"All Our Tomorrows": A Long-Range Forecast of Global Trends Affecting Arms Control Technology

James M. Smith and Jeffrey A. Larsen

INSS Occasional Paper 44

June 2002

USAF Institute for National Security Studies
USAF Academy, Colorado

The views expressed in this paper are those of the author and do not necessarily reflect the official policy or position of the Department of the Air Force, the Department of Defense, or the US Government. The paper is approved for public release; distribution is unlimited.

****

ABOUT THE AUTHORS:

Dr. James M. Smith is Director, USAF Institute for National Security Studies (INSS) and Professor of Military Strategic Studies at the United States Air Force Academy. He is a graduate of the Air Force Academy and a retired USAF officer. He holds an MS from the University of Southern California and a Doctorate in Public Administration (Public Policy) from the University of Alabama. Relevant to this publication, he is the editor of Nuclear Deterrence and Defense: Strategic Considerations *(INSS, 2001), is a chapter author in Jeffrey A. Larsen and Kurt J. Klingenberger, eds.* Controlling Non-Strategic Nuclear Weapons: Obstacles and Opportunities *(INSS, 2001), and is coauthor (with Jeffrey A. Larsen) of* The Historical Dictionary of Arms Control and Disarmament *(Scarecrow Press, forthcoming).*

Dr. Jeffrey A. Larsen, the founding Director of INSS, is a Senior Analyst with Science Applications International Corporation. He is a graduate of the Air Force Academy and a retired USAF officer. He holds a Masters Degree in national security affairs from the Naval Postgraduate School and both Masters and PhD from Princeton University. His relevant publications include editor (with Gregory J. Rattray) Arms Control: Toward the 21st Century *(Lynne Rienner, 1996), editor (with Thomas D. Miller)* Arms Control in the Asia-Pacific Region *(INSS, 1999), editor (with Kurt J. Klingenberger)* Controlling Non-Strategic Nuclear Weapons: Obstacles and Opportunities *(INSS, 2001), editor,* Arms Control: Cooperative Security in a Changing Environment *(Lynne Rienner, 2002), and coauthor (with James M. Smith)* The Historical Dictionary of Arms Control and Disarmament *(Scarecrow Press, forthcoming).*

Comments pertaining to this paper are invited; please forward to:
Director, USAF Institute for National Security Studies

HQ USAFA/DFES
2354 Fairchild Drive, Suite 5L27
USAF Academy, CO 80840
phone: 719-333-2717
fax: 719-333-2716
email: james.smith@usafa.af.mil

Visit the Institute for National Security Studies home page at
http://www.usafa.af.mil/inss

TABLE OF CONTENTS

FOREWORD

We are pleased to publish this forty-fourth volume in the *Occasional Paper* series of the United States Air Force Institute for National Security Studies (INSS). This paper reports the results of a project that takes INSS back very close to its founding vision. Two primary rationale for the establishment of a policy research institute within the military academic community were to tap into the cross-disciplinary capabilities existent within the faculties of military education institutions and to foster and leverage the ready collegial networks that exist across and beyond these institutions and their faculties and students. This project brought the combined efforts of the technical and social sciences faculties of the Air Force Academy, selected members of the faculties from the US Military Academy, the Air War College, and the Air Force School of Advanced Airpower Studies, and representatives from centers of expertise such as Sandia and Los Alamos National Laboratories, the Department of Defense, and the Department of State all together to forecast trends and project requirements for arms control in 2015. As INSS as an Institute both sponsored and completed the paper published here, we deflect further overview to the Executive Summary that follows.

About the Institute

INSS is primarily sponsored by the National Security Policy Division, Nuclear and Counterproliferation Directorate, Headquarters US Air Force (HQ USAF/XONP) and the Dean of the Faculty, USAF Academy. Our other sponsors include the Secretary of Defense's Office of Net Assessment (OSD/NA); the Defense Threat Reduction Agency; the Air Staff's Intelligence, Surveillance, and Reconnaissance Directorate (XOI) and the Air Force's 39th and 23rd Information Operations Squadrons; the Army Environmental Policy Institute; and the Air Force Long-Range Plans Directorate (XPXP). The research leading to the papers in this volume was sponsored by OSD/NA, DTRA, and XONP. The mission of the Institute is "to promote national security research for the Department of Defense within the military academic community, and to support national security education." Its research focuses on the areas of greatest interest to our organizational sponsors: arms control and strategic security; counterproliferation, force protection, and homeland security; air and space issues and planning;

information operations and information warfare; and regional and emerging national security issues.

INSS coordinates and focuses outside thinking in various disciplines and across the military services to develop new ideas for defense policy making. To that end, the Institute develops topics, selects researchers from within the military academic community, and administers sponsored research. It also hosts conferences and workshops and facilitates the dissemination of information to a wide range of private and government organizations. INSS provides valuable, cost-effective research to meet the needs of our sponsors. We appreciate your continued interest in INSS and our research products.

JAMES M. SMITH
Director

"ALL OUR TOMORROWS": A LONG-RANGE FORECAST OF GLOBAL TRENDS AFFECTING ARMS CONTROL TECHNOLOGY

EXECUTIVE SUMMARY

This report summarizes a three-phase research project undertaken by the USAF Institute for National Security Studies on behalf of the Defense Threat Reduction Agency to forecast long-range global trends affecting arms control technologies. The report projects the international political, economic, and scientific environments to the year 2015. It posits economic and technological drivers as shaping the system, including its military and political dimensions. The result will be a two-tiered system, with great danger arising from significant proliferation in the second tier and the transition zone between tiers. The report next draws conclusions from this likely future for the scope, value, and practice of arms control. Arms control will be focused less on limitation and reduction of existing weapons, although the endgame there between the United States and Russia will remain a significant effort. The focus will shift to the less well-defined realm of counterproliferation, and to marginal, failing, and failed states as well as non-traditional and non-state actors. New dimensions will be added, including control efforts toward small arms, advanced conventional weapons, military space, and information operations. The report then extrapolates from this future to assess the likely arms control technology requirements in cooperative, non-cooperative, intrusive, and non-intrusive regimes. The projection here is continuing requirements for each of these specialized sets of technologies, with particular emphasis on multiple-use technologies for remote arms control compliance and verification monitoring as well as for intelligence detection and collection. Similarly, area arms control monitoring systems must be capable of application for force protection applications. Data management/knowledge management will become a top priority for arms control, as will the continuing development of human expertise in this advanced area of specialization.

All Our Tomorrows: A Long-Range Forecast of Global Trends Affecting Arms Control Technology

In 2001 the Air Force Institute for National Security Studies (INSS) assisted the Defense Threat Reduction Agency (DTRA) in its long range arms control planning efforts by conducting a comprehensive forecast of likely national security environments for 2015, potential arms control environments indicated by that analysis, and the resulting technology requirements for verification and monitoring to support arms control in 2015. DTRA asked that the study identify global events and trends that, in varying degrees of likelihood, may have a substantive effect on the arms control environment. We also considered the unanticipated consequences of existing or contemplated strategies affecting the arms control environment and the element of covert proliferation (to include catastrophic military and technological surprise). We looked for both individual and synergistic effects. We specifically enumerated the effects upon the arms control environment and the resultant technology requirements arising from these effects.

IMPLEMENTATION OF THE STUDY

The project was completed in three sequential phases:

Phase One: Faculty Regional and Functional Forecasting Offsites

During the spring semester of 2001 INSS asked members of the US Air Force Academy (USAFA) faculty to undertake a number of brainstorming sessions specifically aimed at projecting disciplinary trends and the resulting effects on the international security environment of 2015. Rather than single trend lines and forecasts, the teams were asked to develop the most likely alternative futures

and the relative likelihood and critical determinants of the realization of each future. INSS consolidated all Phase One inputs into a preliminary forecast report to serve as a foundation for the invited papers and panel discussions at the Phase Two Workshop. USAFA panels, chairpersons, and faculty affiliations are listed in Appendix One.

Phase Two: Arms Control Technologies Requirements Workshop

Phase Two built on the regional and functional forecasts from Phase One to produce a consolidated set of alternative arms control future projections and their associated technology requirements for the United States for 2015. Findings were reported at a workshop conducted at USAFA 24-25 July 2001. The agenda and list of participants are found in Appendix Two.

Phase Three: Final Report Preparation

Phase Three consisted of the preparation of the preliminary results briefing and the final project report. INSS staff prepared these products with selected input from the Phase One and Phase Two participants.

The remainder of this paper summarizes and builds on the findings of Phases One and Two of the study. It begins by setting the stage—assessing the likely political, economic, technological, and military environment almost 15 years hence. It then assesses what that world will mean for arms control in various areas.

Context

The INSS departure point for this study is based in a view of "arms control" as it was viewed in the early Cold War era. The classic description of arms control as a strategic policy construct remains that of Thomas Schelling and Morton Halperin in their seminal 1961 work, *Strategy and Arms Control*.

> We believe that arms control is a promising . . . enlargement of the scope of our military strategy. It rests essentially on the recognition that our military relation with potential enemies is not one of pure conflict and opposition, but involves strong elements of mutual interest in the avoidance of a war that neither side wants, in minimizing the costs and risks of the arms competition, and in curtailing the scope and violence of war in the event it occurs.

This definition firmly established arms control within the overall context of national security strategy. As a strategy instrument, arms control is an integral element of national efforts to enhance security, in this case as both a complement to and substitute for more confrontational strategy elements. This construct assumed that security strategy involved both conflict and cooperation, side by side and often simultaneous, as overlapping stages of a single continuum. For this study, then, "arms control" is considered any cooperative measure intended to reduce the likelihood of war, to limit the costs of preparing for war, or, in the event of war, to reduce its severity and to more quickly bring hostilities to an end. This includes traditional bilateral nuclear arms control, the broader range of unilateral reciprocal and bilateral cooperative threat reduction measures, multilateral arms controls and prohibitions, and a range of cooperative and reciprocal efforts to counter or limit the effects from proliferation of advanced and mass destruction/ disruption weapons and systems. This construct fully encompasses, and even extends, the existing DTRA and USAF "arms control" charters to capture the current and possible future mission sets of the study sponsors and participants.

Overview

This summary report is presented in four sections. The report first addresses the international security environment of 2015 and its broad implications for arms control. It presents a summary of the international system's likely security situation and how outside influences might shape US arms control efforts. This then serves as a foundation for identifying arms control compliance verification and monitoring (CV&M) technology requirements.

Second, the report looks at a range of arms control futures within the international security environment of 2015. It forecasts the status of arms control programs and their implementation with special emphasis on nuclear, chemical, and biological arms controls—the current DTRA areas of charter. It also addresses conventional, information, and space "arms control" not only as potential future expansions of the DTRA mission, but as areas of particular interest to the Air Force. This section emphasizes how these efforts might impact CV&M technologies or their developments in technical areas that might spur future technology requirements.

The third section of this report addresses requirements for arms control CV&M technologies in 2015. It includes a summary of the current and projected CV&M technological focus and capabilities, and their adequacy for meeting CV&M requirements. It also identifies some specific CV&M requirements not met by current and projected technologies. The final section lists the study's major findings and implications, including the main themes and requirements of the overall study.

THE EVOLVING INTERNATIONAL SECURITY ENVIRONMENT

A number of overlapping and interconnected drivers—economic, technical, political, and military—will shape the international security environment to 2015, significantly impacting the future arms control arena and the requirements for arms control verification and compliance monitoring technology. Economic and technical drivers will play the lead role in creating that future security environment. Political and military drivers will be shaped, in large part, by global economic interactions and rapidly evolving technology developments. Trends and interactions creating the 2015 environment could be found in four fields: economics, technology, politics, and the military.

Economics

The world economy will continue to grow and provide increased wealth to its participants. Major growth engines over the next 15 years include technology advances, open global trade, and increased access to information. The rich will get richer and the poor, while less poor than before, will fall further behind. Globalization and interdependence will enable rich states to exert power and influence over poorer states, and the growing gap between the two will breed instability and internal conflict. Intertwined financial systems and trade will be severely disrupted in the event of long-term recessions or economic depression. Poorer states, constrained by trade ties, will be limited in their ability to manage their own economies and security environments. Richer states will have a greater chance of maintaining stability because they can provide resources in exchange for the instruments of internal security. Corporations will gain power at the expense of states as they seek stable, cost-effective environments for

manufacturing and distribution facilities. Intellectual capital and educated work forces will provide significant competitive advantage.

Technology

The United States, with its incredibly robust commercial and military research and development (R&D) capability, will remain the global leader in this realm, which will affect the kind of technology that will be developed, as well as the pace of that development. Russia's ability to export technology will dramatically decrease. Likely breakthroughs or major advances can be predicted in several scientific areas:

- *Chemistry and Biology.* The chemical and biological weapons fields will benefit from advances in targeted agents, improved detection, advances in biotechnology, improvements in batteries and portable electrical power, and new rocket propellants.
- *Physics.* Unmanned aerial vehicles will continue to take on more tasks and missions as advances in the fields of hyperspectral sensors, moving target indicator technologies, global positioning satellite guided munitions, and directed energy weapons come on line. These will be mated to similar advances in micro-electric-mechanical systems and broadband free space communications.
- *Conventional weapons.* Radical changes in conventional weapons are not forecast for technical and fiscal reasons, but existing cutting-edge technologies will proliferate throughout the globe. The trend will be toward smaller, smarter munitions that have the potential to give the possessor a means to more rapidly prosecute a war.

Politics

The nation state will continue to be the dominant player on the international scene, but will confront fundamental tests of effective governance from globalization and increasingly vocal and organized publics. Non-state actors, criminal networks, and the rising dynamics of ethnic and religious groups will also confront the state. The United States should remain above many—but not all—of these troubles, and will remain the leader of the democratic free-market economies.

Military

A number of states will continue to develop or maintain weapons of mass destruction (WMD) programs to help control their security environment, including Israel, India, Pakistan, China, and Russia, among others. The central focus in Northeast Asia will be Korean integration and the resultant repercussions for Japan and China.

International Actors

Interaction among these drivers will deepen the trend toward a two-tier world, with the developed free-market countries of the first tier displaying growth, stability, cooperation, and peaceful economic competition and cooperation. Many of the second-tier states will experience internal divergence, decline, and conflict. Given its internal political problems and economic weakness, Russia is not included in the tier-one states. Several other states may transition from tier two to one, and there will always be a number of failed states, primarily in Central Asia and Africa. Non-state actors, including terrorist organizations, will continue to play a critical role, contributing significantly to further environmental complexity. The United States will remain a global leader, helped

in large part by the world's strongest economy and a commercial and military R&D infrastructure second to none.

In this rapidly evolving, complex environment, arms control will have to contend with an increasing number of actors and potential adversaries. Improvements in adversary technology will be aided by a network of technology trading among rogue states, exports from developed countries, the availability of dual-use technology, and improvements in indigenous technology capability. Indigenous technology capability will improve, and will less likely be constrained by arms control treaties.

Motivations to acquire WMD will vary. States may acquire these weapons as a means to gain national prestige, to dominate a region, to make a statement, or to respond to an outside threat. Advancements in threat technologies for the international security environment in 2015will include:

- WMD and means of WMD delivery
- Information warfare
- Critical infrastructure attacks
- Anti-access strategies
- Hiding forces in populated centers
- Denial and deception

In addition, the second-hand conventional arms marketplace (legal and illegal) will grow significantly, making it harder to control these weapons and to stem third party transfers and sales. This will exacerbate and extend the length of conventional conflicts in tier-two nations.

The current United States approach is to reassure allies, dissuade new threats from developing, deter current threats, and defeat threats or aggression when required. Potential adversaries

will be dissuaded from developing threat technologies through robust US research and the development and prototyping of superior military technologies to meet, deter, and combat new threats.

The United States will rely on tier-one states and regional players to provide broad stability in various regions. There could, however, be a divergence between the United States and Europe, creating a number of regional blocs. This would have a major impact on arms control, export controls, and general security cooperation.

The Future of the Regions

The United States and Europe (indeed, all the G-7 nations) will continue to exhibit economic growth, world leadership, and relative peace and stability. Other parts of the world will not be so lucky. Sub-Saharan Africa will witness the transition of many of its states to authoritarian regimes, the continuing outbreak of internal conflicts in many states, failed governments, recurring humanitarian and natural disasters, the pandemic of AIDS, and the possible rise of anti-Western Islamic leaders.

Compared to those problems, the rest of the world will not look so bad. Latin America, for example, will continue its slow movement toward legitimate democracies and economic development. Northeast Asia will continue to develop into an economic powerhouse, particularly given the inevitable eventual rise of China, but questions remain about the future of Korea and China's aspirations. Russia will still be trying to figure out its identity and overcome four generations of Soviet ineptitude; only its residual nuclear arsenal will make it worth notice by the West. The Middle East faces serious problems, but unlike Africa most of them are self-caused: the proliferation of WMD, conventional conflict

among neighboring states, terrorism and the rise of indigenous factions, and weapons trafficking.

Notably, the Middle East, with its heightened and proliferation-based danger, may be of lower significance on the list of United States national interests as renewable and other alternative energy sources begin to replace western reliance on petroleum-based sources. After 11 September 2001, however, this trend is more difficult to forecast. In the long term, following the United States' global war on terrorism, this may yet prove true. Even as the Middle East represents lowered security significance to the United States, South Asia will take on increased significance. India's rise as a regional power, the India-Pakistan nuclear relationship, and the inevitable increase in India-China contact and potential conflict will demand US attention.

Implications for Arms Control

As threats and adversaries become less clear and more numerous, a premium will be placed on enhanced intelligence capabilities to better determine adversaries, their weapons, threats, and intentions. Maintaining leading edge technology will be a key factor in transforming the US military and making it relevant for the 21st century.

Arms control will remain an important tool that can dampen the tendencies for WMD proliferation. Increasing numbers of adversaries, many with improved indigenous technologies, are less likely to be constrained by traditional arms control and formal treaties. This will result in traditional arms control applying primarily to tier-one countries and those in the transition zone between tiers, and nonproliferation strategies will apply to tier two. These tendencies will alter the position of formal arms control, but

they will also bring closer coordination and synergy between arms control and non- and counterproliferation toward meeting overall US national security needs. These new strategies will retain, and eventually expand, requirements for "arms control" technologies, especially those that also serve as intelligence platforms. Intelligence collection and monitoring requirements will be the primary drivers of future technology standards.

The potential for both state and non-state actors undertaking cyber attacks will make efforts to control cyber warfare extremely challenging. This may require an arms control shift from a diplomatic model to a law enforcement model that would provide better, more discrete, and binding standards. Information operations and protection will, with or without applicable arms control action, become an even more central dimension of United States defense practice. Information assurance and monitoring technology requirements will increase in importance.

ARMS CONTROL IN 2015

Arms control is a tool that can stem the proliferation of weapons, prevent weapons improvements, and reduce or eliminate weapons outright. It can also be a method of establishing norms. These are not mutually exclusive.

The Future Nuclear Arms Control Environment

Nuclear arms control will remain primarily a bilateral US-Russian affair through 2015. While the formal arms control process provides symbolic rights to nuclear parity, Russia will possess fewer strategic nuclear weapons than the United States. However, the gross asymmetry in tactical nuclear weapons in Russia's favor will take on even greater significance. High cost and the impact of missile defense systems may well preclude Britain and France from

being able to sustain a viable nuclear force. They may decide to denuclearize, unless the European Union wants to maintain an independent nuclear capability. China, though it will be more economically mature and more globally integrated, will not yet be a strategic nuclear challenger.

Formal arms control agreements will be considered essential and will continue through 2015. Long-term political stability and verifiability will be more important, increasing the emphasis on negotiated agreements to help maintain stability, verifiability, and transparency in the US-Russian relationship. The value of informal, unilateral agreements has been overblown—they do not create the required stability.

Offensive nuclear arms will still be a component of US deterrence strategy and, as a result, the United States will require a sufficient number of nuclear weapons to guarantee its own security and that of its allies. However, the trend toward further strategic arms reductions is clear, with a 1,500-1,800 floor of strategic warheads expected. With fewer than 2,000 warheads it will be very difficult for the United States to maintain the traditional Triad. Accordingly, it is possible that all fixed land-based MIRVed ICBMs may revert to a single reentry vehicle configuration and only mobile MIRVed missiles will remain. But the United States is on the threshold of a fundamental transition in offense-defense integration, and there will be a defacto meta-Triad consisting of missile defenses, offensive nuclear forces, and strategic conventional forces.

Verification will remain critical with large stockpiles of non-deployed, dismantled, withdrawn warheads and fissile material to be accounted for. Additionally, there will be an increased focus on

limiting nuclear force operations, requiring strict verification measures. Notions about "deployed" vs. "attributed" warheads will eventually be phased out, as the emphasis shifts to actual nuclear weapons loads.

Implications for Arms Control: Future compliance, verification, and monitoring will be challenged by the shift in emphasis from counting deployed warheads to counting the total stockpile, a greater focus on the operational aspects of deployed forces, the need to distinguish between space-launch vehicles and ICBMs, and between ABMs and ICBMs, and increased pressure to monitor strategic conventional weapons. Once the stockpile goes below 2,000 weapons it will be very difficult to retain the traditional Triad. And some argue that a stockpile of fewer than 1,500 weapons could actually encourage proliferation as other states (such as China) find it attractive to build up as the United States reduces its force levels.

Missile defense will be integrated into the Single Integrated Operations Plan and will cover theater, regional, and homeland areas. MIRVed ABM interceptors may be deployed in converted silos, fundamentally altering the offensive-defensive relationship. Freedom to mix offensive and defensive forces will be allowed as states transition to the new paradigm. In addition, the issue of tactical nuclear weapons may be linked to follow-on agreements with strategic nuclear weapons.

The United States may pursue the following objectives in a future negotiation:

- No further reductions beyond the floor of 1,500-1,800 warheads
- Integration of missile defenses into the strategic force posture

- Verifiable elimination of excess warheads and delivery vehicle stockpiles
- Dismantlement of non-deployed delivery vehicles or conversion to space launch vehicles
- Reduction of risk and protection against accidental or unauthorized launch
- Broadened stockpile transparency and ensured reliability and predictability of monitoring
- Monitor de-alerted force postures to guard against the reconstitution of a first strike capability
- Continued attention to address tactical nuclear weapon asymmetries

Future Chemical/Biological Arms Control Environment

The Chemical Weapons Convention (CWC) is touted as the most enforceable, intrusive, and verifiable arms control regime. The treaty's strength lies in its verification provisions, while its weakness centers on the difficulties in verifying and monitoring dual-use chemicals. And while the treaty allows for challenge inspections, none have been conducted.

The Biological Weapons Convention (BWC) bans the development, production, stockpiling, acquisition and use of biological warfare agents; however, it lacks many of the provisions of the CWC. It has no mechanism for compliance and verification and lacks a dedicated organization to implement and police the regime. Though in recent years the United States was involved in international negotiations to develop a verification protocol, it opposed the resulting draft document because of inadequate protection of proprietary and national security information. Allegations and documented cases of cheating, the role of non-signatories and non-state actors, and advances in biotechnology and

dual-use materials will continue to pose problems for the BWC in the future.

Implications and Technical Requirements: Failures or shortcomings, especially in the enforcement mechanisms of these regimes, do not portend their abandonment, but rather should stimulate thinking for new technical and procedural approaches. In the future, increasing reliance may have to be placed on non-treaty means—nonproliferation and counterproliferation—to address chemical and biological weapons (CBW), cheaters, and rogue players. There is a need for a portable area inspection system that incorporates micro- and nano-analytic instrumentation with robust agent identification capabilities. In addition, development should proceed on enhanced remote sensor capabilities (fluorescent biosensors and chemical tracers among them), agent neutralization, and better controls on delivery and dissemination technologies. Stronger information barriers must be developed in order to protect proprietary information. This is critical to the success of any future control regime.

Future Conventional Arms Control Environment

Currently it is difficult to find arms control specialists who focus on conventional weapons. However, by 2015 this will be a critical area of concern. First, conversion of some nuclear systems to "strategic conventional" roles will require a hybrid strategic and conventional approach to arms control efforts as an adjunct to nuclear efforts. Of much wider applicability, another reason for concern will be that except for the wealthiest states, few will be able to afford new advanced conventional weapons systems, and the market for system upgrades will grow significantly. The second-hand legal and illegal conventional arms marketplace will flourish

and rogue suppliers will multiply dramatically, fueling and extending conflicts in tier-two states. Covert and clandestine arms movements will exacerbate the difficulty of trying to control this environment.

Implications and Control Recommendations: While controlling this environment will be difficult at best, both traditional and non-traditional arms control approaches should be used. One effective strategy will be to solve one distinct issue at a time—such as anti-personnel landmines—and use these successes as the foundation for new agreements. Another approach could be to link arms trafficking to war crimes, prosecuting a number of high profile-cases to dissuade other would-be traffickers. However, identifying perpetrators would require the intelligence community to refocus on small arms trafficking.

A number of existing technologies, such as electronic global positioning system (GPS) tagging or "jarking" could be used to track weapons movement and gather evidence against proliferators and traffickers. Another method to handle proliferation is to add degrading chemicals to small arms ammunition.

Space Arms Control Environment

From a national security standpoint, US military space has evolved considerably—from spying on the USSR and Cold War arms verification to supporting the tactical warfighter during recent conflicts. Presently, there are four areas of space use considered most vital to the United States and growing in importance to the rest of the world: civil space (NASA); commercial space (telecom satellites); military space (support to DoD); and intelligence. Of the four, commercial space has grown the most rapidly, but it is the

dual-use aspect of most commercial space technology that underlies the importance of future arms control in this arena.

Although the 1967 Outer Space Treaty is the most comprehensive agreement on space to date, it falls far short on creating a viable verification regime. While it does ban WMD in space, it lacks strong definitions regarding what is meant by "peaceful purposes" or "where space begins." The 1972 ABM Treaty, on the other hand, prohibited space-based anti-ballistic missile systems and, some believe, established a regime on anti-satellite systems (ASAT) by prohibiting interference with National Technical Means (NTM) of verification. Distinguishing between ASAT and NTM interference is an example of just how difficult it would be to monitor a true space arms control treaty.

Future Issues in Space Arms Control: Greater transparency of space activity is critical. Monitoring and tracking orbital debris will become increasingly important and especially difficult for items further out in orbit. This requires an orbital debris regime that could be fashioned along the lines of space traffic control.

Advances in the resolution of commercial imaging systems, radar, and electronic surveillance are impacting the US military's ability to maintain secure operations. The US currently plans to deal with this issue by "shutter control"—requiring industry to shut off data streams in the interest of national security. In the future, this might instead be controlled through arms control and remote sensing agreements. A far tougher challenge will be dealing with high altitude electromagnetic pulse (HEMP) radiation emitted from nuclear detonations in space. HEMP could incapacitate every satellite in the area and damage others as they pass through the residual radiation belt. One alternative is to enhance the hardening

of space systems circuits and other hardware. Another vague distinction is the differentiation between activities in space and activities through space.

Regardless of whether the United States pursues the weaponization or increased militarization of space in the future, space arms control will loom as a larger potential constraint to US actions. Rather than avoiding space arms control all together, the United States should determine what kinds of agreements would be most beneficial to its interests.

Information Arms Control Environment

Information operations are actions taken to affect an enemy's information systems while protecting one's own. These systems can be weapons as well as targets. The United States is the most advanced information state, but that also makes it the most vulnerable. The Russians, too, are quite concerned about the threat information operations pose to their command and control networks; they desire strict controls on what they view as a WMD threat. On the other hand, the Chinese view information operations as a "people's war" where every Chinese citizen would be encouraged to engage in attacks. Both countries perceive information operations as highly destabilizing because they would disrupt the dynamics of deterrence.

The current US perspective is that information operations can be sufficiently governed by existing principles of the laws of armed conflict. However, current international agreements place few restrictions on information operations. The international community has only recently drafted a definition of computer crime and begun working on a cybercrime convention. Russia recently proposed a

UN resolution seeking secure systems that could be protected from computer crime, terror, and cyberwarfare.

Future Issues in Information Arms Control: In the future, broad international cooperation will be critical in order to strengthen and protect information infrastructures. This should be a critical topic on the agenda of the Conference on Disarmament. A variety of potential information operations will warrant such controls: cyberwar (political/military attack); cyberterror (political disruption); cybercrime (financial/non-political); and cyberactivism (political). While there may be advantages to arms control in areas of cyberspace where a state is most vulnerable, the biggest control issue is policing any agreement, a difficult task to accomplish with any certainty.

The best place to start establishing control may be in the realm of cybercrime, where there would be the least international resistance to a control regime. The results could then be used to establish precedents and procedures for other areas where it would be more difficult to establish consensus.

The United States should carefully consider entering into an information operations no-first-use pledge, but it should not miss the opportunity for engagement in this area. If it does, it runs the risk of being surprised by a treaty in which it had little influence.

Arms Control Technology Requirements for Compliance, Verification, and Monitoring

Outlining arms control technical requirements in a rapidly evolving international environment is an inexact science at best. Space and information operations introduce entirely new arenas, exacerbating the predictive difficulty and increasing uncertainty. However, many of the current target technologies are already relatively mature, making major advances less likely. At the end of

the day, practitioners must define what is practical, leveraging other areas when possible to enhance resource efficiencies and the likelihood for success. For example, many of the technologies that are relevant for arms control are also relevant to intelligence monitoring. Another approach for new technology is to enhance sensors and take advantage of a combination of systems, leveraging information technology, system management, and system integration. A promising approach may lie in knowledge creation and management, establishing a single, central repository for all "arms control" information input; processing and analysis of the data into usable knowledge (requiring advanced computing technologies and applications); and analysis and dissemination of that knowledge to further a wide variety of national security programs and objectives. However, that will require compliance verification and monitoring technologies to create the relevant data.

In the future, new technologies must provide more effective verification capability and be less expensive, less intrusive, and more automated. Generating knowledge from massive amounts of collected data will also require a new level of trust in software programs. The one area where we have no verification experience is biological weapons, and the community needs new ideas and a paradigm shift. What that paradigm will look like, no one yet knows. Our Phase Two workshop panelists assumed a relatively straight line continuation from existing arms control regimes and requirements for the next 15 years; they presumed few radical changes in direction.

Intrusive Arms Control Environment: An “intrusive” inspection is one where an inspector is on-site and impeding operations to

some extent. From a nuclear arms control standpoint, inspection activities include materials, weapons, and delivery platforms.

While today's arms control agreements are predominately bilateral, in the future they could become multilateral and expand to include both warhead and facility monitoring. By 2015 there will be a large declared inventory of special nuclear material, possibly including neptunium and americium in addition to plutonium and enriched uranium, further complicating monitoring issues. Classification issues will continue to impede free information exchange, and a variety of warhead limitation treaty scenarios may emerge, including dismantlement verification to identify a weapon's class and reconcile facility throughput; warhead fingerprinting to establish a weapon's unique identity; and exclusionary monitoring to verify whether a container actually holds a weapon.

Over the next 15 years, inspectors will continue to be the key element in verification and will be expected to accomplish more activities at lower cost. Inspection tools will often be supplied by the host country, which may raise reliability concerns. New technology will be required for evolving monitoring requirements such as warhead verification.

Commercial and military technology development will significantly impact future inspection capabilities. Some of the new items on the horizon include the following:

- Quantum computing in both desktops and laptops, improved data generation/handling, and lower power requirements. These will enable robust authentication and encryption capabilities and allow inspectors to more quickly transform large amounts of data to knowledge.
- More effective and flexible power sources will enhance mobility and wireless communication.

- Smart antennas with full directional control will be introduced.
- A micro-machining revolution will emerge.
- New information barriers will ensure protection of sensitive information providing more transparency to inspectors.
- Tamper indicating materials (active and passive), seals, and tags will aid in tamper indication and unique identification.
- New field-portable material characterization methods, techniques, and tools will be critical in identifying non-disclosed activities.

Non-Intrusive Arms Control Environment: Arms control agreements have tended to control either nuclear materials or delivery vehicles rather than weapons or warheads. As weapons and warheads are incorporated into the regime, transparency issues will apply throughout the production and deployment phases.

Technology offers the potential of replacing on-site inspections, providing a more palatable alternative for future arms control regimes. There are four key topic areas for non-intrusive measures in the future—reactor materials, weapon-source materials, weapons and platforms, and pits and warheads.

Reactor Materials: Atomic reactors are the most common source of special nuclear material, but because the raw material going into the reactor is not classified, little attention is paid to reactor operations. However, signatories to the Nuclear Non-Proliferation Treaty have agreed to allow monitoring of their facilities. This is critical because such an effort would require placing monitoring equipment in very specific locations throughout a facility. The technical requirements for facility monitoring are unclassified and non-intrusive and must be conducted in a moderate radiation environment. New technologies to consider in this area include tags, diversion detection, tracking, and a global information

database. A good example of new facility monitoring technology is an anti-neutrino detector which shows changes in the relative percentage of uranium and plutonium in a reactor core, thereby indirectly indicating whether plutonium has been removed.

Weapon Source Materials: Classification issues on weapon design and materials composition coupled with highly intrusive on-site inspections make verification and monitoring of dismantled weapons material very difficult. Areas for future research include developing an information barrier that protects classified information and creating alternative non-intrusive detection methods.

Weapons and Platforms: This is the area that in most past and existing treaties required very intrusive verification methods. Moving to a technology-based, non-intrusive monitoring regime would require a fundamental trust in technology that does not exist today. Because platform location and weapons information cannot be revealed, future technology requirements will include secure tags that do not compromise location and reliable data authentication that does not disclose classified information.

Pits and Warheads: This is the most difficult area in which to direct future, non-intrusive verification technologies, and no current agreement covers the highly sensitive area of nuclear warhead monitoring and dismantlement operations. Trusted technologies must be developed to replace intrusive on-site inspections in order to open a future path to pit and warhead transparency. Close cooperation with Russia is essential. Areas for future technology development include radiation monitoring to fingerprint warheads; reliable data authentication, protection,

encryption and dissemination; information barriers; and reliable, non-intrusive facility monitoring.

Reactor monitoring provides the least controversial activity and would be a good place to begin building expertise and trust. Weapons/platform monitoring, currently highly intrusive, is not likely to change dramatically by 2015. Pit and warhead monitoring may become more transparent, but will face formidable challenges and concerns.

Biological Weapons Monitoring Technology Requirements

A requirement exists for medical practitioners to be able to identify and differentiate a biological attack from a naturally occurring outbreak of disease. Sandia National Laboratories has developed a prototype system that relies on data entry by medical professionals to create a database and identification program that does just that.

There are tremendous difficulties involved in monitoring biological weapons materials. The level of intrusiveness required to be successful goes well beyond what most nations would find politically acceptable. The United States recently rejected the draft BWC Protocol because of a number of issues: questions of ambiguity, high hurdles for challenge inspections, and no means of identifying or tracking international diseases. Sandia's Rapid Syndrome Validation Project (RSVP), a biological anomaly detection and tracking project for the medical community, provides a tool and methodology for differentiating between a BW attack and a naturally occurring disease outbreak. The eventual goal of this project is to map the global biological background, then map diseases, and finally be able to identify a disease signature that stands out against the background. Sandia is working to set up

possible collaboration with biological labs in the former Soviet Union.

Remote Sensing Arms Control Environment

While current technology provides us with the ability to conduct long-range standoff monitoring of selected WMD and conventional weapons, there is currently no good approach to long-range monitoring of biological agents. Remote sensing provides large area coverage, can provide temporal coverage in situations that would otherwise require frequent re-visits or continuous coverage, and can also complement on-site visits.

In the future the United States will continue to use many of the existing remote sensing methods, including seismic, acoustic, hydro-acoustic, air sampling, optical, electro-magnetic pulse, x-rays, neutrons, and gammas. Chemical and nuclear weapons development will continue to be monitored using spectral sensing, imagery, and sampling. Conventional weapons monitoring will be done with spectral sensing, infrared sensing, and imagery. However, enhanced spectral sensing will be developed to characterize effluents, identify objects, and read tags on treaty-limited items. Radio-frequency sensing will be enhanced to identify objects by their electronic emissions. Automated feature recognition tools will be deployed to assist with the analysis of huge amounts of data.

Non-Traditional Arms Control Requirements

There is a need for small, inexpensive sensors that can track and monitor the huge quantities of material left over from the Cold War. Current technology, much of it developed for the INF Treaty, can solve a number of verification issues, such as distinguishing between nuclear and non-nuclear warheads, and identifying how

many warheads are hidden behind a shrouded reentry vehicle. The real difficulty will be creating an agreement to allow this technology to be put into use.

Is it possible to develop a web technology that filters out the background and raises a red flag when required? Miniaturization and nano-technologies are fairly advanced in the nuclear testing arena.

MAJOR FINDINGS AND IMPLICATIONS

The National Security Environment and Arms Control

Continuing Bifurcation: Under the increased influence of globalization, the international system will continue and deepen its trend toward bifurcation. The international system of the future will be shaped primarily by economic drivers. Globalization will continue to advance among the states of the first world—Western, industrialized, free-market states. At the same time, the benefits of globalization will bypass, to greater or lesser degrees, much of the second world. These states will be exploited for resources and labor, but will not advance at nearly the same rate as the continually growing first world. However, some states at the top end of the second world, those that are economically advanced and/or resource rich enough to find themselves entering the transition zone between the second and first worlds, will become the focus of special attention and concern.

Technological factors will also influence the security dimensions of the international system. The first world is today the home of high-tech innovation and development, and it will remain so. The second world will continue as technology users, and it will host assembly operations for some high-tech components, but it will not experience technological innovation or development. The

transitional states will host co-production facilities with first-world states for high-end commercial and conventional military technologies, and some level of reverse engineering is possible here—either with or without first-world permission. Innovation in systems will also be seen here, and innovation in applications will be common.

Thus, the international system of 2015 will consist of three different sets of security relationships for the United States. First, the relationship between the United States and the other states of the first world will, for the most part, be cooperative and peaceful. A high degree of economic integration and industrial internationalization will be the norm. Areas and issues of lingering competition will be addressed through consultation. Political and security consultation, and most often coalition action or toleration, will characterize this relationship. The one wild card identified here is the possibility of a degree of competition and mild divergence between the United States and Western Europe focusing on competitive economic practices and a weakening of NATO bonds.

United States relations with the second world will be shaped by the degree of stability of the individual state and its economic linkages to the first world. Those exhibiting even mild growth, possessing at least moderate amounts of desired resources, and attempting to institute or stabilize nascent democracies will be the focal point of United States policy. At the same time, some of these states' neighbors will likely include failing and failed states—those stagnating or regressing economically, without sufficient resources to exploit for survival, and facing internal chaos and disintegration. The worst cases are likely to spawn and host criminal and terrorist organizations, to be on the receiving end of weapons proliferation

for use by non-governmental organizations (NGOs) or by desperate failing governments, and perhaps to instigate regional conflict. The relative degree of global economic stability and growth will determine the degree of threat posed to United States security interests from this world.

Finally, security relations with the transitioning states will represent the focal point of much of the national security efforts of the United States. These states possess resources, economic linkages, and security interests important to the United States, and they represent both likely partners and protagonists. It is this area that we will not be able to avoid, nor will we be able to unilaterally predetermine the exact nature of the ties nor the relationships involved. If the less developed mass of the second world represents the failing state and non-state conflict threat, the transition zone represents the highest potential for state-level threats to United States interests.

Arms Control as an Umbrella Concept: This system will shape United States arms control. "Arms control" will be a broad, umbrella construct within United States national security policy that includes the full range of cooperative and coercive efforts to enhance security through controlling, limiting, reducing, and eliminating weapon systems and military capabilities.

Arms control efforts within the first world will center on forging a cooperative front toward the second world and transition states, and on securing a continuing and productive future for first-world institutions such as NATO and what is today the G-7. The major issue here, besides establishing a consensus on objectives and burden-sharing for the implementation of second-world and transition zone controls, will be overcoming the residual national

competition to establish meaningful and enforceable export controls to stem proliferation. Such cooperation will become ever more difficult to arrange or enforce as competition endures—particularly between the United States and its US-dominated international corporations on one side and European and EU-dominated corporations on the other—and most particularly in the conventional arms and delivery systems arenas.

The United States arms control relationship with the second world will center on non- and counterproliferation efforts toward weapons of mass destruction and advanced conventional arms, and on disarmament activities within broader peace operations. Many of these efforts will necessarily be unilateral and non-cooperative, seeking to impose arms limitations and transfer restrictions on unwilling states, groups, and networks.

Most of the formal arms control focus, and much of the United States' broader arms control effort, will fall to the transitioning states between the two worlds. The "endgame" of the US-Russian START and Cooperative Threat Reduction programs will continue, with any new strategic systems and warhead reductions—either negotiated or unilateral—requiring cooperative safeguards and monitoring. Non-strategic nuclear weapons will also be added to the equation, and this set of programs will expand greatly, with significantly greater requirements for inspections and monitoring.

Increased United States arms control presence is also probable in Northeast Asia, with informal (and largely bilateral) efforts to forge confidence building and other foundational cooperative measures with China, Japan, and a likely unified Korea. This will be a slow, long-term effort, relying to a large extent on US monitoring technologies to provide transparency and neutral

reliability. United States monitoring technologies could also be central to equally tentative steps toward transparency and nascent cooperation in South Asia between India and Pakistan. Such nuclear "peacekeeping" could also play a role in the Middle East by 2015, although the major arms control focus in that region will continue to be on non- and counterproliferation.

Today's increasing emphasis on dealing with the problems of proliferation—of weapons, of technologies, and of delivery systems—will continue, with increasing coordination between nonproliferation and counterproliferation efforts across the spectrum. The balance within this effort will shift toward counterproliferation, combining active and cooperative efforts to restrict and eliminate potentially hostile capabilities. Detection, tracking, and monitoring technologies will be needed in both intelligence and arms control roles.

Finally, these complicating developments will be multiplied by the continuing problems of non-cooperation among first-world actors on arms controls implementation and compliance verification. Both the continuing military systems development and sales competition between first-world states and the growing power of the multinational corporation even outside of state control will render such cooperation as effective export control regimes unattainable or unenforceable. Even now we see European states moving toward reliance on simple "pledges of compliance" as the verification vehicle for export controls on missile technologies, and this inability to forge effective multinational verification methodologies will only deepen. Unilateral verification and monitoring capabilities are also indicated here, with a further blending of arms control and intelligence systems requirements.

Arms Control Forms and Focus, 2015

Continued Preeminence of Nuclear Issues: The period between now and 2015 will see significant focus on the endgame of Cold War bilateral nuclear arms control between the United States and Russia, as well as continuing emphasis on nuclear non- and counterproliferation. Formal strategic nuclear arms control remains today the bilateral provenance of the United States and Russia. That formal dimension is supplemented by the cooperative threat reduction focus of United States arms control efforts. Russia sees its nuclear capability as both symbolic of residual major power status and essential as its conventional capabilities continue to decline and age. Therefore, it will preserve this capability even as others—notably Britain and France—consider denuclearizing their forces. China, while it might possibly expand its systems, is unlikely to seek nuclear first-tier status through 2025. Other second- and third-tier nuclear states will not become factors in the strategic nuclear equation by 2025, and indeed may opt for at least some level of limited reductions.

For Russia, both unilateral and reciprocal cuts are inevitable, perhaps below a floor of 1800-2000 warheads. This implies a heightened requirement for effective CV&M to guard against cheating as the United States reduces its arsenal toward similar levels. It also implies an expanded requirement for monitored stockpile management and materials disposition for withdrawn and decommissioned warheads. Any formal arms control agreements in this drawdown will require on-site inspections and intrusive compliance monitoring regimes.

Given the vast disparity between US and Russian inventories of non-strategic weapons, it could also become a United States

imperative to incorporate these weapons into the strategic weapons mix. The result will likely be a significant increase in on-site and weapons destruction monitoring requirements, as well as greatly increased requirements for both permanent and periodic non-intrusive verification monitoring. Further, with likely replacement of strategic by conventional warheads on both operational and strategic delivery systems, requirements must specifically address warhead verification capabilities.

A third complicating factor between the United States and Russia will be the introduction of defenses, with a move in arms control toward limits on combined offense-defense mixes. This may require new verification capabilities and systems, and highlights one particularly challenging feature of this future environment: offensive uses of arms control such as shielding. As both formal and informal cooperative controls on strategic systems move toward aggregate limits—on strategic offense/defense mixes, for example—and strategic systems conversions become common—from ICBM to space launch vehicle, or from nuclear ICBM to conventional ICBM—it will become standard practice to shield systems deployed in identical silos as a security measure. The same problem will be present in operational systems with both non-strategic nuclear and conventional warheads. The silo could house a strategic or a conventional weapon, an ICBM or an interceptor, a warhead or a penetration aid, or even a decoy. Verification and monitoring capabilities will be needed to differentiate payloads, certainly utilizing non-intrusive systems but also often using remote platforms.

An important and expanded requirement for nuclear arms control in 2015 will be increased monitoring of operational aspects

of Russian nuclear systems and strategy rather than strictly the hardware dimension. The many systems mixes imply complex employment strategies and doctrines, complex command and control systems, and complicated deployment, exercise, and testing regimes. This situation presents a requirement for monitoring and verification systems that have both technical and human component requirements and that differ greatly from traditional nuclear system verification technologies. These systems will need to be able to identify, translate, collate, analyze, and create usable knowledge from diverse technical signals and operational materials. They lie as much in the realm of information processing and knowledge creation/management as they do in the more widely identified world of arms control, and they require vastly different human skills than do technical nuclear monitoring systems.

Beyond US-Russian nuclear arms controls, one potentially new application of nuclear CV&M technologies by 2015 could be "nuclear peacekeeping." The potential exists for regional cooperative regimes between second-tier nuclear states—particularly between India and Pakistan—that could possibly require an interposition of United States systems for transparency and agreement CV&M. Systems developed for use in US-Russian arms control will likely suffice, but will need to be deployable into different operating environments.

Nonproliferation and counterproliferation will also be increasingly emphasized in 2015. The focus in Russia will be on stockpile surety and conversion monitoring of the withdrawn strategic and non-strategic nuclear warheads. It may also include a broader "systems" focus on the proliferation of nuclear weapons-related hardware, software, and technical expertise. This implies a

shift in emphasis to vigilance monitoring from more narrow verification monitoring, with a mix of both more traditional hardware-focused technologies and software and knowledge management technologies.

Nuclear CV&M, then, will remain a centerpiece of United States arms controls through 2015. Both the criticality and the scope of the nuclear CV&M requirement will increase, with expanded stockpile monitoring requirements that reflect a shift from deployed to aggregate warheads, and from discrete strategic systems to aggregate, mixed systems—strategic and non-strategic, strategic nuclear and conventional, and strategic offense and defense. The landscape will also take on added dimensions from the addition of operational factors as well as systems hardware, from increased focus on proliferation concerns broadly defined, and from expansion from the US-Russian nuclear relationship to include at least some application within the second- and third-nuclear tiers.

Dual Use Issues in the Chemical and Biological Arenas: Chemical arms control and non- and counterproliferation will receive increased focus, and will continue to be plagued by the dual-use dilemma as it complicates compliance verification and monitoring. The control of biological weapons will require meaningful arms controls and enhanced non- and counterproliferation efforts. This arena will face dual-use and proprietary barriers, as well as technical difficulties, in developing meaningful compliance verification and monitoring capabilities.

The 1993 Chemical Weapons Convention bans the production, acquisition, stockpiling, and use of chemical weapons. It also specifies the most extensive and intrusive compliance verification and monitoring regime of any arms control agreement—one based

upon on-site inspections and including a formal implementation and monitoring organization and program. However, verification today fails to reach that promise because of dual-use and corporate proprietary concerns that greatly complicate the design of discriminating technologies, and because state parties cannot agree how to address further cooperation and enforcement. Continuing displacement of state power by corporate power and economic integration across borders will only exacerbate these problems.

The 1972 Biological Weapons Convention similarly bans the development, production, stockpiling, acquisition, and use of biological warfare agents. However, it lacks almost all provisions for compliance verification and monitoring, and it has no dedicated implementation organization outside of the United Nations. Biological weapons verification also faces dual-use and proprietary issues within the highly competitive international bio-medical community.

The chemical and biological arenas require both a new generation of technologies and new procedural approaches to CV&M. Both sets of approaches must be developed in full recognition of the strong and broad opposition to intrusive controls (impediments that are certainly not going to go away in the next decade or two), the complications of discriminating in a dual-use situation, and the absolute requirement for portable area systems and remote monitoring systems. Developing either effective procedural or technical information barriers to allow more direct and intrusive CV&M inspection access while also protecting essential proprietary dimensions would help strengthen the cooperative approaches to controlling these threats. Outside of such cooperative approaches, systems are needed to enhance both non-

and counterproliferation efforts—particularly those adaptable to force protection monitoring and warning for forward-deployed and deploying units and systems.

Growing Significance of Conventional Weapons: Conventional weapons will be an arena of greatly increased significance for arms control efforts on three fronts: strategic conventional weapons, advanced conventional weapons, and small arms proliferation and controls.

Converted strategic-to-conventional weapons raise issues of verification discrimination among offensive strategic nuclear systems, defensive ABM systems, strategic conventional systems, and strategic decoys/penetration aids all sharing similar silos and often identical launch vehicles and deployment shielding. In addition to those significant problems—and the use of converted ICBMs for space launch vehicles, as well—these strategic conventional systems raise issues of operational control such as launch notification, shared warning centers, and observer-monitored command and control systems. Technologies and programs to screen use doctrines, monitor field communications, and remotely ascertain system characteristics are needed.

Advanced conventional weapons and weapon delivery systems are not currently subject to formal arms controls. One primary issue here is that even first-world allies, caught in the combination of domestic economic imperatives to reduce defense spending and the post-Gulf War belief that Western conventional systems are so superior as to not require upgrades, are beginning to raise indirect issues that would impinge on United States weapons development or use. Redefining justifiable collateral damage and other restraining rules of engagement would limit even NATO

operational and weapons options, and this arena is one that will require constant United States attention and vigilance. One possible technological answer here would be improved battle damage assessment technologies—perhaps derivative from arms control verification systems—that would allow continued operational flexibility and assurance of effects to overcome blanket prohibitions against advanced conventional system employment.

Small arms controls are an arena of popular effort both inside and outside of the standard state system and the UN Conference on Disarmament (CD) process. The one major formal agreement in this field, the Ottawa Convention on anti-personnel land mines, was reached though the combined efforts of NGOs and selected governments outside of the normal arms control channels. Parallel efforts to address landmines were under discussion in the CD at the same time, but were stalled because some nations were uninterested in major operational or system changes in their use of mines. That same lack of urgency currently applies to small arms in general; however, continuing proliferation of large supplies may gradually build pressures to act. The widespread proliferation and relative low technology of these weapons effectively precludes traditional export controls. Arms control efforts here, including monitoring stockpiles of weapons cached under disarmament programs within peace operations, will focus on tagging and tracking arms movements using electronic or chemical tagging. Effective operational and strategic monitoring systems are needed. These procedures and systems will also have application in non- and counterproliferation programs beyond the small arms arena.

Demands for Space Arms Control: The United States commercial and military reliance on space systems will lead to an

ever-growing importance of space defense and control. There will be, by 2015, a growing impetus for "arms controls" in military space operations. These efforts represent two-edged swords for DoD. Controls on threatening space systems and activities will, nonetheless, become a major United States interest.

The commercial/governmental space relationships will grow in size, scope, and depth by 2015. This projection was made by all three of the most recent national space commissions. Space use has been shifting from the military toward clear civilian dominance, and almost all space activities are or could be dual-use. As space continues to become primarily commercial, several implications are clear that relate to arms control in 2015.

Military space control will be an ever more significant military mission. The ability to monitor space systems of others—to discriminate system capabilities remotely—is a clear requirement as strategic capabilities migrate from air to space. Cataloging and tracking on-orbit and trans-orbital systems, as well as space debris, is imperative. Real-time tracking of commercial imaging systems—which already provide users with a militarily significant capability—is also needed to either exercise “shutter control” or to provide warning to allow masking of activities on the ground. This situational awareness is a foundational requirement for both space control and enforcement of potential space regulation regimes that are likely as multiple nations vie for expanded space access.

Space control imperatives could lead to a national decision to weaponize space. The few treaties and agreements that today address space place few restrictions on such systems, but many states and groups will oppose any such move. An attempt to bypass the United States, isolating it in world opinion, by banning such

weapons should be anticipated, complicating the US use of space. Any agreement here, as well as the more formal arena of space arms control discussions, will likely focus on regulating broad military uses of space as opposed to specific systems and capabilities. Any such proposals or agreements will certainly have broad externalities.

Arms control CV&M in and from space will become more complicated politically and legally. Regardless, NTM and dedicated CV&M systems will require space access and the ability to operate. Space-based monitoring and reporting will characterize virtually every arms control activity. Finally, the arms control community should continually investigate advances in commercial capabilities for potential adaptation to its needs.

Demands for Controls on Information Operations: The years to 2015 will see a continuation and deepening of the centrality of information to all United States commercial and defense activities. As is true for space arms control, international "cyber arms control" efforts will have dual-edged implications for DoD. However, information infrastructure assurance, protection against cyber attack, and controls on international information operations will be of critical importance to the nation.

The protection and operational assurance of critical infrastructure is today essential to virtually all arms control implementation activities, particularly CV&M. That dependence will not decrease between now and 2015. It characterizes all military and commercial operations for the United States today and into the future. Because of this dependence, infrastructure protection has become a primary concern, and several draft agreements are on the table to address cyber-crime, cyber-terrorism, and cyber-warfare.

As with space arms control, the United States has several significant concerns about the carry-over implications of these drafts for military information operations and legitimate national information warfare operations. Progress will be very slow as we identify and discuss needed arms control exemptions, but the nation will continue to pursue this path as well as unilateral protection and controls. As defensive technologies and practices are developed, the arms control community must immediately incorporate them into its systems to ensure timely and continuous CV&M implementation. As with space, commercial and other military R&D efforts should provide the technologies here. The arms control community, however, must identify useful applications and initiate any adaptations for its unique environments.

Arms Control Compliance, Verification, and Monitoring Technology Issues

Continued Role for Inspections: On-site inspections and associated intrusive technologies will continue to be essential tools for nuclear, biological, chemical, and conventional compliance verification and monitoring. Technical advances are needed in sensor capabilities, globally adaptable power systems, and system operation and reporting capabilities to allow less intrusive applications and unmonitored, automated operations.

The expansion of the scope of United States-Russian nuclear stockpiles to be monitored, a shift from materials and weapons monitoring to warhead monitoring, the expanded application into the chemical and biological monitoring arenas, and the potential addition of multilateral applications of these systems will require both quantitative and qualitative improvements in current systems and capabilities. Specific areas to target for development include miniaturization of systems for global mobility, field encryption and

secure transmission capabilities, reliable and enduring internal power sources, tamper-indicating systems, and expanded field monitoring and characterization capabilities to allow applications in monitoring a wider variety of materials and activities.

Non-Intrusive Technologies: Cooperative controls and non-intrusive technologies will assume greatly increased significance. Technical advances are needed to address problems of warhead monitoring and to assure dependable, deployable global operations.

As with intrusive technologies, area-monitoring systems must be adapted to expanded applications, including warhead monitoring capabilities, and to chemical and biological weapons. As regimes specifying on-site inspections expire and new agreements shift toward less intrusive monitoring, this area must become a central focus of arms control technology development. Within the nuclear arena, improvements are needed to allow monitoring of reactor operations in a moderate radiation environment. Systems are needed to provide information barriers to protect classified aspects of weapons source materials while simultaneously allowing detection and monitoring. Mixing of diverse weapon systems between silos and other operational trends also require effective tagging and warhead "fingerprinting" that does not compromise exact location, as well as selective information barriers to ensure effective transparency and security. Informational technologies and knowledge management capabilities are as essential in the nuclear monitoring arena as are traditional technical hardware systems. Finally, a miniaturized, portable and multi-agent capable chemical (and eventually selected biological) agent detection and identification system is essential both for arms control and force protection applications.

National Technical Means: Remote monitoring and compliance verification via national technical means will link intelligence and arms control even more closely together and will be at the heart of year 2015 United States efforts in this entire arena of controlling weapons and threats.

Several findings have noted shared technology requirements for arms control CV&M and intelligence. The expanded focus outward from nuclear to chemical, biological, conventional, space, and information will necessarily move arms control efforts from formal, treaty-based regimes to less formal, multilateral, and unilateral efforts. These changes in focus all increase the requirements for area and global systems for effective CV&M. Remote monitoring of nuclear testing is today very well developed; efforts should begin there to expand from those systems and concepts into the new arenas. The full range of sensing systems and capabilities must be investigated for effective applications to nuclear and chemical proliferation, to conventional weapons tracking and space systems transparency, and to biological and informational process applications. Hardware development here must also be accompanied by effective informational system development to allow and ensure full capability utilization.

Special Requirements for Biological Weapons Monitoring: Monitoring and compliance verification associated with the biological threat represents a special case for technology and systems development. Given the limitations faced today, this is an area that requires increased attention and resources.

Requirements to develop an enhanced biological agent detection and identification capability for arms control, and for counterproliferation and force protection applications, have already

been noted. Beyond that, there is the requirement to track national (and eventually global) disease vectors to differentiate natural occurrences from biological attacks and to project disease progression and plan responses. Prototype systems are being demonstrated on a smaller scale. As these systems mature, data processing and decision-support systems capable of enduring real-time access to and analysis of huge amounts of data will be required. Development of those informational systems must proceed apace with the maturation of the monitoring systems.

The Human Dimension of Technology: The success of United States compliance verification and monitoring programs—and indeed of all arms control and national security efforts—depends directly on the critical and often overlooked human dimension of technology.

The Department of Energy has noted a growing and critical shortage of nuclear engineering expertise that is already affecting their ability to support the DoD nuclear weapons programs. This specific shortage also will increasingly affect nuclear arms control efforts. Similar shortages—or the inability of government to compete with industry for chemical engineering and biological/medical expertise—will negatively affect other arenas of arms control. The development of more sophisticated CV&M systems as envisioned throughout this report will also increase the requirement for capable technicians to employ these systems and technologies in the field. In addition, the military services are already facing both personnel shortages and the direct elimination or reduction of programs that have traditionally supplied personnel with experience and expertise in the strategic-level conceptualization and integration of nuclear strategy and arms

control. Such human shortfalls—plus probable equivalent requirements for space and information strategic expertise—must be specifically addressed. This includes deliberate requirements definition, development program specification, and resources allocation.

Data and Knowledge Management: Singular attention must also be given to arms control data handling, knowledge creation, and knowledge management. Year 2015 efforts, programs, and technologies will require greatly expanded capabilities.

Data security from fixed and mobile CV&M systems—permanently deployed, temporarily deployed, and remote—must be assured for effective monitoring. And data identification within a flood of diverse technical and operational electrons, translation and collation into useable information, tailored analysis into useful knowledge, and management and presentation of that knowledge into decisionmaking format is essential. This requires advanced supercomputing capabilities for data handling and processing, enhanced software to discriminate and compile that data into information, and sophisticated knowledge management and decision support systems to display and manipulate the knowledge toward strategic program management. It also requires human skill development and procedural system design to make optimal use of the potential that hardware and software developments will create.

CONCLUSION

The international security environment in the year 2015 is likely to place less emphasis on traditional arms control, with a concomitant increase in emphasis on countering WMD proliferation. The net result will be continued requirements for arms control technologies, and increased requirements for new

applications of arms control verification and monitoring technologies in counterproliferation and intelligence applications. Further, the national security policy of dissuasion will emphasize continued US R&D efforts in basic sciences and technology, many of which will have potential spillover utility for the arms control community.

Arms control will remain a central instrument of United States national security policy in 2015. It will incorporate many more informal and unilateral approaches than were employed across the Cold War and its immediate aftermath, as well as formal mechanisms from that earlier period.

Less intrusive area monitoring technologies and remote systems will predominate. This requirement and these systems will even more closely link cooperative means of arms control with more unilateral approaches such as counterproliferation and force protection, and with national technical means and other more general intelligence efforts.

Advances in the wide array of science and technology—particularly micro- and nano-technologies and almost unforeseeable advances in computing—can both greatly facilitate CV&M systems and greatly complicate CV&M problems, as can new arms control arenas such as space and information. The United States must make a strategic effort to lead these advances and manage their impacts toward enhancing rather than detracting from US security interests.

Both the human dimension of technology and the treatment of geometrically increasing cascades of data will pose major challenges to any 2015 arms control effort, regardless of the capabilities of CV&M systems. A deliberate and strategic effort is also essential here, both to grow a competent and capable bench of

scientists, technicians, and strategists to oversee and implement these controls, and to ensure that wisdom and strategic vision can be applied in light of conclusions drawn from critical elements of useable knowledge drawn from focused and fully informed analysis.

As recent events have underscored, the world of the early twenty-first century presents us with a full spectrum of dangers—enemies both new and old; weapon systems both high-tech and low; applications both traditional and innovative; attacks both abroad and at home. Arms control efforts, enabled by effective CV&M technologies used in both cooperative and unilateral applications, must be a central focus of threat reduction, force protection, homeland defense, and overall security enhancement.

Appendix One

USAFA Faculty Chairs of Phase One Study Groups

(Spring 2001)

Global and Regional Political and Economic Trends and Military Futures

Europe: Dr. Charles Krupnick, Military Strategic Studies
Russia and Its Neighbors: Maj David Wilkins, Foreign Languages
Middle East and North Africa: Maj Brent Talbot, INSS
Sub-Saharan Africa: Dr. Fran Pilch, Political Science
East Asia: Dr. William Berry and Col Thomas Drohan, Military Strategic Studies
The Americas: Col Douglas Murray, Political Science
Global and Regional Economic Futures: Lt Col Steven Slate, Economics

Basic Science Trends and Military Futures

Chemistry and Biochemistry: Maj Susan Hastings, Chemistry
Physics and Nuclear/Radiological Science: Lt Col Geoff McHarg, Physics
Conventional and Non-Conventional Weapons and Delivery: Lt Col Peter Van Wirt, Astronautical Engineering

Appendix Two

Phase Two: Conference Agenda and Participants

(August 2001)

Panel 1: National Security Environment 2015

Chair: James Smith, INSS
Economic Environment
John Basso and Michael Meese, US Military Academy
Technological Environment
Steve Maaranen, Los Alamos National Laboratory
Discussant: James Smith, INSS

Panel 2: Arms Control Environment 2015

Chair: Jeffrey Larsen, Science Applications International Corporation
Nuclear Arms Control Environment
Kerry Kartchner, Department of State
Chemical/Biological Arms Control Environment
James Smith, INSS
Conventional Arms Control Environment
Christopher Carr, Air War College
Space Arms Control Environment
Peter Hays, School of Adavanced Airpower Studies
Information Arms Control Environment
Gregory Rattray, US Air Force
Discussants: Jeffrey Larsen, SAIC
Kurt Klingenberger, US Air Force

Panel 3: Arms Control Technology Requirements 2015

Chair: Joseph Pilat, Los Alamos National Laboratory
Intrusive Technologies
Dianna Blair, Sandia National Laboratories
Non-Intrusive Technologies
Mark Grohman, Sandia National Laboratories
Special Case—Biological Technologies
Al Zelicoff, Sandia National Laboratories
Remote Technologies
Tim Murphy, Los Alamos National Laboratory
Discussants: Joseph Pilat, Los Alamos National Laboratory
Dennis Mangan, Sandia National Laboratories