zangger Committee (named after its Chairman Professor Claude Zangger of Switzerland) comprising 22 states, mostly West European nuclear suppliers, began informal meetings in Vienna in 1971 on the exact meaning of Article III.2. In 1973 and 1974, the Soviet Union and states from Eastern Europe were included. While France, which was not a party to the Treaty did not participate, it did support the substance of the Treaty. The group decided that its status was informal, and that its decisions would not be legally binding on its members. The Zangger Committee established the definitional criteria for source and special fissionable materials and equipment or material especially designed for or prepared for the processing, use or production of special fissionable material. Agreement was reached on two memoranda which were published by the IAEA as INFCIRC/209 in September 1974. Memorandum A covered materials, and specified that all export of nuclear source or special fissionable materials were to be subject to safeguards. Additionally, such material, when exported to, or retransferred to, states outside the NPT were to be covered by a nonnuclear explosive use assurance.

Memorandum B covering equipment, was composed of a trigger list of items, which could be exported or retransferred only if the source or special fissionable material produced, processed or used in the equipment or material in question was subject to safeguards under an agreement with the IAEA. The trigger list included: nuclear reactors and equipment such as zirconium tubes and coolant pumps, deuterium and heavy water, nuclear grade graphite, reprocessing plants, fuel fabrication plants, and uranium enrichment plants. The Zangger Committee has continued to meet bi-annually, and conducts its meetings confidentially. In 1978, heavy water and deuterium production facilities and gaseous diffusion plants, in 1984 gas centrifuge equipment, in 1985 reprocessing equipment and in 1990 gaseous diffusion equipment again were added to a consolidated list published in 1990 as INFCIRC/209/Rev.1. The Zangger Committee began a kind of cartelization of the nuclear industry which was formalized and enlarged under the Nuclear Suppliers' Group (NSG) which followed it.

The Formation of the NSG

The NSG, first known as the London Suppliers Group, set up in the mid 70s, began the process of compartmentalizing materials, technology and equipment. The Group is independent of the IAEA. The NSG initially comprised seven major supplier states: the U.S., the Soviet Union, the U.K, France, the Federal Republic of Germany, Canada, and Japan (all except France members of the Zangger Committee). Its purpose was two fold: to integrate France (then a non-NPT State) more closely into global nuclear trade controls, and to achieve consensus on further restrictions on their nuclear exports.

The NSG decided that two sets of conditions should be attached to exports of certain nulcear items. First, the Zangger Committee condition of "peaceful use, safeguards, and the retransfer provision" would apply not only to the items themselves, but also to the design and knowledge embodied in the technology. Second, the physical protection of these items was to be agreed to between governments. In addition, suppliers would exercise restraint in transferring material (plutonium and enriched uranium) and facilities (reprocessing and enrichment facilities), and suppliers would insist on the right to veto the reprocessing or further enrichment of nuclear fuels. These conditions were published in February 1978 as INFCIRC/254, by which time the NSG had attracted seven additional members (all European) to make a total of 14. Further additions to the NSG were made in the 1990s, when following the dissolution of the USSR, Russia, France and several East European states joined it. Currently, the NSG has 31 members, with the Republic of Korea seeking entry as the 32nd member.

COCOM and its Demise

Although the Soviet Union and Eastern European states took part in the Zangger Committee and the NSG, significant nuclear trade barriers administered by the Coordination Committee for .Multilateral Export Controls (COCOM) also existed between the Communist bloc and the west. COCOM began operating in January 1950, although discussions for its export guidelines had been underway since 1948. COCOM was designed orginally by western states to restrict the transfer of militarily significant and other sensitive technologies to the Soviet Union, Eastern Europe and China. There was no treaty establishing COCOM, and it operated in a manner similar to the NSG through an informal system of export control guidelines which participating states agreed to implement on a national basis. It had its organisational headquarters in Paris.

The COCOM export control guidelines were divided into three separate lists, the International Munitions List, the International List (covering several dual-use items), and finally the International Atomic Energy List containing the items in the nuclear field for which transfers were subject to review among states participating in COCOM. All three lists were secret, but formed the basis of many national export controls. The collapse of the Soviet Union and dissolution of the Warsaw Treaty Organisation led to a review by those states subscribing to COCOM (all the members of NATO, except Iceland, plus Japan and Australia) of the export control list and criteria for technology transfer. This led to changes in some of the lists, including the nuclear one and an expansion of the items that might be transferred to the former republics of the Soviet Union, Eastern Europe and China. In 1994, COCOM was wound up in favour of a new arrangement, the Wassenaar.

National Controls

Several states imposed their own controls over the nuclear exports. For example, the U.S. 1978 Nuclear Nonproliferation Act (NNPA) sought to permit supply of nuclear fuel to nonnuclear weapons states only if such states accept IAEA safeguards on all their nuclear activities, do not establish any new enrichment or reprocessing facilities under their de facto or de jure control and place any such existing facilities under effective international auspices and inspection. Existing agreements for cooperation were made subject to review on a case by case basis. India is pursuing a closed fuel cycle which in our view is not only optimal from our resources perspective, but also from energy resource utilisation point of view. As is common knowledge, breeders generate tens of times as much energy as once-through cycles. The U.S. stance on reprocessing, and its aversion to civil plutonium use appears contrary to the objective of sustainable nuclear energy development.

The formulation of the NSG guidelines together with the stringent national export control policies of some of the western suppliers led to strong criticism being voiced by developing countries in several international forums, including the International Conference on Peaceful Nuclear Cooperation in Persepolis, the International Fuel Cycle Evaluation, and the second NPT conference in 1980. This led to the initiation of two efforts to seek a consensus in nuclear trade. The first was the creation of an IAEA Committee on Assurances of Supply (CAS). This tried to establish agreed roles for nuclear trade that would both enhance peaceful nuclear cooperation and strengthen nuclear nonproliferation. The second was the 1987 United Nations Conference on Promoting International Cooperation in the Peaceful Uses of Nuclear Energy. Both failed due to the attitude of those supplier countries who insisted on the right to make export decisions on a case by case basis.

Increasing Prominence of Dual Use Items

The revelations in 1991 about Iraq's clandestine nuclear programme and the big role played in it by foreign suppliers (mostly European), following the pattern of similar Pakistani activities, showed that procurement practices appeared to have changed over time. Rather than seeking items contained in the Zangger or NSG List, purchase of dual-use equipment and material, and the use of on-site consultants for technology transfer appeared to be the new modus operandi. The experience with North Korea which followed immediately after this demonstrated also that NPT membership, was not a guarantee of adherence to the principles enunciated by the west. The two isolated cases of Iraq and North Korea were treated as adequate justification for the supplier states to uniformly apply the axe on all, such that trade with even the vast majority of nonnuclear weapon states (NNWS) signatories to the NPT, with bonafide programmes were to be subjected to scrutiny, thereby affecting peaceful civilian programmes.

The NSG met again after a gap of 13 years in the Hague in May 1991 and in April 1992, 27 nuclear supplier countries meeting in Warsaw agreed to a list of 67 categories of dual use technologies and materials to be controlled. Dual use items were defined by the agreement as having legitimate nonnuclear uses, but if diverted, could make a major contribution to the nuclear explosive and unsafeguarded nuclear fuel cycle activities. States subscribing to the new dual use export controls agreed not to transfer any of these items to nonnuclear weapon states unless accompanied by IAEA or equivalent safeguards. The items included, inter alia, industrial equipment such as spin and flow forming machines that could be used in uranium enrichment equipment; materials such as maraging steel, zirconium and lithium-6; uranium isotope separation equipment; heavy water production plant related equipment; implosion system development equipment; and specialist types of explosives and related equipment.

The cartelization which had earlier been referred to as having begun informally through the Zangger Committee was thus crystalized. Recipient states had no say. Supplier states ensured that they provided whatever material, equipment or technology on their terms. Moreover, unlike the principles of conventional justice, here one was judged guilty unless proven innocent. The system of curbs developed in a way that led to denial of even innocuous technology on the specious plea that it could be used for purposes inimical to those specified in the NPT. The entire trade regime thus became discriminatory, being dictated according to the commercial interests and geopolitical strategies of supplier states.

Technology Inhibition Through 93+2 and CTBT

The Iraq and North Korea events had another profound impact in that they gave rise in the IAEA of the possibility of so called undeclared nuclear activities in countries which have comprehensive safeguards arrangements with the IAEA. With this as the focus, the Agency commenced discussions on strengthening the effectiveness and improving the efficiency of the safeguards system under Programme 93+2. The programme has been divided into two parts, Part I consisting of those measures which could be implemented under present legal authority and Part II comprising those measures which would require complementary legal authority. Measures under the latter envisage intrusive inspection regimes including environmental sampling, access to additional information through unrestricted access to any relevant location and explicit support of the United Nations Security Council.

By itself, the IAEA safeguards regime did not have any specific enforcement mechanism, but such a mechanism is formally considered under Programme 93+2. Apart from impinging on state sovereignty, environmental sampling for safeguards purposes allows for chemical and isotopic analysis of minute samples (as small as 10^{-15} g) which may be collected within declared facilities or at locations away from nuclear facilities. This includes water, soil or biota samples that might provide indication of clandestine activity. Indeed any place where the Agency's inspectors suspect the presence of "undeclared activity" can be subjected to close scrutiny under the Additional Protocol now being contemplated. While limited provisions for managed access are under discussion, it is clear that confidentiality of all research and development activity being carried out in a country is likely to be revealed through such intrusive measures. Such comprehensive information would reveal in detail the directions of research and development in different areas of nuclear technology, including military uses as permitted under the NPT. It would enable advanced countries to block, and therefore, inhibit the development of certain technologies in which they desire to retain an upper hand through control of strategic and critical materials, equipment and technology (both direct and dual use).

Further more, the requirement of no notice inspections and the declaration of export and import of material and equipment, information on available natural resources, minerals and ores, as well as all activities presently being carried out, and those under contemplation would necessitate revealing confidential commercial, economic and strategic information whose disclosure could be against the national and security interests. Such information as may have been obtained by supplier states through national technical means (NTMs), satellites, espionage and human intelligence could be used to generate reasons for inspections under 93+2 and be utilised to apply political and economic pressure. Parallel, though less extensive verification measures as contemplated under 93+2 are those being put in place under Comprehensive Test Ban Treaty (CTBT) with for example environmental monitoring, inspections and access. Many of these provisions are likely to have serious impact through inhibiting technology development in NNWS. The NNWS are already subjected to fullscope safeguards. By further subjecting them to scrutiny under the series of measures contemplated under verification for CTBT, they are under double scrutiny. On the other hand, the CTBT is irrelevant for NNWS unless they cheat through carrying on clandestine activities and also unless the IAEA fails in its safeguards operations in spite of stregthening them recently.

However, the continuous monitoring of data under the CTBT through on line seismic (primary and auxiliary), hydroacoustic, infrasonic and radionuclide stations worldwide together with the capability for detection of radioactive noble gas would strengthen monitoring and verification capabilities providing information of relevance to 93+2 or CTBT, both of which could be used to impose embargoes and sanctions on suspected deviant states which are not parties to NPT, especially when such information as obtained through on-line stations would be complemented and supported by the use of NTMs. The current CTBT has provisions for accepting NTMs with the exception of espionage and human intelligence. It is our belief and that of many other developing countries that with the flood of information flowing worldwide, selectivity, and therefore, discrimination is likely to be applied in focusing on certain regions of the world. The NWS will exclude themselves from excessive scrutiny through mutual consensus; they will not concentrate on those NNWS party to the NPT whom they consider friendly to themselves. Instead those states still away from NPT which are nuclear capable (India, Israel and Pakistan) and some other states like Libya, Iraq, Iran, and North Korea will be the objects of greater attention.

India is not directly affected by the strengthened measures proposed since it is not signatory to the NPT. However, during discussions on 93+2, the involvement of states which have voluntary offer safeguards (such as the NWS) and those with facility related safeguards (such as ourselves) has been raised under the so called banner of universality. We maintain that this has no legal status since by definition, undeclared nuclear facilities have no meaning for states which are not treaty bound to declare the nature and range of their nuclear activities. Nevertheless, increased access to information could enable suppliers to make judgments which could inhibit supply of material, equipment and technology, a factor India shall have to guard against. With the CTBT text now having been pushed through the UN General Assembly, efforts may now be on to commence negotiations on a so-called universal, comprehensive and effectively verifiable Fissile Material Cut-off Treaty (FMCT). Of course, the FMCT, like the CTBT, is irrelevant for NNWS signatories to the NPT and some other states like Brazil which, without signing the NPT have comprehensive safeguards arrangements with the IAEA. Very intrusive regimes are likely under such a treaty and our approach towards it has to be cautious. Our reaction to this proposal, if and when it is made, will, of course, be based on our (altruistic) desire for global nuclear disarmament and our national security concerns. Also, if and when the FMCT comes into force, there should be no prospective proliferation concerns, and therefore no embargo regimes should operate after that date.

The Wassenaar Arrangement - A Successor to COCOM

In July 1996, after three years of intensive discussions, the successor regime to COCOM, the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual Use Goods and Technologies, has been agreed to by 33 countries of Western and Eastern Europe, the Russian Federation, the U.S., Canada, Japan and Australia. The Wassenaar Arrangement has two lists, a Munitions List and a Dual Use Goods and Technology List. The second list has 2 annexes for Sensitive and Very Sensitive items. The Dual Use List consists of the following nine categories: advanced materials; materials processing; electronics; computers; telecommunications and information security; sensors and lasers; navigation and avionics; marine technology; and, propulsion technology.

It has been agreed that the decisions on transfers will be the responsibility of each participating state and will be implemented on the basis of national discretion, but a mechanism for notifying transfers and denials has been coordinated. The Wassenaar Arrangement is described as an agreement open to all countries, subject to its being a producer/exporter of relevant nuclear industrial equipment but stipulations on conformity with nonproliferation policies (NPT) and admission of new participants through consensus appear to indicate that India is unlikely to be accepted as a party. The Wassenaar Arrangement is not a replacement for NSG, despite the fact that most of the members of these two groupings are common. Rather, they overlap, and in a sense apply a double check, thereby imposing double burden, with Wassenaar having a far more detailed and comprehensive dual use goods and technology list. It is indeed most ironic that the Wassenaar, as successor to COCOM, has included in its midst the very states COCOM was once targeted against. In the post cold war, supplier states and their dependent buyers appear to have made common cause for a greater cartel to ensure sustained growth.

Shortcomings of Dual Use Controls

Though the professed objective of dual use equipment and technology denial is to control proliferation, it cannot be disputed that such control would go further in retaining the technological superiority of certain countries and manufacturers in diverse areas not directly connected with atomic energy. Integrated chips, computers, software, telecommunications, marine acoustic systems, optical sensors, underwater cameras, lasers, and test equipment to check the safety and reliability of such systems are all covered under dual use and could be denied for reasons which may not be transparent, and may affect development in countries without indigenous capabilities or developed country patronage. History bears out that violators acquire technology in defiance of such dual use regimes. On the other hand, in the fast developing technological world of today, it seems absurd to attempt such all encompassing restrictions on the flow of technology and equipment. It is grossly unfair to deny certain technologies to developing countries merely because these could have a dual use function. We feel that such technology should not be denied, as it will keep the developing world at a perpetual technological disadvantage to the developed world.

A related question which arises is whether intellectual property rights can be attached to equipment or technology subject to embargo. Just as we seek to remove the barriers hampering free trade in other areas, we must equally seek the free flow and exchange of nuclear technology and equipment, especially in areas like nuclear power and safety, and peaceful uses, such as in medicine, industry and agriculture. Such transfers should, of course, be monitored to prevent diversion to non-peaceful applications. As in previous years, we have, this year introduced a draft resolution at the Disarmament and International Security Committee of the UN General Assembly calling for holding multilateral negotiations, aimed at establishing nondiscriminatory guidelines for transfers of dual use technologies.

Low Impact on India

What will be the impact on India of such embargo regimes? Since 1974, we have been facing some degree of restrictions on imports of materials and equipment, as well as for transfer of technology. When we see the progress that we have made in these 22 years in different sectors of atomic energy, it is clear that the impact on India of such restriction or sanctions has been low. It is true that some of the projects then on hand were slowed down, and I would be the last person to avoid mentioning the considerable hardships that we have, collectively, as a team, gone through to accomplish our set goals. Yet, we have done so, proving that even if India can be slowed down in the short run, her technical reservoir of competence and skill will ensure that she cannot be stopped.

Technology embargo may have been a hindrance, but it has also been a motivation for striving for self reliance. We embarked from the beginning on a programme of self reliance. That programme was accelerated and intensified in the face of the closed doors to cooperation which we faced, and indeed, our self reliance and self determination increased due to the obstacles faced in developing our own technologies. This is apparent from some of the developments we have made indigenously in response to such challenges. The Anupam super computer, based on the parallel processing technique, with up to 64 computers interconnected by a high speed communication system is a typical example. We have recently undertaken the coolant channel replacement at RAPS-2 at considerably lower cost and radiation exposure than that achieved by the Canadians. For diverse applications, we have developed our own software, for intricate nuclear power station design as well as start up/shut down operations. We have demonstrated capability over the front and back end of the fuel cycle and have just completed our third reprocessing plant at Kalpakkam which has already undergone cold commissioning.

We have acquired expertise in fuel fabrication for all kinds of nuclear fuels, including mixed oxide fuels (MOX). When denied enriched uranium oxide fuel for our Fast Breeder Test Reactor (FBTR), we went ahead and introduced for the first time in the world an indigenously produced mixed uranium plutonium carbide fuel for the FBTR which has worked excellently so far up to a burnup of 26,000 MWd/tonne. Kamini, a 30 kw mini neutron source reactor, which went critical only on October 29, 1996, is currently the only reactor in the world running on the Uranium U^{233} isotope fuel. We have developed the hydrogen sulphide process for our heavy water plants. The list is long and includes requirement for our research and development, ranging from lasers and cryogenics to high speed molecular pumps, from master slave manipulators to complete chemical plant design. It is perhaps the reason the IAEA Director General Hans Blix said a couple of years ago in Vienna, "when you think of self reliance, there is no better example than India."

Reverse Flow of Technology

There is also a reverse flow of technology, capabilities, services and equipment now experienced. In this sense, India is perhaps very fortunately placed in the nuclear field in that, despite being a developing country in the economic sense, we are in a position to offer goods and services to match those from the developed world. This reverse flow has been apparent in the fellowship programmes in advanced areas in the field of nuclear sciences, both bilaterally and under the IAEA's technical cooperation programmes. We also host and participate in a number of seminars in association with the IAEA and with other bodies such as the Candu Owners Group and the World Association of Nuclear Operators (WANO). We have signed a contract for export of a modest quantity of heavy water. In 1995, we had gifted some environmental stack monitoring equipment to the IAEA laboratories at Seibersdorf, Vienna, and this year we have just gifted laser fluorimeters for detection of trace quantities of uranium to the same laboratories. The equipment would be used for training technicians from developing countries. We are also prepared to offer research reactors as well as reprocessing services, and feel these would find a market when the climate is more conducive.

Future Trends

While we have witnessed the rise of controls including those on dual use goods and technology over the past few years, there has also been considerable interest shown in the Indian nuclear programme by several western suppliers, especially in the wake of the slow down of nuclear programmes in their respective countries. Clearly, the world is aware that there is nothing India cannot do and what we have not done is a reflection of our self-restraint rather than our lack of capability.

We are also confident that economic factors will prevail increasingly in cooperation in areas of nuclear power and safety, particularly with the increasing globalisation of our economy and capabilities of Indian scientists and engineers working in the country and outside. In this we must see the example of the desire of even the U.S. for cooperation with China. The answer lies in economic strength which will lead to adoption of policies of appeasement rather than those of denial. In these last few years, we have embarked on the road towards a powerful economy and we need to ensure we proceed speedily along this path. We currently have ongoing research programmes with several countries which are very active. Indeed, one of our objectives in recently setting up the Indian Atomic Industrial Forum (IAIF) was to provide a platform for cooperation in nuclear energy programmes among the Nuclear Power Corporation of India Limited, the Indian industries and Department of Atomic Energy but also international agencies, industrial groups and organisations.

The winding down of nuclear power programmes in the west is complemented by a corresponding increase in such plants in Asia, particularly in the Republic of Korea, Taiwan, China and India. Nuclear energy is the inevitable option for fulfilling the electric power requirements of the future. The developing countries of Asia, with their large populations and present low per capita electricity consumption, need nuclear power more than the developed countries for improving the standards of living of people, and represent the future focus for growth in the nuclear power industry, a factor which commercial organisations in the field of nuclear power can ill afford to ignore.

THE IMPLICATIONS OF THE WASSENAAR GROUP

Brahma Chellaney

Technology controls have a long history. Ancient empires sought to zealously safeguard technological innovations, ranging from new tools of warfare to fresh discoveries in navigation science and astronomy. However, it was only with the advent of the industrial revolution that technology was fashioned into an effective political tool to subjugate alien civilisations.

The European states, the first to benefit from the industrial revolution, employed superior military strength derived from industrial advantage to colonize the world's ancient civilizations. In other words, they employed dual use technology, the main target of export controls today, to achieve their strategic objectives. The so-called Third World emerged as a technologically and economically backward region because, having been colonized by the Europeans, it missed the industrial revolution and even the initial post-World War II electronics revolution. More than three quarters of the United Nations' present 185 member states have been independent for less than 40 years.

Colonialism was a classic case of the pursuit of economic interests through superior military technology. Even today, greater military prowess remains crucial to the assertive pursuit of economic interests. The geostrategic value of nuclear weapons is evident from the fact that most of the major economies today have the protection of a nuclear arsenal or umbrella. Much of Western Europe and other significant economies such as Australia, Japan and South Korea are ensconced under the U.S. nuclear umbrella. Security is seen as an essential requisite to the pursuit of economic goals.

Tightening of Technology Controls

Today, the relationship between industrial technology and military technology is closer than ever. Technologies for civilian modernization are equally useful for building military power, and vice versa. It is thus becoming increasingly difficult to separate civil and military research and production. Military products and innovations are relying more and more on commercial technologies and items. The United States' unmatched conventional force power projection capability derives mainly from the application of commercial advances in the processing and transmission of information. It is a big challenge to effectively control technology flow in an interdependent world in which the private sector is spearheading the advancement of civil and dual use technologies. Moreover, all advanced technologies today are dual purpose.

In the period after World War II, technology controls, for the first time in history, began being fashioned in the form of elaborate, institutionalized, multinational structures, backed by national export control barriers. After the end of the cold war, the institutional structures for technology control are being broadened in terms of their membership. The United States has led efforts to tighten and expand domestic and international export control mechanisms to limit the diffusion of sensitive technologies, and national export controls in western supplier states have also been harmonized in recent years.

Why are technology controls being strengthened and expanded after the end of the cold war? The termination of the cold war was widely expected to yield a peace dividend, promote genuine disarmament and lead to the loosening of technology controls. The reality seven years after the fall of the Berlin Wall is very different. The opportunities opened up by the cold war's conclusion to build a durable world order pivoted on truly collective or cooperative security are being frittered away. The peace dividend remains largely elusive and the prospects of comprehensive nuclear disarmament remain bleak despite a recent International Court of Justice (ICJ) ruling that the nuclear powers are legally obliged not only to negotiate in good faith but "to achieve a precise result nuclear disarmament in all its aspects."

The tool of technology control and denial is indeed being sharpened to bolster great power interests. To lend legitimacy to the reinforcement and expansion of technology controls and to justify the retention of cold war doctrines and strategies, it is being argued that the proliferation of weapons of mass destruction has replaced the cold war as the main threat to international security. Declaring that the "proliferation of weapons of mass destruction continues to pose an unusual and extraordinary threat to the national security, foreign policy and economy of the United States," U.S. President Bill Clinton in November 1996 extended for the third straight year the "national emergency" regarding such weapons.

It has become an article of faith among U.S. officials and analysts that horizontal proliferation is the new threat to American security and global peace. No empirical data, however, has been presented to show that such proliferation is taking place and is threatening U.S. or world security. Nevertheless, the ghost of Iraq continues to be seen everywhere, and the Pentagon has even embarked on a "Counterproliferation Initiative" that seeks to develop capabilities and technologies to militarily knock out, if necessary, facilities of proliferation concern.

The main arms control efforts have been concentrated on making "nonproliferation" a respectable and lawful enterprise, erecting new technical barriers to horizontal proliferation and stabilizing deterrence between and among the nuclear powers. Treaties such as Intermediate Nuclear Force (INF), Strategic Arms Reduction Treaty (START I) and START II, which were products of coldwar surpluses, were designed to safeguard deterrence, not undermine deterrence, by eliminating the most vulnerable and *destabilizing of the weapon systems. It is unthinkable that treaty related* restrictions would be accepted on the most sophisticated of the nuclear weapons, i.e., the submarine based systems, or on the movement of such arms through international water and the so called "nuclear weapons free zones."

As arms control is aimed primarily at reinforcing the present status quo in the global power structure, new strategies are unfolding to stem the diffusion of militarily significant technologies which are also at the cutting edge of economic modernisation. These strategies are designed to augment the four ways in which the spread of advanced technology is being controlled. These methods are:

1. National Export Barriers. The United States has the most elaborate and expansive export controls, with overlapping lists of controlled goods and technologies. At U.S. urging, the export controls of European countries have grown dramatically since the 1991 Gulf War. The emphasis now is on harmonizing the national technology controls among the western allies.

2. Multinational Controls. The control lists of goods and technologies maintained by the London Club of nuclear suppliers, the Australia Group on chemical and biological precursors and the Missile Technology Control Regime have all grown since the end of the cold war. These controls are also being supplemented with national export barriers. For example, the United States has fortified the MTCR controls with its Enhanced Proliferation Control Initiative (EPCI) controls. According to Clinton, EPCI "is a catch all control on items that are not in the MTCR Annex, but could be used directly in projects of missile proliferation concern."

3. End use Controls. These include on-site monitoring in the recipient state.

4. Technology Embargos. These involve denial of all technologies classified as sensitive or having potential dual use to the usual suspects, Iran, Iraq, North Korea and Libya, which have been branded as "rogue states," "renegade states," and "pariah states." Such embargoes often seek to bar the transfer of even industrial technology, as exemplified by the 1996 U.S. ban on energy sector investments in Iran and Washington's ongoing efforts to persuade European allies not to help develop or upgrade oil fields in Iran.

Three developments are under way on the technology control front as part of the new strategies and initiatives:

i) the regulatory focus of technology controls is changing ominously from an East-West perspective to a North-South perspective, with the ex-target states in the East bloc being brought into multilateral regimes and encouraged to set up national export control mechanisms;

ii) all possible dual purpose technologies are being subjected to export controls, with the result that all cutting edge technologies are consciously being kept beyond the reach of the targeted countries; and

iii) the principal targets, as acknowledged by western officials, are now increasingly South Asia (defined as India and Pakistan) and the Middle East (excluding Israel).

In some areas, there has been a loosening of export controls in response to the global diffusion and development of technology. One such example is high performance computing (HPC), an area in which the United States has been forced to liberalize its export policy in response to the availability of more powerful supercomputers from other suppliers, including India. India has shown how export controls can at times be counterproductive. After being denied an export license to purchase the U.S. Cray XMP-14 model supercomputers, India has built its own supercomputer, Param, and exported it to users in Russia, Germany, Canada and Britain.

Under the new American HPC policy, countries have been categorized in four tiers. Nations in the fourth tier comprise the alleged rogue states and are precluded from all sales. India is in the third tier which provides for no licensing requirements for export of computational machines with speed up to two billion theoretical operations per second (TOPS). In practice, however, the policy works differently. Even as the export of supercomputers is being decontrolled to destinations like China and East Europe, the United States has "reinforced the burden on exporters of satisfying themselves that exports are not going to destinations of proliferation concern," according to U.S. Arms Control and Disarmament Agency Director John Holum. Washington regards India as a country of proliferation concern.

Birth of the Wassenaar Arrangement

The establishment of "The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual Use Goods and Technologies" should be seen against that background. The Wassenaar cartel represents the most ambitious multinational venture in controlling trade in dual purpose goods and technologies and conventional arms.

The new regime is designed to allow the winners and losers of the cold war to jointly tackle potential strategic threats from elsewhere in the world, although the western allies will continue to hold closely among themselves their most sensitive technology. The cartel began regular meetings in September 1996 and its control lists of goods and technologies came into force November 1, 1996. The cartel can also be called the Vienna Club since it is headquartered in the Austrian capital.

The Vienna Club is modeled on the London Club, the Australia Group and the MTCR. These clubs are tied by six common elements.

1. They were born in secrecy and were publicly unveiled months or years later.

2. They continue to lack transparency, functioning behind closed doors. The London Club is now considering steps to develop transparency in its functioning in keeping with the call in Principles 16 and 17 of the 1995 Nuclear Nonproliferation Treaty (NPT) Review and Extension Conference.

3. They lack international validating agreements or the sanction of the United Nations. Despite the addition of new members in recent years, the cartels continue to face international legitimacy problems. The naming of the Australia Group in the Chemical Weapons Convention documents and of the London Club in the NPT Review and Extension Conference's principles represent back-door efforts to lend international credibility to these cartels.

4. They involve some degree of intelligence sharing among their members. The London Club did not provide for intelligence sharing until fairly recently. Russia's formal membership in the MTCR was held up for several years because the cartel was functioning on the basis of close intelligence sharing among its founding members, the G-7 states.

5. They have the same set of core members, many of whom are former colonial powers. However, the clubs, which with the exception of the Wassenaar Arrangement comprised only western states, today have among their members not only ex-East bloc nations but also states such as Argentina, South Africa and South Korea.

6. They were set up under U.S. inspiration. The United States remains the effective leader of all the cartels.

The Wassenaar Arrangement was stealthily founded on December 19, 1995, at Wassenaar, a village near The Hague, by 28 countries including the former Coordinating Committee on Multilateral Export Controls (COCOM) partners, cooperating countries, Russia and the Visegrad states. Its birth was a slow and painful process that began much before COCOM was folded up at midnight on March 31, 1994. COCOM was fashioned and nurtured for four decades principally to target the East bloc. In June 1992, COCOM eased controls on sale of advanced telecommunications technology to the newly independent states of the former Soviet Union and invited them and other East European nations to join the regime. However, Russian reluctance to embrace a cartel that targeted Moscow for decades prompted the 17 western members of COCOM to propose a successor regime under a new label. When COCOM was dissolved in spring 1994, its controls on strategic technologies were kept in force against "countries of proliferation concern" by the new forum, and adhoc interim arrangement.

Clinton and Russian President Boris Yeltsin met four times between 1993-95 to resolve bilateral differences standing in the way of forming the successor cartel to COCOM. Among the issues that figured in the Clinton-Yeltsin discussions were Moscow's space and military cooperation with India and its pending arms and commercial nuclear power exports to Iran. Russia's decision in July 1993 to break a 75 million dollar contract with India to sell cryogenic engine technology came after Clinton personally took up the matter with Yeltsin.

The last hurdle in the establishment of the Wassenaar Arrangement was cleared in mid-1995 when Yeltsin supplemented a pledge not to export new weapons to Iran by releasing details of all arms sales pending or in the pipeline. The clarification of Russia's export intentions was then formalized under the Chernomyrdin-Gore process, also known as the Russia-U.S. Inter-Governmental Commission on Economic and Technological Cooperation. This opened the way for the holding of the pre-Christmas founding conference of the Wassenaar cartel. That meeting came after several rounds of detailed negotiations among the founding members on the regime's structure and controls.

But even after the Wassenaar cartel was founded, its start up was delayed by fresh differences, principally between Washington and Moscow. The first plenary meeting of the new regime held in Vienna in April 1996 broke up without agreement on beginning the cartel. The key discord was over a U.S. proposed rule against undercutting which Russia was reluctant to accept. Under the rule, when one member notifies the others that it has rejected a proposed export, then any other member is required to provide advance notification to the others if it intends to approve the same export. Russia wanted the notification provision to be operative only after delivery of the export. Moscow eventually fell in line with the rest of the members, opening the path for another plenary meeting in July 1996 to reach agreement on implementing the cartel's lists of controlled goods and technologies. By then, the cartel's membership had swelled to 33.

The establishment of COCOM in 1949 helped usher in the cold war. The question that arises today is whether the new Wassenaar cartel will be the harbinger of a new kind of a cold war. As then Indian Prime Minister

P.V. Narasimha Rao said in 1995, we can almost feel the chill of the cold war in the air once again.

Significance of the Wassenaar Cartel

The central significance of the Wassenaar cartel is that the two former cold war blocs now united in this technology control venture believe that the diffusion of technology poses such a threat to their vital interests that it is necessary to join hands and impose high-tech controls. There is no explanation, however, as to how the potential dissemination of high technology to the rest of the world comprising mainly impoverished, formerly colonized states could threaten their core interests.

The significance of the Wassenaar Arrangement is self-evident from the fact that it has roped in all the important supplier states with the exception of China. When discussions on forming the cartel began, China was invited to join, with greater access to advanced technology being offered as an inducement. The United States unilaterally relaxed restrictions on the export to China of a number of high-tech goods, including telecommunications equipment, microprocessors, memory integrated circuits, digital integrated circuits and field programmable gate arrays and logic arrays. However, the cartel's core founding group later decided on a participation criteria that rendered Beijing ineligible, i.e., membership in all other technology control regimes and effective national export controls in place. China, however, is being encouraged to adhere to the Wassenaar syndicate's guidelines and control lists in the same way it has publicly pledged to heed (while covertly violating) the guidelines of the MTCR.

Another significant element is that the cartel's membership criteria has a "critical requirement" that the participating states should already have in place "national policies to prevent transfers of arms and sensitive technologies for military purposes to the four pariah countries," according to U.S. Undersecretary of State Lynn Davis. In other words, the Wassenar Arrangement's control lists despite public claims to the contrary are not directed at the "pariah" states but at some non-pariah nations.

With much of the ex-East bloc coopted into the Wassenaar cartel and technology already embargoed to the "pariahs" as a condition of its membership, which nations is the regime targetting? If we go by the public statements of its guiding functionaries, it is targetting no one. But obviously the club was set up to promote the interests of its members through a proactive mission. The cartel has no targeted countries named in its guidelines but its controlling role nonetheless will squeeze certain nations.

The Wassenaar syndicate, unlike its predecessor regime, COCOM, is not to have a permanent list of target countries since it has not been set up to mark some specific nations. Rather, it is designed to be a dynamic, evolving institution that can cope with new threats as and when they emerge. The cartel thus will continually assess regional situations and come up with its responses, a sort of revolving door approach. To facilitate reliable assessments, the cartel provides for intelligence sharing and a permanent experts level dialogue on threats to regional and global stability.

Moreover, the Wassenaar Arrangement theoretically is not supposed to exercise collective veto on the export decisions of individual members. In practice, however, the permanent dialogue process, the rule against undercutting and other procedures could make it difficult for an individual member to defy the rest of the group. Only time will tell whether the cartel matures into an effective technology control institution or is weakened by conflicting pulls and pressures from within. The tensions between commercial and security interests are visible not only between supplier states but within their own governments.

Irrespective of how the Wassenaar cartel evolves, certain countries are going to be its victims. Which are those? Lynn Davis has acknowledged that the syndicate's regulatory focus will be on "regions of potential instability, such as the Middle East and South Asia." South Asia is being cited in U.S. policy as the area of greatest proliferation concern since it is home to two of the three nuclear threshold states. The United States, of course, has an complaisant, indeed cooperative, policy toward the third threshold state, Israel.

Implications for India

What are the implications for India of the formation of the Wassenaar cartel? For India, already pursued by the other cartels as a key target and confronting additional national export control barriers erected by the advanced industrial states, the Wassenaar regime holds important implications. While it has dramatically opened up its domestic market to Western goods and services, India faces shrinking access to high technology. The new cartel's secret list of controlled items is believed to mirror the COCOM controls on microelectronics, material processing, high-performance computing, marine technology, sensors, advanced materials, propulsion systems and other strategic goods and technologies.

The implications for India are also evident from the cartel's "no-undercut" rule and from Russia's inclusion in it. The rule against undercutting means that if a request for an export licence is rejected by one member, it is likely to be spurned by the other 32 members as well. India, therefore, will have to proceed prudently before signaling interest in importing a controlled item or technology.

It remains to be seen how India's strategic cooperation with Russia will be affected by a regime that theoretically is not supposed to exercise collective veto on the export decisions of its individual members. Although a member of the London Club, Russia is currently negotiating to sell two VVER-1000 commercial nuclear power plants to India without demanding "full-scope" safeguards as mandated by the Club's revised guidelines. The negotiations reportedly are at an advanced stage, although it is puzzling why India, forgetting the lessons of the bitter Tarapur dispute arising from its dependency on external fuel and spare parts supplies, should be interested in importing old fashioned reactors.

In the past while transferring arms production know-how under licence, Moscow effectively blocked reverse engineering by supplying only fabrication relevant drawings and specifications to India. Also, by its 1993 annulment of the cryogenic engine technology contract, Russia has shown itself to be an unrealiable supplier even when not in a cartel.

India can only blame itself for coming under growing pressure on the technology front. For three decades since starting to produce plutonium, it has not been able to make up its mind on the nuclear issue. While nuclear profligate China is courted by all cartels, nuclear abstinent India is targeted by them. The marking of India by technology control regimes is proof of the fact that the country's unparalleled nuclear self-restraint has won it no international admiration and only brought it under greater external pressure. Meanwhile, India's security challenges have been exacerbated.

The new cartel is thus a reminder of India's mounting costs of indecision. It also exposes the vulnerability to external pressure of India's conventional defence posture, heavily dependent on arms imports and bereft of the resources to sustain conventional modernization. The biggest lesson the new regime can teach India is that it cannot secure its future with solely a conventional force posture.

India's problems are being compounded by the fact that it is pursuing conflicting economic and foreign and defense policies. While economic reforms seek to integrate India with the western driven global economy, the country's political stance mocks the west's strategic panorama and security order. India needs to blend its political and economic positions into a harmonious, long-term national vision. Until it does so, it will continue to incur rising costs even as it continues to twiddle its thumbs on the nuclear issue.

Conclusion

Technology controls are principally aimed at preserving the military and economic interests of the leading powers and their allies. These interests include direct or indirect security threats, market access for selling goods and services, cheap imports of oil and other raw materials, favorable trading rules, and preventing the rise of regional hegemons. In the post cold war years, new barriers to trade in technology are being erected even as import and investment barriers are being dismantled and new economic opportunities are being availed of in countries such as India.

The new Wassenaar cartel is part of the growing consensus and cooperation between the former cold war antagonists on controlling the diffusion of technology that could potentially impinge on their interests. The "rogue-states doctrine" has come handy to justify new technology controls although the real intended targets of such controls are different.

The Wassenaar syndicate will impose significant costs on certain countries, although its long term viability and effectiveness will depend on continued consensus and cooperation among its partners. While there will be growing demands for a shift to transparent and internationally validated policies on technology control, the present national and multinational export control mechanisms will continue to be strengthened so long as the current security order holds. However, if NATO and the U.S.-Japan security treaty crumble, the present technology control system will also collapse.

While history bears testimony to the long term ineffectiveness of technology control strategies, countries that will have to bear significant short and medium term costs could lower those costs by pursuing a holistic approach to national security, developing independent assets and harmonizing their defense, economic and foreign policies with each other and with an overall national strategy.

NUCLEAR POWER AND TECHNOLOGY: INTERNATIONAL COLLABORATION

NUCLEAR POWER DEVELOPMENT: THE SOUTH KOREAN EXPERIENCE

Hong, Jang-Hee

In modern times, electricity has contributed greatly to the development of civilization and the promotion of human health and longevity through many applications in medicine, agriculture and industry. Nuclear power is providing an ever-increasing percentage of the world's electrical energy and has contributed to a stable supply of electricity as well as environmental conservation by greatly decreasing the emissions of carbon dioxide by fossil generation.

Historically, Korea has imported more than 90 percent of its total energy requirements because indigenous energy resources are scarce. Because of this, and the oil shock in the 1970s, Korea committed itself to a policy of nuclear power development as part of a national strategy to acquire alternate energy sources. Through the expansion of our nuclear power program, our country has overcome chronic power shortages, which lasted into the 1970s. Nuclear power generation has played a key role in the economic development of Korea by providing long-term stability in our electric power supply system.

Status of Nuclear Power in Korea

The Korea Electric Power Corporation (KEPCO), is the sole electric utility in Korea. Since the beginning of commercial operation of first nuclear unit, Kori unit 1 in April 1978, KEPCO has achieved rapid growth in nuclear power development.

Korea now has eleven operating nuclear units including ten Pressurised Water Reactors (PWRs) and one CANDU. The total capacity of these eleven units is 9,616 MWe, or 28.9 percent of country's total installed capacity. The nuclear power generation in 1995 reached 67 billion KWh or 36.3 percent of the country's total electrical generation.

The latest unit is Younggwang unit 4, a 1,000 MW unit, which was constructed as a part of the national nuclear technological self-reliance program. Younggwang unit 4 went into commercial operation in January 1996. Younggwang units 3 and 4 were awarded the 1995 "Project of the Year" award by "Power Engineering International" magazine for their excellence in design, construction, and operation. Seven additional units, consisting of four PWRs and three Pressurised Heavy Water Reactors (PHWRs), are under construction, and two PWR units are in the planning stage.

The performance of Korean nuclear power plants has shown remarkable improvement in recent years, and compares favorably with the rest of the world. For example, in 1995 the average capacity factor of Korean nuclear plants was 87.3 percent, while the world average was 71.6 percent. It has been over 84 percent for the last 5 years.

This remarkable achievement is the result of well coordinated operations and maintenance efforts. While maintaining plant safety as the top priority, KEPCO has made every effort to improve plant capacity factors, which has resulted in improved plant reliability. These efforts included adopting extended fuel cycle periods and working diligently to shorten refueling outage durations. The resultant is the accumulation of its own operating experience and technology, as well as information exchanges with nuclear industries worldwide.

Table 1
Nuclear Power Plants in Korea

Units		Reactor Type	Capacity (MWe)	Manufacturer		Commercial Operation
				Reator	T/G	
Kori	#1	PWR	587	WH	GEC	Apr. 1978
	#2	"	650	"	"	Jul. 1983
	#3	"	950	"	"	Sep. 1985
	#4	"	950	"	"	Apr. 1986
Wolsung	#1	PHWR	678.7	AECL	NEI Parsons	Apr. 1983
	#2	"	700	AECL/KHIC	KHIC/GE	(Jun. 1997)
	#3	"	700	"	"	(Jun. 1998)
	#4	"	700	"	"	(Jun. 1999)
Young-gwang	#1	PWR	950	WH	WH	Aug. 1986
	#2	"	950	KHIC/CE	KHIC/GE	Jun. 1987
	#3	"	1000	"	"	Mar. 1995
	#4	"	1000	"	"	Jan. 1996
	#5	"	1000	"	"	(Jun. 2001)
	#6	"	1000	"	"	(Jun. 2002)
Ulchin	#1	PWR	950	Framatome	Alsthom	Sep. 1988
	#2	"	950	"	"	Sep. 1989
	#3	"	1000	KHIC/CE	KHIC/GE	(Jun. 1998)
	#4	"	1000	"	"	(Jun. 1999)

( ) : Under construction

Long Term Power Development Plan

It is expected that the annual growth rate of the demand for electricity in Korea will average 8.5 percent between 1995 and the year 2000. The average growth rate from 1995 to 2010 is expected to be 5.9 percent per annum. As a result, the power development program of 1995 stipulates the addition of new generating facilities of some 47,367 MWe by the year 2010. Among them, 17,713 MWe will come from nuclear energy.

In the long term nuclear power development plan, the Korean standard nuclear power (KSNP) plant and the Korean next generation reactor (KNGR) plant will be the major options, and 900 MWe PHWRs will be alternative nuclear power sources. The KSNP plant is a 1,000 MWe PWR unit and the KNGR plant is a 1,300 MWe PWR. When the program is completed, the total installed power capacity should be 79,551 MWe.

The current capacity ratio between nuclear, fossil [coal, oil, and liquified natural gas (LNG)], and hydro sources is 29:62:9 respectively. This ratio will be 33:59:8 in the year 2010. The share of electricity produced by nuclear power will increase to 46 percent in 2010 from the current level of 36 percent.

Table 2
Long Term Power Development Program

Source	1995	2000	2005	2010
Nuclear	8,616 (26.8)	13,716 (26.0)	18,716 (27.5)	26,329 (33.1)
Coal-fired	7,820 (24.3)	15,825 (30.0)	22,025 (32.4)	21,700 (27.3)
LNG-fired	6,736 (20.9)	14,201 (26.9)	16,214 (23.9)	22,014 (27.7)
Oil-fired	5,919 (18.4)	5,135 (9.8)	5,495 (8.1)	3,525 (4.4)
Hydro	3,093 (9.6)	3,878 (7.3)	5,483 (8.1)	5,983 (7.5)
Total	32,184 (100)	52,755 (100)	67,933 (100)	79,551 (100)

Technology Development

Nuclear power history in Korea can be divided into three stages. During the first stage, nuclear power plants were constructed on a turn-key basis. In turn-key construction, the reactor vendors were responsible for the entire project, from design, engineering and construction to the startup and turnover of the plant to the owner. The first three nuclear units were built on this turn-key basis.

In turn-key contracts, the opportunities for technology transfers were very limited. Also, the participation of domestic companies were limited to site preparation work. In other words, Korean companies participated as subcontractors of foreign contractors to provide small portions of field design, equipment supply and construction. In order to develop a stable energy infrastructure that was less reliant on foreign technology, it was widely recognized that Korea should become as self-reliant as possible in nuclear power technology.

In the second stage, KEPCO took responsibility for project management along with the direct procurement of balance of the plant equipment. Contracts for supplying Nuclear Steam Supply System (NSSS), Turbine Generator (T/G), and engineering services were made with foreign contractors. Korean contractors took responsibility for site construction, while other Korean companies were strongly encouraged to expand their roles in engineering services and equipment supply. Six units of 950 MWe were constructed under this approach, which significantly strengthened Korea's capability to construct nuclear power projects using domestic resources.

The third stage of nuclear power development started with the goal of finalizing the nuclear technology self reliance program. This program has been in effect since the construction of Younggwang units 3 and 4, with Korean industries as prime contractors. KEPCO has been in charge of project management and technology transfer. Several other domestic organizations have participated in plant design, construction and management, with assistance from foreign subcontractors. All Korean organizations and entities which have participated in the nuclear power program have improved their capabilities through technical on-the-job involvement in all disciplines of nuclear power technology.

Additionally, KEPCO has pursued the standardization of a nuclear power plant design, pursuing technological self-reliance and localization. KEPCO has developed the design basis for a KSNP plant, reflecting operating experience from existing nuclear power plants and the proven technologies used in the Advanced Light Water Reactor (ALWR) program in the U.S.A.

The commercial operation of Younggwang units 3 and 4 signified the beginning of a new era of technological self-reliance in Korea's nuclear industry. The Younggwang units will serve as basic models for the development of the KSNP. The KSNP plant design is now applied to the construction of Ulchin 3 and 4 and Younggwang 5 and 6. It will be also applied to subsequent PWRs, including the two units in North Korea, until the development of the KNGR.

In 1992, the Korean government and KEPCO launched the KNGR project to develop a standardised advanced light water reactor based on previous experience acquired through the KSNP's design and technological self reliance program. The KNGR project's goal is to complete a standardized KNGR design by February, 2000. This project will be applied to new nuclear projects which are anticipated to begin operation in 2007.

Developing a new design for nuclear power plants requires a great deal of resources and experience, and an integrated project has been organised to maximize all experience and technology shared within Korea's nuclear industry. The KNGR design will meet the enhanced safety requirements and economic goals of future nuclear power plants in Korea, particularly with regard to investment protection and accident prevention.

International Cooperation

By joining several owners groups set up by utilities operating and constructing the same type of reactors, KEPCO is continuously making efforts to improve plant safety and availability. KEPCO has been affiliated with international organizations such as the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO), in order to exchange information in the nuclear field. KEPCO is also participating in various international cooperative activities for the promotion of nuclear energy development through the International Atomic Energy Agency and inter-governmental nuclear cooperation agreements.

In addition, KEPCO has made technical cooperation agreements with thirteen foreign utilities or nuclear organizations from eight countries to promote technological development, information exchanges, and training. Based on the agreements' frameworks, various cooperative activities are being executed, including periodic meetings and regular exchanges of information.

Based on KEPCO's accumulated technology and international confidence building through its success in providing local electricity, KEPCO is now expanding its operational sphere to include the global community. Also KEPCO is laying the foundation for global operations in the Asian region, where the demand for electricity will increase rapidly.

In December 1993, KEPCO signed its first international contract for engineering services for the maintenance of Guangdong nuclear power plant in China. In February 1995, KEPCO signed a memorandum of understanding with China National Nuclear Corporation (CNNC) for a technical and economic joint study for the construction of nuclear power plants in China.

This year, KEPCO made an agreement with the Chinese government for a joint study on the construction of Shandong Haiyang Nuclear Power Plants, and also provided Quinshan Nuclear Power Company (QNPC) with consulting services for the contract between QNPC and AECL in Canada for the Quinshan Phase III project in China. Korea is stepping up its efforts to build a cooperative relationship with the Asian countries in various fields for the peaceful use of nuclear energy. KEPCO is also pursuing cooperative joint ventures with advanced foreign suppliers such as ABB-CE in the USA and AECL.

Conclusion

Nuclear power has contributed greatly to diversifying energy resources, lessening dependence on energy import, and improving environmental conservation in Korea.

Considering the current energy situation, Korea will continue on the chosen nuclear power path. KEPCO will make every effort to ensure safer and more economic nuclear power plants through technological development and international cooperation programs. With much experience accumulated over the last two decades, Korean industries are now ready to contribute to our neighbors' nuclear power programs.

NUCLEAR POWER DEVELOPMENT: THE INDIAN EXPERIENCE

Y.S.R. Prasad

The total energy consumed in India, both commercial as well as non-commercial form per capita is around 380 KgOe. Forty percent of the energy (non-commercial) is derived from bio-fuels, such as, fuel wood, crop residue and animal waste. Thus the primary commercial energy per capita consumption is about 235 KgOe. The energy demand has grown at about 9 to 10 percent in past decades and is expected to grow further at a rate of 6 to 7 percent per year up to 2020.

The India's population has grown from a mere 300 million at the time the country gained independence to 940 million (1996) and with the projected growth rate, it is expected to double by 2027 and attain hypothetical stationery level of 1880 million. India has made rapid strides in capacity addition. The installed capacity has risen to 86,000 MWe from a mere 1400 MWe at the time of independence.

The present installed capacity is about 86,000 MWe (utility and nonutility) constituting thermal 73 percent, hydel 25 percent and nuclear 2 percent. The country's per capita electricity consumption is 310 kwh, which is very low, and is 40 times less than that of Latin American countries and 8 times less than that of world average. As per the projection made by various agencies based on certain assumptions, an installed capacity of about 400,000 MWe will be required by the year 2020. However, a minimum capacity of 200,000 MWe is required to be set up by the year 2020, for maintaining sustenance at present levels.

Energy Resources

India is poorly placed in terms of world energy resources. While 16 percent of world population lives in India, only 0.6 percent of oil and about the same portion of gas reserves exist in the country. However, India is endowed with 6 percent of coal reserves of the world. India is a net importer of energy. As per the present projections the proven reserves of coal are expected to last for 100 years. The oil and gas would last for 24 and 23 years, respectively. Moreover, oil, gas and coal also have nonenergy uses. The hydel and coal reserves are concentrated in certain regions of the country.

Based on the uranium resources available in the country, it will be possible to build a maximum of about 10,000 MWe of Pressurised Heavy Water Reactor (PHWR) capacity. However, by adopting the fast breeder

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Based on the uranium resources available in the country, it will be possible to build a maximum of about 10,000 MWe of Pressurised Heavy Water Reactor (PHWR) capacity. However, by adopting the fast breeder technology, it is possible to build a nuclear power capacity of about 300,000 MWe by using vast resources of 360,000 tons of thorium.

As the projected demand is considerably high, there is a need to diversify energy resources. However, nuclear power will have to play an increasingly important role in long term energy management. An installed capacity of about 10 percent by the year 2020, i.e. 20,000 MWe should be added by nuclear power.

India's Nuclear Power Programme

Indian nuclear power programme commenced with the construction of Tarapur Atomic Power Station (TAPS-1 and 2) with 2 x 160 MWe (present capacity) Boiling Light Water Reactors (BWRs), using enriched uranium as fuel and light water as moderator and was set up in 1969, on a turn-key basis by General Electric Company. These two units were set up essentially to demonstrate the technical viability of operating them within the Indian regional electric grid system, which was at that time relatively small. These units also helped us to gain valuable experience in operation and maintenance of nuclear power plants. After more than twenty five years of safe and successful operation, these reactors are still in service, providing much needed electricity to the western grid.

From the very beginning, as a long term strategy, the nuclear power programme formulated by Dr. Bhabha, embarked on a three stage nuclear power programme linking the fuel cycles of PHWR and Liquid Metal Fast Breeder Reactor (LMFBR), was planned for judicious utilisation of our limited and low grade (less than 0.1 percent U_3O_8) uranium ore (78,000 tons) but vast thorium resources. The emphasis of the programme was self reliance and thorium utilisation, as a long term objective. India has selected PHWR, because of several inherent advantages. PHWR uses natural uranium as fuel, natural uranium being easily available in India, helps cut heavy investment on enrichment, as uranium enrichment is capital intensive. Another reason is that the natural uranium requirement for PHWR is the lowest and plutonium production is highest. Finally, the infrastructure available in the country was suitable for undertaking manufacture of equipment for PHWR Reactor.

The three stages of India's nuclear power programme are:

Stage-I envisages construction of natural uranium, heavy water moderated, PHWRs. Spent fuel from these reactors is reprocessed to obtain plutonium.

Stage-II envisages construction of Fast Breeder Reactors (FBRs) fueled by plutonium produced in Stage-I. These reactors would also breed U-233 from thorium. It is also planned to develop an Advanced Heavy

Water Thermal Reactor (AHWR), as an extension of Stage-I PHWR programme. The AHWR, using a Pu-239 enriched uranium fuel in the driver (booster) zone and U-233 enriched thorium fuel in the driven zone, would generate a large part of its energy output from thorium through fission of insitu bred U-233.

Stage-III would comprise power reactors using U-233/thorium as fuel.

In order to be self-reliant in the field of nuclear power generation, the Department of Atomic Energy, opted for "CANDU" technology in collaboration with the Atomic Energy of Canada Limited, and commenced construction of a power station comprising two units of 220 MWe at Rawatbhata in Rajasthan in 1964. The CANDU technology involved the use of natural uranium as fuel and heavy water as moderator. To achieve self sufficiency in this field in the long run, the Department of Atomic Energy established facilities for fabrication of fuel and zirconium alloy components, manufacture of precision reactor components and production of heavy water. Momentous efforts were put in to develop manufacturers in the country to produce components like calandria, end shields, steam generators, fueling machines, nuclear pumps and other critical equipment required for setting up of nuclear power stations, conforming to international nuclear standards. Development of world class manufacturing facilities in public and private sector organisations was achieved.

The Rajasthan units were followed by two more units at Kalpakkam near Madras. Thus, the first stage program with short term goals of complementing generation of electricity at location away from coal mines progressed steadily. The erstwhile Nuclear Power Board was incorporated as Nuclear Power Corporation in 1987 with an aim to accelerate the first stage of the nuclear power programme, by having access to finances from the market.

With the evolutionary changes taking place with the development of the nuclear power plants to meet seismically qualified equipment and systems coupled with new safety criteria, improved designs were developed and implemented at the Narora Atomic Power Plant (NAPP) in Uttar Pradesh. The 220 MWe design was also standardised. The innovation and improvements implemented at the nuclear power plant involved considerable efforts in research and industrial infrastructure in the country. India had to achieve this by itself in view of various embargoes it faced and still faces in several technologies concerned with nuclear power.

The successful commissioning of Narora Atomic Power Station (NAPS) established total capabilities for design, construction, fabrication of equipment, operation and maintenance of nuclear power plants in India. In the process, a good industrial infrastructure has been created in the country for nuclear power programme. Self-reliance has been established in the reactor technology in all its aspects. Subsequent to Narora, two more atomic power stations at Kakrapar have been built and commissioned in the shortest possible time, using the indigenous technology. By successful commissioning of KAPS, Kakrapar, it was once again demonstrated that India had matured in this technology and is fully capable of exploiting it. This also established nuclear power as a safe, environmentally benign and economically viable source of power generation, its cost comparable with coal based thermal plants.

With the second unit in KAPS at Gujarat, achieving commercial operation from September, 1995, the Nuclear Power Corporation of India Limited has attained an installed power capacity of 1840 MWe. Presently, four units of 220 MWe, namely, Kaiga-1 and 2, near Karwar and RAPP-3 and 4 in Rajasthan, are in the advanced stage of construction.

Enhancing Growth

With a view to augmenting the growth of nuclear power and PHWR system, and also eventually realise economies of scale, it was necessary to design a larger PHWR system, and the 500 MWe PHWR was evolved to fulfill this need. The design for 500 MWe is ready, and is well set to proceed with the construction of 500 MWe PHWR units, with the first units at Tarapur. Sites for setting up of 6 X 500 MWe (PHWR), (4 units at Rajasthan and 2 at Tarapur) and 4 X 220 MWe (Kota, Rajasthan), have been cleared and advance action for developing infrastructure and procurement of long delivery items has been taken up.

The nuclear power programme in India has addressed all aspects that are of concern to the public which mainly relate to safety, and management of high level and long lived radioactive wastes. Safety standards followed in nuclear installations are high and generally in line with that of international norms. All the technical aspects associated with the handling of the wastes have been addressed.

Both the old (Tarapur, Rajasthan and Madras) and new generation nuclear power stations (Narora and Kakrapar), have performed very well attaining cumulative life time capacity factor near to normative value and selling power at competitive rates. Recently, the nuclear power plants crossed the generation of one lakh million units mark. The 120 reactor years of operating experience has been free of any incident leading to release of radioactivity into the environment. While operating these plants, a number of challenging maintenance activities have also been handled successfully by developing indigenous technology.

A beginning has been made for the second stage of nuclear power program with the setting up of a Fast Breeder Test Reactor (FBTR) at Kalpakkam, and recent commissioning of a 30 KW research reactor "KAMINI," which uses uranium 233 as fuel. It is planned to set up one unit of 500 MW(e) prototype FBTR, and its design is in progress.

India has also mastered fuel cycle technologies, from mining to fabrication of natural uranium fuel, fabrication of enriched uranium fuel, reprocessing technology, and fabrication of plutonium and thorium based fuel required for the future program. All the technological aspects related to short term and long term storage of nuclear waste have been appropriately addressed. The related waste management facilities have also been satisfactorily developed.

To summarise, the concerted efforts put in by Department of Atomic Energy (DAE) and its constituent units together with Indian industries and institutions have led to development and full capabilities to design, manufacture equipment, construct, operate and maintain nuclear power plants. Today, India is among the select band of few countries of the world who have developed such capabilities. India's nuclear power programme has now matured as a safe and economical option for not only meeting the country's power demand, but also can embark on exporting the technology, and it is poised technically for an accelerated pace of growth.

Notwithstanding the indigenous developments, the light water reactors have been the mainstay of nuclear power programmes in most countries. These were offered as possible international projects in the past. Presently, India is considering the offer by Russia for two 1000 MWe VVERs to be built by 2008-2009. Similar additions to our nuclear power programme in terms of additional LWRs of advanced designs from international projects can be considered to augment nuclear power programme in the coming decades, assuming that the terms of offer are appropriate to the Indian context.

Problems Confronted

In most countries, development in the nuclear power sector have been achieved by international cooperation supported by funding credit. However, the innovations and improvements incorporated by India in its standardised 220 MWe PHWR (Narora onward) involved considerable efforts in research and development, as well as technological improvements in the industrial infrastructure in the country due to various embargoes. It is because of this that earlier plants took somewhat longer periods of gestation. India is also facing similar difficulties in developing technologies for in-service inspection, life extension programmes and spares for imported plants.

India is in a position to develop all related technologies and recent coolant channel removal work from Unit-2 of Rajasthan, within a reasonable time and manrem consumption, has amply demonstrated our capabilities.

Nuclear power, which has proved to be a cleaner source of power and is not associated with emission of any harmful gases associated with global warming and acid rain, is expected to play a significantly larger role in meeting electricity demands. It is worth mentioning that nuclear power generation in any part of the globe will not only serve that region, but should be considered as an essential element in the global energy policy.

Programme Needs

The country's nuclear power programme has not grown due to the financial crunch. Unlike other infrastructure, proposals to set up nuclear plants with foreign technology and soft term loans from the international financial institutions, is not available for the nuclear sector due to technology regime controls. Financial borrowings from the domestic market are for a limited period of five years only. It is too short a period considering the gestation period for power plants, even at the international level. This also leads to a vicious circle where further borrowing becomes inevitable to pay the previous debts, especially, when new capacities are to be added. For a nuclear power station, it takes 10 to 12 years to repay the loans after commencement of operation of plants. Long term financing from the pension fund / provident fund, and similar such funds, should be considered.

So far, nuclear power has been owned and largely funded by the Government of India, with limited finances from the public, in the form of short term maturity period bonds. The programme has been implemented by the Nuclear Power Corporation (NPC) and Department of Atomic Energy(DAE). The nuclear power programme in India could not grow at the desired pace due to the financial crunch and limitation of borrowing money from the public. However, in view of the larger role which nuclear power has to play in the future, it has become imperative to consider various other options and possibilities of implementing the programme.

The Indian Atomic Industrial Forum (IAIF), an association of NPC, DAE and its other constituent units, nuclear industries, R&D organisations, and consultancy and financial institutions, has been launched recently with a prime objective of working on various options for accelerated implementation of the nuclear power programme. Various options which can be considered are:

a) Loans from industries in the form of supplier's credit
b) Equity participation from private parties, both Indian and foreign
c) Joint ownership, with NPC/DAE being responsible only for the

nuclear island of the project and the entire conventional and utility system resting with the other partner.

d) Entire project management together with (c) above, and further operation of the plant with similar areas of demarcation.

The Indian Atomic Industrial Forum would also establish and enhance coordination with the developing and developed countries in the areas of nuclear science, technology and power by providing mutual cooperation, and technical assistance. The Forum would also establish and maintain close contact with various international agencies and industrial groups and organisations engaged in similar activities, and with countries already having a nuclear power programme or planning to have one.

COMMENTS ON NUCLEAR POWER DEVELOPMENT IN JAPAN

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In June 1994, the Atomic Energy Commission of Japan formulated and issued its new long term programme for research, development and utilization of nuclear energy. First conceived in 1954, the policy has been revised seven times in order to take stock of developments and changing energy circumstances. The last one was issued in 1987.

The latest policy statement is designed with a view toward global society in the 21st century and the role that nuclear energy may play. Its assumption is that given increases in world population, energy consumption and resource constraints, along with environmental problems and international movements, nuclear energy is capable of significantly contributing to sustainable global development. The programme generally outlines the course for Japan to follow up to 2030 and treats in greater detail the requirements for the period until 2010.

A major goal in Japan's utilization of nuclear energy is to secure reliable energy supplies. Two so-called "absolute premises" identified are adherence to the principles of peaceful use only and assurance of safety. A number of criteria guide the overall programme. Work is undertaken on the basis of promoting nuclear fuel recycling, taking into account Japanese and world situations. The programme seeks to establish a consistent system of light water nuclear power generation. It is also committed to diversification in nuclear technology development as well as the reinforcement of basic research capabilities.

Power Generation in Japan

By 1996, 20 percent of Japan's total power requirements were being met with nuclear power. Thermal power at 60 percent and hydro power at 21 percent provided the remainder. The growth of nuclear power in Japan is expected to be strong well into the future. The following table provides the projected growth of nuclear power in the country.

Table 1
Expected Growth of Nuclear Power in Japan

1996	42,547 MW
2000	45,600 MW
2010	70,500 MW
2030	100,000 MW

To meet the above projections, Japan's power station capacity is expected to expand from current capacities as described in the table below:

Table 2
Nuclear Power Stations in Japan

Operating	50 Units (42,547 MW)
Under construction	3 Units (3,361 MW)
Planning	2 Units (1,925 MW)
Candidate	21 Units (27,324 MW)
R&D	2 Units (445 MW)

The Japan Atomic power Company has been at the forefront of power generation, with its Tokai power station being Japan's first commercial nuclear power plant. Tokai No.2 was Japan's first large scale nuclear power plant. In addition, the Tsuruga station's unit 1 was Japan's first nuclear power plant with light water reactor technology.

SUMMARY OF ROUNDTABLE ON CONFIDENCE BUILDING

This essay is an abridged summary of the discussions on the confidence building exercise. The existing global scene presents an ideal situation for undertaking confidence building exercises in light of past rigidities breaking down with the end of the cold war. Confidence building measures (CBMs) constitute building blocks which could provide operational substance to the notion of common or cooperative security. CBMs may in fact be viewed as techniques for gaining results without war.

CBMs can be classified into two categories, military and nonmilitary. The functions of military CBMs relate to communication, information, verification, observation and monitoring, stabilization and regulation of military arrangements and crisis management. The nonmilitary CBMs cover areas such as collaboration in science and technology, free movement of people and ideas, and exchange of views and analyses. Confidence building through technical cooperation can pave the way for dealing uniquely with more intractable political issues or at least diffuse such issues. In the current era of global interdependence in which India is increasingly getting linked through its economic and technological liberalisation and globalisation policies, isolating or punishing a country through embargoes is counterproductive and ultimately not sustainable. Rather than using technology as a weapon, it could be used to bind nations together. CBMs tend to be slow institutional processes that may take decades to provide results and the process needs political will, meaningful cooperation and patience.

The purpose of the Seminar's Roundtable was to explore areas where mutual cooperation between states would prove fruitful and successful in various areas of nuclear technology. Participants offered a range of comments, some more directly focused on confidence building than others.

One participant commented on the relevance of nuclear power and how to meet India's growing energy requirements. In this sector, it was felt that there is an opportunity for cooperation between India and the U.S., as well as other Asian countries in particular. The need to evolve cooperation on technological aspects was emphasised. In this connection, this participant pointed out that despite certain Indian perceptions regarding U.S. intentions, American policies in the technology realm are not just targeted against India. It was suggested that the number one target of United States is Japan and that the future direction of Japanese defence policy depends on whether and to what degree, the political circumstances that currently limit Japanese military power change. According to one school of thought, Japan will inevitably correct the imbalance between its military and economic power. According to this participant, it is clear that the use of technology should play an important role in strengthening the economy of any nation, and a strong plea was made that there should not be any hindrance for any state in transfering technologies to other states.

It was the view of another participant that the time had come now to form small working groups and discuss five or six key questions and discover where the commonalities lie, especially between India and the U.S., and see whether the differences can be resolved. This would provide a specific way of moving beyond the more general concerns which are inevitably raised in the broader settings of seminars or conferences. It was argued that after the end of the cold war, a series of changes in both the American foreign and military policy decision making system and information gathering system have taken place. It was noted that this has resulted in an information gap between the more generalist strategic decision makers versus regional specialists on Indian strategic thinking, both inside and outside the government, which if not somehow corrected, could have an adverse impact on actual policies formulated.

One participant called for much more consistency between the rhetoric and actions of states. In this connection, it was stressed that the intentions of the U.S. regarding its policies toward India in particular, and South Asia in general, should be transparent. One impediment to collaboration in technology has been the enduring communication gap between scientific communities and the policymaking bodies and bureaucracies. It was suggested that confidence building should start with trying to achieve a common understanding among scientists. Moreover, it was urged that the roots of misunderstandings should be explored before setting off into an era of mutual cooperation.

One of the participants emphasized the challenge of developing nuclear energy safely, which will require cooperation at a global level. While technical alternatives to produce nuclear energy without the production of weapon grade fissile material need to be pursued further, given the vast resources necessary, larger pools of funds have to be made available. In this case, the common good which may result needs to be balanced against narrower commercial/economic interests.

Another viewpoint presented in the confidence building exercise focused on the changing global scenario. It was felt that the time has now come to replace old ideas and old relationships with fresh thinking. According to this participant, the fact is that India is not on the top of the U.S. list of concerns and vice versa. India is neither an enemy nor a major concern for the U.S. Moreover, it was felt that it is very difficult to even understand a country like India. It was argued that there are a lot of contradictions in its policies. For this participant, it is difficult to comprehend at times why India, in keeping its own options open which it is free to do, feels that plans, efforts and regimes established by other countries to promote their security are a threat to India. For example, India made it very clear throughout the years that developing countries should have access to nuclear technology and that is what Article IV of the NPT is aimed at. But, on the other hand, India was against the indefinite extension of the NPT. In considering India, it was pointed out that although India was the pioneer of the Gandhi Plan, it has now become its opponent. The same is the case with the CTBT proposal. The participant posed the question whether it is really in India's interests to have more nuclear weapon states.

During the Roundtable, the participant speaking on the U.S. stockpile stewardship and management programme reiterated that it is still a work in progress, but suggested that some of the same techniques can be applied in India's case to maintain a very robust nuclear weapon capability without recourse to nuclear explosive tests. In this connection, it was pointed out that a non NPT state or nuclear threshold state like India would be especially concerned about getting four things right in the design of nuclear weapons, which were then explained as hydrodynamics, neutronics, timely initiation of the fission chain reaction and estimation of yield. For example, hydrodynamic behaviour of a device during the assembly phase can be predicted by well established computer modeling techniques and confirmed experimentally by hydrodynamic testing. The behaviour of implosion systems design with fissile Pu-239 or highly enriched uranium cores can be investigated at reduced scale to avoid criticality. And finally it was suggested that the full scale implosion system designs can be tested with non-fissile cores made of U-238 or 80 percent Pu-242.

Another participant pointed out that the subject of nuclear cooperation was not just CBMs between India and the U.S. or India and other countries, but needs to be seen within the context of the entire gamut of nuclear cooperation. It was argued that the gap in perceptions between states is wide and real. Moreover, while all countries and political leaders use rhetoric, it was felt that a major problem in Indo-U.S. relations is that India treats much of U.S. rhetoric as policy, and the U.S. treats India's policy formulations as rhetoric. To rectify this problem, both countries require much greater dialogue and understanding. It was asserted that while cold war mindsets have not fully dissipated, the new foreign policy agenda of the Clinton administration should be carefully studied.

In connection with the Clinton administration's ostensible policy of capping, reducing and eventually eliminating, nuclear capabilities in South

Asia, especially targeting India's missile and nuclear policy, it was argued that India will not accept denuclearisation under the rubric of a global or regional nonproliferation policy. It was felt that India will maintain its nuclear weapon status, either at a "recessed deterrence" level, or if pressures to de-nuclearise continue, at a "minimum deterrence" level. The challenges for cooperation therefore, should be viewed in this context. The longer it takes to establish a dialogue, the more difficult it will be to arrive at mutually acceptable arrangements for cooperation.

Further, one participant presented a series of options for building nuclear cooperation focused on Indo-U.S. relations. These included more open trade and investment in the nuclear power sector which will require requisite modifications in export control regimes. As an interim step, a strategic arms reduction treaty between India and the five nuclear weapon states was proposed to limit the size of arsenals, range and numbers of delivery systems.

An additional option, seen as the most difficult to achieve, but likely to offer the maximum pay-offs to all was also put forth. This included India and the west on the same side of nonproliferation on the assumption that India will accept restraints and nonproliferation regimes, while concurrently, the U.S.-led west will accept the reality and sustenance of India's nuclear weapon status. A protocol to the NPT could be signed by India which commits India to all provisions of the NPT regarding transfer of technology and Article VI, and India in return, could be allowed to have access to nuclear technology, trade and investments.

According to another participant, a major problem in reaching understanding in the nuclear field is the existence of double standards in policy making. It was underlined that any agreement reached by persuasion only will last. It was suggested that one of the urgent needs regarding confidence building in the nuclear field, is to have a no first use commitment from all the nuclear weapon powers. This should be the starting point for discussions on elimination of nuclear weapons. In moving toward global nuclear disarmament, as a practical matter, states have to be convinced of the declining utility of nuclear weapons. As long as nuclear weapons states retain the right of first use, as many important ones are continuing to do, the argument exhorting a country to give up its nuclear option is considerably weakened. The participant concluded that no first use, especially in the post cold war era, is something around which the international community must strive to reach a universal consensus.

SUMMARY OF SELECTED DISCUSSIONS

On the basic question of India's strategic perspective, there was general agreement by the Indian participants that the CTBT debate had clarified India's thinking on the continued need to keep India's nuclear option open. Some participants were of the view that India and the U.S. need to shed their tendency for the "normative approach." For example, the U.S. claims that nonproliferation has now become the international norm whereas India argues that elimination of all weapons of mass destruction must be the norm. This rigid approach is seen as making it difficult to resolve the nuclear question.

In this view, India is faced with tough choices similar to what China had to go through earlier. Both attempted different sorts of alliances and associations but ultimately realised they had to rely on their own means, because they were too large to fit into bigger alliances. This leaves out the alliance option for sorting out the security balance. It was pointed out that China used left wing internationalist super power hegemonism to justify its own position. India argues liberal international principles. But significantly, China successfully gate crashed into the nuclear club whereas India has been indecisive. While the thinking surrounding the CTBT has led to a new articulation of "national security," it has not removed the traditional focus on disarmament. Ironically it is India which continuously hovers around the threshold status, which invites the full wrath of the global nonproliferation regime.

Another Indian perspective was that despite the clarity on national security gained through the CTBT debate, India's past emphasis on disarmament has not changed. The reason, according to this participant, is that disarmament is in India's national security interest. Thus India presses for disarmament not because it is anti-America or as opposition to someone else, but because it is a national security goal. However, there was some agreement that Russia and China may not see nuclear disarmament as in their national security interest for a long time.

There was some division on the probability of U.S. moves toward nuclear abolition, with an American participant presenting an optimistic scenario against a much more skeptical Indian interpretation. The participant suggested that one of the reasons for Indian skepticism was that the conclusions were deductively reached, based on a paradigm of realism governing international relations. In response, it was pointed out that in empirical terms, the trend did not show any real shift from realism thus far.

Some discussion took place on whether a purely technical solution could be found for getting around the proliferation problem. The discussion began on the use of weapons plutonium for power production. The issue of the U.S. obtaining Russian origin highly enriched uranium (HEU), denaturing it and using it in U.S. reactors was raised, especially in the context of America holding enormous stockpiles of plutonium which could as well be used for this purpose. The point was made that the concern regarding reprocessing, lack of enthusiasm in the U.S. for utilising plutonium for power production, and political pressures have all dampened the developmental efforts of other countries as well. The U.S. expert explained that the nonuse of plutonium is based on its poor economics. While molten salt reactor (MSR) and fast breeder reactor (FBR) have had successful developmental history, their commercialisation history is rather poor. They are unlikely to be competitive in the energy market for at least the next fifty years, during which period more and more of weapon plutonium will find use as energy source.

Some discussion followed on economics and technology development costs and a point was made that earlier technology development costs relating to thermal reactors were underwritten by the U.S. defence department which made it appear as though the development costs were lower. One of the U.S. delegates explained that the U.S. gave up FBR development after spending approximately 12 billion dollars and that it was no small amount. In response the Indian delegate pointed out that the U.S. views on plutonium will be coloured by its own national interest and perceptions. For India which has no access to presently cheap (global) uranium market, and limited uranium resources, but abundant thorium, there is an absolute need to reprocess and push ahead with breeder programmes. Certain other delegates stressed the need to increase the nuclear share in energy production, especially in the context of growing environmental concerns.

In this connection, one area which generated much discussion related to nuclear energy development, especially lessons from the South Korean experience. Several questions were raised on the South Korean programme regarding fuel cycle time, spent fuel storage, costs, and dependence on fuel from outside sources, particularly with reference to the security of supply. The South Korean respondent noted that while they would like to establish total fuel cycle capability and also close the fuel cycle, they are unable to do so due to perhaps political considerations. Currently, they do not have enrichment and reprocessing facilities. They import fuel and store the spent fuel at the station sites. Some details of the programme were also given including the capital cost per KW (1800 U.S. dollars); the unit energy cost per KWH (3 cents); the fueling interval (15 to 18 months); and refueling outage time (30 to 45 days).

Discussion followed on the growth of nuclear power in South Korea and possible effects from the slowing down of growth from the year 2000. A comparison was made to France where huge investments in infrastructure and manufacturing facilities built for a large programme could not be effectively utilized after the country achieved the target of over 80 percent, at the same time that there was a slowing down of nuclear power programmes globally. In response, it was pointed out that there are several countries like the Philippines, Vietnam, North Korea and Indonesia in the region which needed power and an effort could be made to establish collaboration, with India also participating. One of the Indian delegates felt that under the pretext of proliferation, development and cooperation in the area of nuclear power is being curbed in Southeast Asia. On the question of the use of irradiated fuel from light water reactor as a feed in heavy water reactors, the Korean respondent noted that discussions are still on with the U.S. and Canada but that details are unavailable.

Regarding why South Korea chose two different reactor types i.e. pressurised water reactor (PWR) and pressurised heavy water reactor (PHWR), the response was that despite capital and unit energy costs of PHWRs being higher, the source and conditions of funding and political considerations (involving U.S., U.K., Canada) could have been responsible for deciding on the type of reactors. On the subject of South Korea providing nuclear reactors to North Korea, some participants were critical of the policy of rewarding a Nuclear Nonproliferation Treaty violator which will send the wrong signal. One of the U.S. participants explained that the deal struck was in the interest of North Korea giving up its reprocessing plan, and hence achieving a broader nonproliferation objective.

Turning to the Indian programme, discussion focused on long term planning, the reasons for slow progress, safety, the three stage programme starting with PHWR and fast breeder and thorium utilisation. The Indian expert explained in detail the reasons for the slow progress, the great emphasis on the safety culture, and development of advanced heavy water reactors. There were comments on the plant load factor (PLF) being on the lower side. In response, data was provided to indicate good improvements in the PLF over the past few years which has resulted in life time capacity factors touching around 60 percent. The reasons for PLF being lower in comparison to the world average was also explained. It was categorically stated that the problems are more related to conventional areas, but also that given the need to totally indigenise nuclear power production, this is the price one has to pay for such efforts. The benefits that accrue in terms of upgrading indigenous technologies and quality were also pointed out. Some discussion also took place on the Indian energy policy, the tariff structure, privatisation and the need for government to fund nuclear power.