MIT Project on
Promoting Nuclear Stability in South Asia

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South Asia continues to be a volatile region marked by political instability, terrorism, and a shortage of democracy. All of the countries in the region – India, Pakistan, Afghanistan, Bangladesh, Sri Lanka, Nepal, and Myanmar - have varying degrees of continuing violence, and social and political instability. Although India maintains a solid democratic posture, it is challenged by armed insurgencies in certain parts. Pakistan is in the midst of a transition toward a multi-party democracy. Also, the unresolved Kashmir issue continues to both hamper genuine progress in the development of friendly relations between the two important countries in the subcontinent and take its toll both in terms of human lives and resources.

U.S. President Bill Clinton a few years ago described South Asia as the most dangerous place on earth – an allusion primarily to the presence of nuclear weapons in the region during the so-called Kargil crisis in 1999. A major catastrophe was avoided and tensions have abated a great deal since then.

In the wake of the tragic earthquake in October 2005 in Muzaffarabad, which was the capital of the Pakistan-controlled region of Kashmir, both countries cooperated in providing humanitarian relief to the thousands of victims – many of whom had close relatives in the Indian part of Kashmir.

In the past several years, progress has also been made in the bilateral dialog between Pakistan and India on nuclear confidence building measures. A significant agreement was reached on a pre-flight notification of ballistic missile launches. The two countries have also negotiated an agreement to reduce the risk of accidents related to nuclear weapons.

However, progress is slow and subject to many external factors. For example, immediately after the multiple train bombings in Mumbai in July 2006, which killed scores of people, all such talks were cancelled by India and tensions rose significantly. India has accused Pakistan-supported terrorist groups of masterminding the terrorist attacks, while Pakistan has rejected such claims.

President Pervez Musharraf of Pakistan and Prime Minister Manmohan Singh of India made a joint statement following their meeting at the Non-Aligned Movement Summit in Havana in September 2006 vowing to carry the peace process forward.

As a sign of the further warming of the relations, just a few days ago, a historic truck route across the border in Wagah was reopened for the first time since partition 60 years ago. This was once an ancient trade route, dating back 600 years and linked India to Afghanistan and Central Asia. Trade between the two countries could reportedly reach $6 billion a year from a paltry $1 billion or less currently, if both sides ease restrictions.

Conventional arms building in South Asia also continues adding to tension as both India and Pakistan embark on purchases of advance military aircraft, submarines, radars, and surveillance systems, among others. The two states are also continuing their large missile programs that include cruise missiles. India is considering acquiring missile defense systems such as the U.S. Patriot Advanced Capability and the Israeli Arrow, while at the same time pursuing an indigenous ABM program. It has recently announced a "successful" test of the system.

In the mean time, the U.S.-India nuclear - signed in July 2005 - is in the final stages of negotiations before a up or down vote in the U.S. Senate. While it is experiencing some rough weather in the Indian Parliament, and may also have difficulties in the Nuclear Suppliers Group, the chances of its eventual approval seem reasonable. The implications for both the non-proliferation regime and nuclear stability in South Asia, although not clear, are likely to be negative.

Government-to-government dialog between the two countries is subject to many external factors and has a checkered history. It is essential therefore that other means of communication remain open between the two countries, especially those involving scientists, arms control experts, and policy analysts including government officials.

With this perspective, we launched the project *Promoting Nuclear Stability in South Asia*, or simply, the "*South Asia*" project, in September 2005 with our primary focus on finding common ground between Pakistan and India on nuclear weapons and ballistic missiles proliferation. We also included early on in our agenda prevention of weaponization of space, recognizing the traditional similarity of viewpoints between the two countries, as expressed in international fora.

While recognizing the centrality of the Kashmir issue toward improving relations between the two countries, we believe the conflict is primarily political in nature. Thus, given our mostly technical background and focus, we were ill equipped to make substantive contributions in this regard.

The focus of our project continues to be on nuclear weapons and their delivery systems, and cooperation in space. However, we believe that we need to broaden our dialog to include other pressing issues affecting the region, especially the growth of nuclear power and its ramifications.

<u>Session One</u>: Missile Defense: The Technical Challenges

#1 *Status of the U.S. Missile Defense Program*
Philip Coyle, World Security Institute, Washington, DC, USA

Collectively, the Missile Defense programs in the United States have been funded at about $10 billion (U.S.) annually since President George W. Bush took office. What has the United States gotten for its money? And what are the capabilities and weaknesses of the missile defense systems being developed and fielded by America?

The Pentagon wants a <u>layered</u> missile defense system, with interceptors launched from land, sea, from aircraft, and from space - all capable of shooting down enemy missiles in all phases of their flight: In the boost-phase ascending, in the mid-course of flight, and in the terminal phase, coming back down. The idea is that if one layer misses, the next layer won't, and so forth.

What has been accomplished in each of these missile defense segments - on land, at sea, from aircraft, and from space - and what are the missing pieces?

Some of these systems are being deployed in other countries, and the U.S. has proposed a Ground-based Missile Defense system with interceptors to be deployed in Poland and an X-band radar in the Czech Republic, ostensibly to defend against a postulated threat from Iran. What is the nature of this threat and would the proposed system for Europe effectively defend Europe and the United States from missiles launched from Iran?

This presentation will review the status of the various U.S. missile defense systems, including those established and proposed for other countries, and will review the impact that these systems have had in the Middle East, in Russia, in Europe, and in Asia.

#2 *Technical Challenges toward Building an Operational BMD System*
Theodore Postol, Massachusetts Institute of Technology, USA

(Abstract not available at press time)

#3 *Missile Defense: A perspective from India*
V. K. Saraswat, Defense Research and Development Organization, India

(Abstract not available at press time)

#4 *Boost-phase Missile Defense: The ABL*
Jan Stupl, University of Hamburg, Germany

The Airborne Laser (ABL) program is part of the United States National Missile Defense (NMD) effort. The basic idea behind this project is to integrate a high energy laser (HEL) into a Boeing 747 airplane, position the plane near potential missile launch sites and destroy ascending missiles using the laser. Using freely available information, this paper will discuss the current state of the project and introduce research which has been undertaken in order to assess technical and political implications of the ABL project.

The ABL program has been in existence since 1998. A first test against a ballistic missile was scheduled for 2002, but has been postponed several times, most recently, until 2009. This is not totally surprising since the ABL is a very complex system, consisting of a high energy laser with several megawatt output power, a computer-controlled optics system to compensate atmospheric distortion, and complicated sensor equipment, which have to be integrated into one system. So far, 4.3 billion US$ have been spent on the project. Some weeks ago, the Missile Defence Agency announced that testing of the subsystems was successfully finished and, finally, the high energy laser will be installed in the plane. At the moment, it is not certain whether that will happen as scheduled.

There are also funding uncertainties because the US congress has not yet approved the budget request for US $548.8 million for 2008.

The trajectory of a ballistic missile is divided into the boost phase, midcourse-flight and the terminal phase. The goal of the ABL is to engage ballistic missiles in their boost phase. During the boost phase, the rocket engine is still running, which implies that tracking of the missile is simplified, as the exhaust from the engines leave a bright infrared signature. On the other hand, attempting this in the boost phase adds a time constraint to the already difficult task of missile defense, as the boost phase only lasts a few minutes. Using a laser weapon in order to overcome this time constraint might seem to be a good choice. As the beam is traveling with the speed of light, the target is reached almost instantaneously. But there are disadvantages, too. The beam is widening with increasing distance between the ABL and the missile, because of diffraction. Therefore, the laser intensity is decreasing with range, and even with an assumed continuous output power of several megawatts, it will not be sufficient to destroy the warhead of the missile. Even if the system is designed so as to damage the comparable weak mid-section of a missile, it might be necessary for the laser beam to dwell on the target missile for several seconds until a sufficient amount of energy is deposited to destroy it. The warhead might be left intact and it will likely fall “short” of its intended target. Depending on how long the engine was already running before the missile is destroyed, the warhead will come down somewhere between the launch site and the intended location of the target and might endanger third parties.

The time needed for the destruction of the booster is the critical factor in assessing the ABL’s capabilities and the problem of “short-falling” warheads. After a general introduction into the ABL project, this presentation describes calculations and experiments which have been undertaken to determine this critical time. For the purposes of these calculations, one has to look at the incoming the laser intensity, the resulting local heating of the booster wall and the corresponding mechanical stresses. The first step is to calculate the incoming laser intensity. Decisive in this calculation are diffraction, beam widening by atmospheric turbulence and absorption of laser power in the atmosphere. Diffraction and atmospheric turbulence both widen the laser spot on the target, therefore reducing laser intensity. Absorption of laser energy in the atmosphere

decreases the total incoming power. The second step is to calculate the resulting temperatures in the booster. Radiation of heat to the ambient and heat conduction inside the missile wall is taken into account. Finally, the resulting mechanical stresses because of the local temperature increase are calculated, as these stresses might reach destructive levels before the melting point of the material is reached. In order to validate the temperature and structural mechanics calculations, scaled experiments have been undertaken.

The simulations allow a more precise estimation of the time needed to destroy a booster. Results show that the capabilities of the ABL strongly depend on the engagement geometry, i.e. the position of the ABL in relation to the missile’s trajectory. Even for medium sized countries it might be difficult to station the ABL close enough to missile launch sites, in order to destroy missiles in time.

<u>Session Two</u>: ***Deployment of Missile Defense Systems in Europe***
Viewpoints from:

#1 *Europe*
Alexander Bitter

#2 *USA*
Theodore Postol, Massachusetts Institute of Technology

(Not available at press time)

#3 *Deployment of US Missile Defense System Components in Europe: Russian Assessment.*
Leonid Ryabikhin, Committee of Scientists for Global Security and Arms Control

On December 13, 2001 the US President George W. Bush announced that the U.S. intended to withdraw from Anti-Ballistic Missile Treaty. The withdrawal took effect June 13, 2002. The ABM Treaty has been signed in 1972 and the USSR and then Russia considered it as “a cornerstone of strategic stability”. Russian President Vladimir Putin on December 13, 2001 responded to President George Bush announcement: “We believe this decision to be mistaken”.

The Bush administration dismissed concerns that other states, particularly Russia and China, might build up strategic arsenals in respond to the construction of the U.S. global ABM system.

The former Secretary of Defense Donald Rumsfeld, the principal proponent of a nationwide ABM system, said on December 15, 2001: “Any suggestion by anybody, attributed or unattributed, that some changes in the ABM Treaty is going to lead to an arms race is just flap…In fact, the next five years will prove what I’ve said to be the case”.

From the beginning, Russia was always very suspicious towards the U.S. plans to develop strong ABM defense in the absence of the ABM Treaty or other international bilateral or multilateral agreements. Even though the recent BMD program being pursued by Bush Administration is modest and limited, the scientific and technological achievement resulted from this program could lead to a much larger program and create the infrastructure of a large scale advanced ABM system, which will be able to seriously devaluate Russian nuclear deterrent potential.

The U.S. plans to deploy the components of a global ABM system in Europe as a defensive reaction to missile threats from Iran and North Korea do not seem credible. Of course, the deployment of ten GBI in Poland can not seriously threaten Russian Strategic Missile Forces. But deployment of GBR in Czech Republic close to the Western Russian borders will be the key element in forming a full-scale European component of the U.S.

worldwide ABM system, which will impose overwhelming control over Russian "missile activity" as far as the Ural Mountains, including monitoring of the Northern Missile Test Site "Plesetsk".

According to the estimation of Russian experts, the proposed location of the U.S. ABM System in Europe is perfect to defend European states from ballistic missiles coming from an easterly direction. It means defense against BM attacks from Russia, China, and potentially from North Korea, India and Pakistan. These three countries have active BM programs. But such attacks are unlikely in the foreseeable future, even theoretically.

The proposed location of an ABM system in Europe is not ideal against potential Iranian BM attacks on Central and Western Europe and the U.S. The more suitable locations for ABM system defending Europe could be the Balkans and Turkey. The Russian proposal to use the EW radar in Gabala in Azerbaijan allows the control of BM threats from the South. But it can not be used for BM interception. Potentially the Moscow regional ABM System is ideal for interception of the unlikely in the nearest future Iranian ICBM attacking the U.S. continental territory. This system is located just on the way of the missiles trajectories in case of such attacks. But this kind of the U.S.-Russia cooperation depends on political will of the leaderships of both countries.

Luncheon speech – *"Nuclear Stability in South Asia"*

Ambassador Tariq Osman Hyder, Ministry of Foreign Affairs, Pakistan

There has been much debate on the concept of nuclear stability in general. Some have held it to be a contradiction in terms. There are the empirical examples of nuclear stability between the USA and the USSR/Russia as well as between NATO and the Warsaw Pact.

The relationship between India and all the rest of the South Asian countries has traditionally been difficult. It has been even more complex and difficult between India and Pakistan. The attainment of normal relations between these two important South Asian neighbours and countries of importance in the global context requires a broad framework transcending nuclear stability. This framework demands conflict resolution, strategic stability and conventional balance.

The introduction of strategic capabilities on both sides has led to the better management of this bilateral relationship and contributed to the most recent phase in which conflict has been avoided and a peace process has commenced.

Both sides have recognized that the nuclear and strategic capabilities that they possess constitute a factor of stability, and this public mutual declaration and recognition constitutes a new and unique development in this field.

At the same time the nuclear capabilities of both countries, with their history of past conflict, leaves no ground for complacency, with the attendant risks that may ensue. A heavy responsibility lies on India and Pakistan, and also on the international community.

There are two important challenges. The first is for both countries to ensure that strategic stability is maintained, while also trying to enhance confidence building, and moving towards restraints. The second is for the international community to play its part towards these objectives, rather than to promote initiatives which, whatever their declared intent, would have a negative impact on strategic stability and the future of South Asia.

Session Three: *Missiles and missile defense in South Asia*

#1 *Missile Defense in South Asia*
Ashley J. Tellis, Carnegie Endowment for International Peace, USA

This presentation will focus on the strategic environment in Southern Asia and the interest in missile defense programs in that context. It will survey the responses to missile defense in China, India, and Pakistan, and it will explore how each of these countries views missile defense in the context of their own strategic modernization programs. The prospects for operational missile defenses in each state are examined and their consequences for regional strategic stability will be evaluated.

#2 *View point of Pakistan*
Khalid Banuri, Strategic Planning Division

(Abstract not available at press time)

#3 *Missile System: Application and Performance*
Subir K. Chaudhuri, Pulak Halder, Pramod Jha, Madhu Kumar, and Lalith Shankar; Defense Research & Development Organization, India

The future war demands fast and swift attack where the aggressor and defender need to be classified as per the threat scenario vis-à-vis geographic location of the country. For a country like India, the aggressor role is taken mostly by combat aircrafts or ballistic missiles. Surface to Air Missile (SAM) against the combat enemy aircraft is the prime necessity for air defence. To achieve this goal, short range quick reaction missiles and medium range SAMs have been successfully test fired and their development is under progress. To neutralize the threat caused by ground attack, a 3rd generation Anti Tank Missile (ATM) has been developed successfully in India. It is equipped with indigenously designed and developed state-of-the-art stabilized Imaging Infra Red (IIR). Development of stabilized Milli Metre Wave seeker for ATMs is being undertaken. Furthermore, short and medium range tactical Surface to Surface Missiles have been developed as deterrents. Similar classes of missile have proved to be very effective in the European theatre. Finally, to overcome the threat from ballistic missiles, development of an Anti Ballistic Missile (ABM) system is also in progress.

Many critical technologies have been indigenously developed for missile systems. Sophisticated and proven inertial guidance technology aided by external sensors/satellites has been developed and demonstrated in flight tests to achieve a remarkably low circular error probability.

In addition to typical Unmanned Air Vehicles, surveillance with intelligent information gathering using weapon system radar is a necessity to make the missile more effective for precise attack. For ABMs and missiles launched from moving platforms, the on-board data fusion techniques for mixing the information from radars, inertial sensors along with various kinds of seekers are the key technological challenges. For on-board applications, various estimation methods, including Extended Kalman Filter, Adaptive Kalman Filter, etc., along with guidance and linear/nonlinear control design have been realized with satisfactory performance as seen in flight trials. Implementation of new theoretical methods and complex recursive algorithms has become a reality due to the availability of low-cost and high-speed embedded microprocessors, digital signal processors and data links. Weapon control configuration with multi source data handling using powerful compute engines, appropriate data links and fault tolerant launch control systems have increased the scope of launching missiles from various platforms against different classes of targets.

Since a missile system is expensive and not reusable after a test launch, all critical technologies need to be validated through simulation. Each subsystem can be represented by a proper mathematical model in a rapid-proto environment for ease of introduction of the actual hardware. It demands a sophisticated Hardware-In-Loop-Simulation (HILS) facility to evaluate the performance of each subsystem along with embedded mission software subjected to trajectory dynamics. Classical guidance and control laws are mostly applied for aero space vehicles (which are aerodynamically unstable and non-linear) with varying degree of performance in terms of positive, negative gain margins and phase margins using available seekers, sensors, actuators along with weapon system radars and data links. Guidance and control law studies with respect to gathering basket and capturing capability have been carried out. Accuracy requirements with dynamic tactics of modern warfare demand performance improvements, which is a trade-off between costly sophisticated hardware and computationally intensive software. HILS facilities and methodology form a well integrated system for transforming a preliminary guidance and control system design to flight worthy software and hardware from lift-off till end of mission. Nearly full spectrum of dynamically accurate six degrees of freedom (6-DOF) model incorporating various complex characteristics of missile like flexibility modes, etc. was realized. Higher dynamics motion simulators and various IIR, RF scene generation facilities are continuously growing in their sophistication to satisfy the need of

target/battle field scenarios, which proves to be most effective in design and performance evaluation of IIR and RF seekers over wide band of frequencies along with INS. In addition weapon system radars and various stages of actuation systems are also included in HILS. Remote “missile-in-loop” simulation technique is used before the launch as an effective validation tool for integrated missile design. The off nominal cases due to uncertainties in inertia, propulsion and aerodynamics are also simulated in HILS for demonstrating the robustness of guidance and control system design. Missing links in model and design were traced back through HILS proving its efficacy as a powerful tool for Post Flight Analysis (PFA). HILS results have fairly matched with those of actual flight trials resulting in reduction of number of flight trials. State-of-the-art visual

simulation techniques with appropriate walk through during simulation and depiction of terminal engagement scenarios will aid in finding design flaws at an early stage.
In lieu of conclusion it can be highlighted that in a short span of 20 years, India – a developing nation starting from embryonic stage of missile development with lot of constraints and embargos, has created a niche in the world map.

Session Four: *A Global Missile-Launch Surveillance System for Strategic Stability*
Part-1: The System and Improving Nuclear Stability through Missile-launch Surveillance

#1 *Motivation and a Conceptual Design for a missile-launch warning system*
Geoffrey Forden, Massachusetts Institute of Technology, USA

The international community should establish a constellation of satellites designed to detect the launch of a ballistic missile whose data would be shared among the countries of the world. This talk will discuss one region where such a system would help increase nuclear stability: the South Asian subcontinent. All countries of the world would have access to the data and could in fact participate in the satellite's construction. After a brief overview on observing missile launches from space, this talk will lay out some the system's attributes and, after showing similar cases in the history of the US-Russian/Soviet nuclear standoff, discuss one possible scenario where the system could prevent a nuclear tragedy.

If there was one day an accidental nuclear detonation, the country that suffered the calamity could use the information from the satellites to reassure itself that no missiles had actually been launched. At that point they could step back from the brink of catastrophe and let cooler heads prevail. While such a system would benefit a number of regions of the world, it would have immediate applications to the South Asia subcontinent. As an additional benefit, Indian and Pakistani participation in such a global endeavor—even during design and construction—would be a significant confidence building measure between the two nuclear armed states. The constellation proposed in this paper has, at full complement, five geostationary satellites. With such a five satellite constellation, most areas of the earth's surface that are a concern for missile launches can be covered by at least two satellites and in some cases three; multiple simultaneous tracking allows a three-dimensional reconstruction.

Part 2: System Capabilities for Increasing Missile Proliferation Transparency

#1 *System Capabilities for Improving Missile Proliferation Transparency*
Geoffrey Forden, Massachusetts Institute of Technology, USA

Today, much of the world is reliant on the intelligence gathering capabilities of a single nation when it comes to judging the threat associated with missile proliferation. It is possible, however, to use a space-based missile launch surveillance system, whose data is shared among all nations in the world who elect to participate, to increase the transparency of missile proliferation through observing missile characteristics during test flights. This paper will discuss some of the possible characteristics such a system, as discussed in the first portion of this session, might have.

A constellation of satellites capable of observing and tracking missiles during their powered flight has the potential to determine a wide range of missile characteristics and capabilities. These include range and throw-weight, numb of stages, type (solid vs. liquid) propulsion type, and possibly the number of engines clustered in the first stage. It should be able to do this for a wide variety of missile ranges; from short-range, SCUD-type, missiles, to intercontinental missiles.

Of course, different choices for system capabilities might severely limit the system's capability for determining missile characteristics while at the same time still allowing the system to increase nuclear stability. It will be for the international collaboration of nations participating in the surveillance system to determine just how much information they want the system to gather.

#2 *Launch transparency and collective security for space – a non US point of view*

Bertrand de Montluc, French Ministry of Foreign Affairs, Paris

I shall set out a few words what might be our objectives, actions, but also problems in making space secure. Our objectives are not revolutionary. They would involve stepping up our discussions on space security issues with a view to promoting the idea that the best interests of each member state would be best served by a common approach in this area, rather than following a set of compartmentalized national policies. Concerted analysis of options for sharing capabilities on space surveillance and some day hopefully information on detection and identification of objects in orbit could offer advantages under a win-win logic by the accumulation of greater quantities of data, the achievement of a degree of interoperability, and holding back sterile and costly competition.

Various reasons argue in favor of raising the issue of security in space in a more concrete, matter of fact, manner – less theoretical, doctrinal, legal or ideological than in the years before. In the case of a country such as France, three very basic principles guide our thoughts on this: 1) freedom of access to space for all for peaceful purposes; 2) preservation of the security and integrity of satellites in orbit; and 3) due consideration for the legitimate defense interests of States. The issue of weaponization is only one

specific aspect (aimed at lethal responses to illegal actions prejudicial to vital interests) of a broader and more immediate subject, which is how to make space more secure.

The establishment of a guide of good practices (or international minimum guarantees willingly accepted by states) could be eventually based on the stepping-up of a "surveillance of space infrastructure" shared internationally by mutual interest. However, such a space surveillance networking tool would be truly meaningful if other nations with concerns for space security were willing participants in it.

If space awareness can help define and foresee accidents, abnormal, anomalous or prejudicial behavior in connection with civilian, commercial and defense space assets, it could also provide advance protection from objects in orbit that may collide with satellites when these are launched or when they are functioning in orbit. In this sense, the ultimate purpose of space transparency is fully coherent with global values Europe in the field of security.

Session Five: *Energy Issues in South Asia*
#1 *Nuclear power and its alternatives for a carbon-constrained world*
Robert H. Williams, Princeton University, USA

Interest in resurrecting the nuclear energy option stems largely from the view that it will be needed to mitigate climate change. To have a significant impact in this half century, nuclear power would have to grow several-fold, with much of the growth in developing countries.

Nuclear power offers a carbon free alternative for electricity generation, which accounts for 40% of CO_2 emissions from fossil fuel burning. But nuclear power would face stiff competition. Other low-carbon baseload electricity options that would be ready for widespread deployment during 2010-2020 include coal power plants with CO_2 capture and storage (CCS) and wind/compressed air energy storage (CAES) systems.

All the required technology for CCS is commercially ready. The IPCC *Special Report on CCS* (2005) concluded that it is likely that there is at least of the order of a century of CO_2 storage capacity in geological media and that "…the fraction [*of injected* CO_2] retained in appropriately selected and managed reservoirs… is likely to exceed 99% over 1000 years…" Understanding better the "gigascale" potential of CCS requires carrying out a number of "megascale" projects (each storing at least a million tonnes of CO_2 annually) for a variety of geological formations.

Good wind resources are sufficiently abundant that the world's electricity needs could be met several times over with wind. But wind electricity is intermittent (and thus inherently less valuable than baseload electricity), and good wind resources are typically remote from major electricity markets. Coupling wind to CAES so as to provide baseload power can effectively address both challenges. CAES technology is commercially available. The key issue is whether there is sufficient suitable geological capacity for CAES in wind-rich regions of the world. For the US, it is estimated that suitable geologies exist for over 80% of the land area and in almost all of the wind-rich regions. But more detailed assessments of CAES capacity are needed, especially for air storage in aquifers, the storage medium that is especially well correlated with good wind resources in the US. Much will be learned about aquifer CAES from the world's first wind/CAES plant, which will involve storing air in an aquifer in Iowa; the plant is expected to come on line in 2011. As in the case of CCS technologies, there is an urgency to put into place wind/CAES systems in a variety of geological settings to get a much better understanding of the overall wind/CAES potential.

The most pressing issue relating to a possible nuclear renaissance is the nuclear weapons link to nuclear power. At the high levels of nuclear power needed to "make a dent" in addressing climate change, the nuclear weapons link would come into much sharper focus than at present and would require a much stronger non-proliferation regime.

Priorities for public policy for the major non-nuclear options that could enable a shift to low carbon electricity are to proceed rapidly with megascale CCS and wind/CAES projects to get a better understanding of the gigascale potentials of these baseload power options; with concerted efforts these potentials should become clear by 2020. In the case of nuclear power, the major forecasts envision only modest nuclear power growth through 2030 because of the lack of investor and public confidence in the technology. So, if nuclear power is to make a major contribution in addressing climate change, it would be after 2030; the priority for public policy in the interim should be to strengthen the non-proliferation regime to the extent of making the world "safe" for a major expansion of nuclear power.

If these three public policy objectives could be met, we might witness a "horse race" in power markets post-2030. All three options could provide baseload electricity with near zero GHG emissions. All three could probably provide electricity at comparable generation costs under a stringent carbon mitigation policy. And resources for all three are sufficiently abundant that low carbon electricity needs in essentially every world region could be met with low GHG-emitting technologies without deploying all three options. This means that the mix of options chosen could probably be decided mainly on the basis of externalities other than climate change.

#2 *Pakistan's Vision 2030 Plan*
Shaukat Hameed Khan, Pakistan Planning Commission

(Abstract not available at press time)

#3 *The Indian Energy Scenario: Its Global Security Implications*
E.A.S. Sarma, Power Secretary, India (ret.)

India has sizeable deposits of coal and nuclear energy resources and also, a large untapped hydroelectric potential. Nonetheless, to sustain a high rate of economic growth and secure clean energy supplies at affordable prices for the disadvantaged people is a formidable challenge faced by the country's energy planners. India will soon be required to make difficult choices in terms of demand management, the fuel mix for its energy system and the investments to be made on different segments of the energy supply chain.

Those decisions will have long-term security implications, both global and regional.

The paper examines the present energy scene in India, the likely trends in energy development in the coming decades and the implications of energy choices in terms of regional and global security. The paper suggests possible sets of intervention that could minimize the adverse implications from the security point of view, without compromising the core development concerns of the country.

In the business-as-usual scenario, the country is likely to move towards a highly coal dependent electricity sector and also, transport and domestic sectors heavily reliant on imported oil and gas. Indian coal has low calorific value and high ash content. Apart from the problem of transporting it over long distances, the ash from it causes serious environmental problems. Increasing civil society resistance to all large projects that displace people has also posed a serious roadblock to most energy projects. This explains the recent trend towards considering the use of imported gas for incremental power generation.

Still, compared to domestic energy resources, imported gas is going to be more expensive. The two major consuming sectors, for example, fertilizers and electricity, generation would find the cost of imported gas unaffordable, whereas Indian industry that would require lesser quantities of gas is likely to absorb gas more readily. This could be an inhibiting factor in proceeding with the proposed pipeline gas imports from the Middle East, especially Iran.

In regions distant from the coalmines, nuclear energy would offer a convenient long-term alternative. Like imported gas, nuclear energy is also going to be expensive. Unless there are major cost reductions possible through economies of scale and there are technological answers to the safety concerns, its contribution to total electricity generation may remain modest for years to come.

Logistic constraints and cost compulsions will force the country to import oil from the Middle East. Already, a few countries alone in that region contribute to more than 67% of India's oil imports. It will not be easy for India to diversify its import sources. Similarly, high-calorific coal will have to be imported from a few nearby coal-producing countries.

According to a recent study commissioned by the national Planning Commission, the steep increase in the overall energy demand could drive the country into importing 315-451 million tonnes of oil, 97 million tonnes oil-equivalent of gas and 72-462 million tonnes oil-equivalent of coal by 2031-32, depending on different levels of coal intensity planned for the energy system. In proportion to the likely quantities traded in the world market, these work out to 9.3-13.3% for oil, 0-7.7% for gas and 5-29% for coal. This would impose a heavy cost burden on the economy. If the demand pressures force the country to resort to oil imports, within the next two and a half decades, India could become a significant player in the world energy markets. Asymmetric dependence on a few import sources renders the country's energy system vulnerable to disruptions, apart from its overall geo-political implications. Economic compulsions arising from it could shape India's foreign policy.

India is a signatory to the Kyoto Protocol and is well aware of the need for collective, equitable and voluntary global effort to contain global warming. Climate change mitigation measures adopted in this context, coupled with the necessity of enhancing the overall efficiency of the energy system could contain the country's gross energy needs to some extent but any deliberate attempt to minimize the use of coal would push the country further towards the long-term expensive option of using its Uranium and Thorium resources for meeting the rapidly increasing demand for electricity.

In fact, the same Planning Commission study suggests that, in order to meet the increasing electricity demand, the quantum of nuclear energy generation will have to be stepped up to 76-98 million tones oil-equivalent by 2031-32, from the present level of only 4.4 million tones. This would have cost implications for the electricity sector. The country cannot also be expected to ignore the emerging developments in the region from the security point of view.

While the objectives of domestic energy security and the overall global security concerns may not always be congruent with one another, there are also areas of convergence. This paper will discuss some of them.

Finally, it must be recognized that continuing economic inequities, including energy inequities among the nations of the world, are in themselves a threat to global security. They need to be addressed in a determined and time-bound manner.

Session Six: *U.S.-India Civil Nuclear Cooperation Agreement: Global and Regional Impacts*

#1 *An analysis of the Indo – US Civil Nuclear Cooperation Agreement (2005)*
Krishnamurthy Santhanam, Director, Inst. of Defense Studies & Analysis, India (ret.)

The Agreement has been hailed as historic and, simultaneously, panned as abridging India's autonomy in decision-making. It is also strongly invested with `political' color because India's Left - which critically supports the minority government in New Delhi - has chosen to question and confront the agreement. The debate is being conducted with vim and vigor in the media. There are some critics in USA as well. They say that the agreement rewards a country which has cocked a snook at the nuclear non-proliferation regime in 1974 and 1998. Secondly, it would damage the structure of the non-proliferation regime.

The main point being made by critics in India is that it would inhibit India's ability to conduct nuclear tests in the future. Secondly, India would get `sucked' into the vortex of USA's global security plans and interests - a point which is forced advanced by the Left parties, especially the Communist Party of India (Marxist) – the CPI(M).

There are seven important features in the Agreement which deserve to be highlighted:

a) Both Parties will cooperate in creation of a "strategic reserve" of fuel "to guard against any disruption of supply over the lifetime of the reactors". There will be not automatic fall of the guillotine.

b) There will be prompt "consultations" to avoid actions or resolve disputes that could have :"adverse effects". Implicitly, it means that if India conducts nuclear tests in the future, the consultations would cover aspects like changes in the security environment or nuclear testing by another country.

c) To avoid any disruption of fuel supply for safeguarded power reactors, USA will work with Russia, France and the United Kingdom and ensure that no discontinuity occurs.

d) Reprocessing of by India of spent fuel from imported turn-key power reactors will be permitted; and, India will build a new, safeguarded reprocessing facility for this purpose.

e) If the India's security environment changes drastically and the need arises to conduct nuclear tests, consultations with USA would precede actual testing. (Obviously, USA would not be taken by surprise).

f) Termination of the agreement will need one year's notice and be preceded/followed by consultations. There will be no automatic fall of the US guillotine.

g) The validity of the agreement is for 40 years; extendable by 10 years.

These features address comprehensively India's concerns over stability and continuity of fuel supplies.

Most new nuclear states (eg India) have declared a doctrine of Minimum Credible Deterrence. *Ironically, the phrase was first used by USA.* It may be instructive to explore the method(s) for a new nuclear state to ensure that its `Minimum Credible Deterrent' is perceived by other nuclear states as credible; and continue to be credible as time goes by. At the technical level, the following elements would appear to be of importance:

a) sustained research and development for phased implementation of essential improvements of the stockpile;

b) indigenization of critical components and materials which are denied by export control regimes;

c) repackaging, testing and clearance of the payload for new vectors;

d) adherence to the rule that `The better is the enemy of the good";

At the politico-diplomatic level, some initiatives need to be considered and implemented as long as nuclear weapons continue as the currency of power :

a) working with the international community to seek elimination of nuclear weapons in a time-bound framework;

b) supporting bilateral approaches to reducing nuclear tension between paired adversaries;

c) cooperating with bilateral/multilateral initiatives to prevent WMD falling into the hands of extremist/terrorist outfits.

It needs to be emphasized that MCD cannot be static. Dynamic developments in the security environment would impact MCD. And, technology obsolescence would have to be met in a phased manner.

Parity (or near parity) between paired adversaries would bring some sobriety and force both to re-think political strategies because of the realization that *"More is not better when less will do"*. Further, after near-parity has been reached, the natural and inevitable process of Confidence Building Measures (CBMs) may be expected to commence. These could be useful to ensure that a nuclear war is not triggered by misperceptions, miscalculations and ignorance - or worse.

#2 *US-India Nuclear Agreement: A Pakistani point of view*
Parvez Butt, Secretary, Ministry of Science and Technology, Pakistan

(Not available at press time)

#3 Author: Ashley J. Tellis, Carnegie Endowment for International Peace, USA

(Title and summary not available at press time)

#4 Author: Lawrence Scheinman, Monterey Institute, USA

(Title and summary not available at press time)

#5 *A Japanese perspective on the U.S.-India Nuclear Deal*
Mitsuru Kurosawa, Osaka University, Japan

During the recent summit meeting between Prime Minister of Japan, Shinzo Abe and Indian Prime Minister Manmohan Singh in August 2007, Singh sought Japan's support of the U.S.-India nuclear deal. Abe stopped short of taking a clear stance on this issue, and noted: "As the only country in the world to have experienced atomic bombings, we will carefully consider the impact the agreement will have on the nuclear non-proliferation regime."

Prime Minister also told that: "While we understand the strategic importance of India and importance of nuclear energy to deal with climate change, we think it indispensable for India to properly work for the negotiation of a safeguards agreement with the IAEA in order to meet the interest of the international community."

The issue of the U.S.-India nuclear deal is so complicated including many aspects that we have not be able to decide so far how to respond to it. The debates in Japan about the deal contain four aspects; first, nuclear disarmament and non-proliferation aspect, second, energy security and environment aspect, third, economic and business aspect, and fourth, strategic and geopolitical aspect.

Regarding the first aspect, Japanese Government and overwhelming majority of Japanese people support the promotion of nuclear disarmament and maintenance and strengthening nuclear non-proliferation regime. The Government has submitted a resolution on this issue to the United Nations General Assembly for more than ten years.

Civil society working for nuclear disarmament in Japan is also influential. In Japan there is strong anti-nuclear weapon feeling among ordinary people.

Regarding the second aspect, Japan has been developing nuclear energy mainly for energy security as we have almost no oil or gas in its territory. In order to avoid the green house effect in accordance with Kyoto Protocol and beyond, the use of nuclear power for main energy source will be accepted among Japanese people.

Regarding the third aspect, nuclear industry in Japan has a long experience in peaceful uses of nuclear energy and also high technology including uranium enrichment and plutonium reprocessing. They are looking for new business chances and demanding to conclude a bilateral agreement on nuclear cooperation between Japan and India.

Regarding the fourth aspect, Prime Minister Abe emphasized the importance of strategic aspect with India, agreeing on Strategic and Global Partnership with India in December 2006 and on a road map to realize it in August 2007. He mentioned the shared or common values such as freedom and democracy among the two states. Beyond that, he said that Japan should cooperate with the United States, India and Australia.

Japan's attitude to the U.S.-India nuclear deal will depend on how to make balance or give priority among these four aspects.

Session Seven: ***Space Policy – Challenges and opportunities for cooperation***

#1 *The Indian space program*

Ajey Lele, Institute of Defense Studies and Analysis, India

The Indian Space Program has a long history. During five decades of its existence it has contributed immensely towards development of India as a powerful nation-state. This success in the 'space' arena is a long tale of domestic and international struggle. Subsequent to the launch of the first artificial satellite Sputnik 1 in 1957, the technological vision of the then Prime Minister Jawahar Lal Nehru gave birth to this program which now has accomplished many laurels for its professionalism.

In India, initially space research started as a part of India's atomic energy program. Subsequently, understanding the need of a separate and independent agency to look at the countries growing space ambitions, in the year 1969, the Indian Space Research Organisation (ISRO) was born. The main charter of this organization is to cater for the state's communication, education, remote sensing, space research and meteorological needs.

The Indian space program was not born out of any military program like the ballistic missile program, but focused on establishing satellite launch capabilities. Initially, the first team of Indian 'space scientists' received their training in the United States. India did take help from the US, erstwhile USSR and France to launch first few sounding rockets. However, since its inception India's space vision has mostly revolved around the doctrine of self reliance. Today, although India is in a position to put heavy satellites (2000 kg variety) into orbit, but, is yet to gain full independence to put heavier satellites into the Geo-stationary orbit.

In recent years, the Indian space program has achieved a major global dimension. This is because India offers inexpensive but reliable launch facilities to other states. India is expected to control 10% share of this fast growing ‘space launch’ market in years to come.

During 2008 India proposes to send an unmanned mission to moon. At the same time, India believes that pushing forward human presence in space has become important essentially for planetary exploration.

Since its inception the Indian space program essentially does not have any military rationale. However, space technology inherently being a ‘dual-use’ technology naturally could perform many military related tasks like communication, surveillance, reconnaissance, etc. Today, India has an aerospace command and uses space inputs for military purposes too. But, at the same time, India has no intentions of weaponising space.

In the Asia-Pacific region apart from India, two other powers namely China and Japan have significant space programs. Space being an arena which offers enormous potential for peace, the presence of other space powers in the region offers India an opportunity for collaboration. In the South Asian context, there is ample scope for states like India and China to come together. In November 2006, during President Hu Jintao’s visit to India, both Indian and Chinese space scientists had reiterated that time is ripe for both countries to work together on various aspects of space technology.

With the above backdrop, this paper analyses the Indian space program and its evolution. The paper also attempts to compare the space policies of India and China and examines the possibility for cooperation in space between India, Pakistan, and China.

#2 *China's Space programme: Problems & Prospects*
Srikanth Kondapalli, Jawaharlal University, India

China’s space programme has achieved significant milestones in the last decade in the three key areas of satellite launches and manned spacecraft while beginning efforts in lunar probe efforts. These are reflective of the continuous progress achieved in science and technological fields and the relative attention paid by the leadership in allocating financial, technological and human resources to such programmes.

Two factors are driving the Chinese space programme today. One is the commercial and scientific advance of China in the last four decades and reflected in the civilian space programme of launching different satellites. In the civilian sphere three phases of the space programme were identified by China, viz., launching satellites, manned spacecraft and moon probe project. China made concerted efforts in this direction. The second driver is the urge for protecting its national strategic interests, or probably a contest, in the face of challenges from the advanced countries like the United States (US) and the European Union (EU). This second factor is also related to countering the proposed ballistic missile defence (BMD) programme of the US and its allies in East Asia, in terms of an active anti-satellite (ASAT) programme. China became the first country in the world to have tested explicitly a land-based missile to destroy a space-based object on January 11, 2007. This ASAT test has led to concerns in Asia with objections raised by Taiwan, Japan, South Korea, and India and by others such as the US, Russia and the EU countries. This has the potential to initiate further arms race in space and contribute to the destabilisation trends.

China has expanded *selective* multilateral efforts at international space cooperation with several countries, especially in improving communications. China's initial cooperation with Russia in the *GLONASS* and with the EU in the *Galileo* programmes appears to be waning due to its own *Compass* programme. If the Beidou-series of satellites also cater to the civilian customers, as announced, then the other international cooperative efforts specifically with the EU- are likely to suffer. More importantly, while China through its Compass programme intends to protect its autonomy in strategic and military sphere, the long-term objective is to exert its leadership position in the Asian context. As with several countries, China viewed space faring efforts as a part of expanding its strategic and military prowess. The dual-use nature of China's space programme is evident from the beginning with its emphasis on military applications. Although the commercial launches for foreign customers provide China with hard currency, some of these programmes are also intended to expand its sphere of influence in different part of the world.

In the context of India, while China has expressed concern of the growing space capabilities of India and in fact opposed any expansion of Indian space programme in the mid-1990s, it has now expressed willingness to cooperate with India in this field. The Chinese Premier Wen Jiabao visited Indian Space Research Organisation and the two countries are likely to sign a MoU to further cooperation in this field. Nevertheless, it appears that such cooperation has limits in the long-term perspective.

#3 *Pakistan's space program*
Arshad H. Siraj, Director General, SUPARCO

(Abstract not available at press time)

#4 *The use of outer space for security and defence - the European perspective*
Thomas Beer, European Space Agency

Today it is widely accepted that outer space can contribute decisively to the successful implementation of crisis management operations. This fact has now also been recognized by the European Union which, in its role as global player, is considering outer space increasingly as a mandatory part of the European Security and Defence Policy (ESDP). ESA is playing a major role in this process, supported by the provisions of the newly adopted European Space Policy and the wish of its member states to see ESA getting gradually more involved in the area of security and defence. The presentation highlights the coming into being of the ESDP and the role of outer space therein. ESA's position towards the ESDP and its current and potential activities in this domain are described and analyzed against the most important milestones.

Session Eight: ***Preventing Weaponization of Space***

#1 *U.S. space security policy*
Nancy Gallagher, University of Maryland, USA

During the Cold War, the United States sought to protect its satellites through a combination of equitable international rules and reciprocal strategic restraint. The 1967 Outer Space Treaty established the basic principle that space was free for all to use for peaceful, mutually beneficial purposes — implicitly including reconnaissance and other passive military-support activities to help stabilize deterrence, but excluding nuclear weapons in space and offensive uses in violation of U.N. Charter rules on force.

Now that the United States has no peer competitor in space and views satellites as a critical element of its superior war-fighting capabilities, it is placing more emphasis on unilateral strategies to exploit space for national military advantage, to protect vulnerable space assets against what it sees as inevitable threats, and to prevent other countries from using space in ways that contradict U.S. policy objectives.

Bush administration spokespeople assert that there is nothing particularly new or different in the 2006 National Space Policy, but this obscures how far the United States has moved away from its original preference for mutual strategic restraint in space — and how much farther it would like to go toward total U.S. military space dominance. The context for U.S. military space policy has changed in critical ways, especially the Bush administration's emphasis on coercive prevention rather than deterrence as the organizing principle for security policy and its efforts to acquire prompt global strike capabilities.

If current trends continue, though, U.S. policy and predictable counter-reactions could make space a much more difficult, dangerous, and expensive place to operate. Already, dangerous dynamics can be seen, for example, in China's decision to test an anti-satellite weapon after years of U.S. refusal to talk seriously about how changes to its space policy and strategic posture might affect deterrence stability, followed by efforts on the part of some Americans to use the Chinese ASAT test as a reason to develop conventionally armed intercontinental ballistic missiles and other global strike options.

There is a growing recognition across different groups in the U.S. space community that budget constraints and procurement problems will preclude the acquisition of transformational military space capabilities by 2020 (the original target date) or even 2030 (the target date used in some more recent planning documents). There is also more American interest in informal measures to reduce space debris, avoid space traffic collisions, and exchange certain types of space information — so long as they do not create new legal obligations or otherwise constrain U.S. military space operations.

These are positive developments, but they do not address the central problem posed by competitive efforts to control space for national military advantage. Even if one country has a disproportionate advantage in resources, capabilities, and technical expertise, it is unrealistic to expect that it could protect all of its own space assets and prevent all hostile uses through military means alone. International negotiations are desperately needed to strengthen and extend the basic principles of the Outer Space Treaty to address the much broader range of military space activities that are possible today, or might become so in the foreseeable future. Since most space technologies can be used for multiple purposes, some clearly peaceful and others not, the rules will need to focus primarily on behavior rather than capabilities. Thorny issues include the relationship between missile defense and anti-satellite weapons, the limits of legitimate military-support operations from space, and the appropriate verification.

Reaching agreement will require considerable time and effort, so it is better to start soon than to let technological developments and national military programs develop on their own schedule without any discussion of international control. A decision by the next American president to engage constructively in space security negotiations could provide the world with very valuable reassurance about how the United States intends to use its preponderant military power.

#2 *Indian view*
Maj. Gen. Dipankar Banerjee (ret.), Inst. of Peace and Conflict Studies, India

(Abstract not available at press time)

#3 *Pakistani view*
Amb. Masood Khan, Permanent Representative of Pakistan to the UN in Geneva

(Abstract not available at press time)

#4 *European view*
Ambassador Rüdiger Lüdeking, German Foreign Office

(Abstract not available at press time)

Session Nine: *Global Nuclear Disarmament*

#1 *The German view*
Uta Zapf, Chairwoman, Subcommittee on Disarmament, German Bundestag

(Abstract not available at press time)

#2 (Title and summary not available)
William Walker, University of St. Andrews, Scotland, U.K

#3 *A Nuclear Weapons Free World (NWFW): Desirable; Feasible?*
Marvin Miller, Massachusetts Institute of Technology, USA

The very first resolution of the United Nations, adopted unanimously by the General Assembly in 1946, called for the elimination of nuclear weapons, and this goal has been endorsed repeatedly since that time in many treaties as well as in statements by senior political and military figures and scientists. We recall in particular the commitment by the nuclear weapons states party to the Nuclear Non-Proliferation Treaty (NPT) to negotiate in good faith to nuclear disarmament (Article VI) and the vision shared by Ronald Reagan and Mikhail Gorbachev (Reykjavik: 1987) that all nuclear weapons should be abolished because, in Reagan's words, they are "totally irrational, totally inhumane, good for nothing but killing, possibly destructive of life on earth and civilization."

Given this history, the statement in January 2007 by George Schultz, William Perry, Henry Kissinger, and Sam Nunn setting as a goal a world free of nuclear weapons broke no new ground. However, the eminence of the authors and their emphasis on the threat of nuclear terrorism and the risk that new nuclear weapon states may be especially prone to accidental, erroneous or unauthorized use of nuclear weapons has renewed the debate about the desirability and feasibility of a Nuclear Weapons Free World (NWFW). In this paper, we discuss three of the prominent issues in this debate: (1) the distinction between "rogue" and "responsible" nuclear weapons states; (2) whether the elimination of nuclear weapons would make conventional wars more likely; and (3) given that the "nuclear genie is out of the bottle" and that verification means will inevitably be imperfect, would the risk of breakout in a NWFW make such a world more dangerous than the nuclear status quo?

#4 *Global Nuclear Disarmament*

Mitsuru Kurosawa, Osaka University, Japan

An article "A World Free of Nuclear Weapons" by George Shultz, William Perry, Henry Kissinger and Sam Nan in the Wall Street Journal on January 4, 2007 could be a fresh starting point for the argument of nuclear abolition in the current international circumstance where nuclear terrorism or new nuclear-weapon states could be new threats.

They argued not only for the setting of the goal of a world free of nuclear weapons, but also for taking eight urgent steps as ground work for it. It is necessary to pursue both measures in parallel just like the 2000 NPT Review Conference agreed to the final document which included an unequivocal undertaking of the nuclear-weapon states to abolish their nuclear arsenals and other twelve concrete measures for nuclear disarmament.

Although a primary responsibility rests on the nuclear-weapon states, in particular, the United States and Russia, those non-nuclear-weapon states which are under the nuclear umbrella of the United States should work more positively for nuclear disarmament. Japan, Australia and Canada (JAC group) and non-nuclear NATO states should make a coalition to promote nuclear disarmament.

The United States argues that the U.S. is decreasing the reliance on nuclear weapons, as is shown in the new triad presented in the Nuclear Posture Review. One of the triad is nuclear and non-nuclear striking forces. As conventional weapons of the U.S. are strong and precise enough to prevent a possible attack from other states, we should consider the possibility of deterrence by conventional weapons, that is, conventional deterrence.

Nuclear disarmament and disarmament in general could not be achieved by pursuing disarmament only. We need to promote the situation in other three areas in parallel. First, the norm of no-use of force should be strengthened. Second, the mechanism for peaceful settlement of disputes should be strengthened. Third, International security mechanism to cope with illegal use of force should be strengthened. These four elements are interdependent as a progress in one area gives good effect on other areas. By taking a small step in each of the four, we can make progress for more peaceful and secure world.