

TWENTY-FIRST CENTURY THREAT REDUCTION:

NUCLEAR STUDY RESULTS FROM DTRA/ASCO



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EXECUTIVE SUMMARY

ASCO's research program addresses nuclear, chemical, and biological weapons threats and responses. This paper summarizes results from ASCO-sponsored studies in the nuclear area for fiscal year 2000–2001. ASCO studies surveyed prospects for nuclear *proliferation* as well as its implications for *deterrence* and other tools of coercive threat management. ASCO also assessed the utility of *preventive threat reduction*, that collection of non-coercive tools ranging from reciprocated unilateral action to orchestrated international agreements, with special emphasis on the efficacy of the Cooperative Threat Reduction program. In brief:

Proliferation. The absolute number of nuclear weapons in the world is going down, as major nuclear powers' stockpiles shrink, but Chinese forces are modernizing and perhaps growing, and India and Pakistan may weaponize their forces to a greater degree than they have to date. The risk of nuclear use in South Asia may grow as a result, while the prospect of regional theater missile defense presents a closing window of opportunity—real or perceived—for China to coerce Taiwan into reunification.

Nuclear proliferation is not a wildfire—only a few states are willful proliferants—but regional powers seeking to counter US military superiority may turn to weapons of mass destruction. Most need outside help to complete the task, meaning that international collaboration to control the flow of critical technologies to and between would-be proliferants continues to be urgently important. To contain proliferation, current nuclear testing moratoria are more important than is entry-into-force of the Comprehensive Test Ban Treaty. Current nuclear states are unlikely to alter their testing policies unless one of the five principal nuclear powers resumes sustained nuclear testing. Collapse of the international non-proliferation regime would, however, accelerate rogue states' nuclear programs by opening the gates to international technical assistance and encourage other near-nuclear states to re-evaluate their abstinence.

While most proliferation concerns focus on the risks of terrestrial conflict, the spread of nuclear weapons and ballistic missiles means that low earth orbit (LEO) will likely be targetable by more "rogue" regimes in coming decades, even as military and commercial use of LEO increases. An unclassified study indicated that the residual effects of a 10–50 kiloton nuclear weapon detonated at 120–300 km altitude could disable, in a matter of weeks, all LEO satellites not explicitly hardened to absorb a total radiation dose 3–4 orders of magnitude greater than natural background levels. Such hardening has been estimated to add perhaps three percent to the cost of a new satellite constellation; market forces alone are unlikely to generate support for spending against the occurrence of what is a low-probability but potentially high cost event.

Deterrence. Terrorist acquisition of WMD presents the most stressing case for deterrence. Because the threat is ill-defined—Osama bin Laden and al Qaeda notwithstanding—there has been disagreement within the policy community as to the proper focus of vulnerability reduction efforts. One camp emphasizes reducing civilian vulnerability at home to covertly-delivered WMD; a second worries about U.S. sensitivity to casualties and quagmires, such that small but sustained U.S. military losses, even without enemy recourse to WMD, could produce big results for bad guys; a third camp seeks to reduce U.S. vulnerability in limited wars against a nuclear-armed major power, as in protecting Taiwan; and a fourth focuses on U.S. vulnerability in major theater war against a WMD-armed aggressor. The events of 11 September 2001 have highlighted the worries of the first camp. The resulting national resolve has perhaps reduced the concerns of the second. However, those events leave the concerns of the third and fourth camps *unchanged*, something important to appreciate as the 11 September response unfolds.

Possession of WMD could make regional powers harder to deter, much less compel to act as we would like. In attempting to coerce WMD-armed powers, U.S. threats should be more explicit than "calculated ambiguity" would permit. ASCO studies concluded that any attack against U.S. interests involving nuclear weapons, any high-damage WMD attacks against U.S. forces or allies, and any WMD

attacks against U.S. territory should be known in advance to risk immediate U.S. military efforts to destroy the regime responsible, if such attacks can be traced to a particular state. Such a strategy, while leaving all retaliatory means on the table, should emphasize end-states rather than the means to be used to achieve them.

When crafting U.S. strategy and policy, it is important that U.S. planners take into account a country's "strategic personality." Such an assessment can offer insights into how a country's leaders translate ultimate concerns into current action, how they calculate unacceptable risk, and how the United States and its allies can exploit that calculus to achieve their objectives while minimizing blind alleys and potentially dangerous miscues to allies and adversaries alike.

Preventive Threat Reduction. In the wide gap between implacable hostility and unshakeable friendship, states use the tools of preventive threat reduction to shore up relations, avoid misperception, and scrap unwanted weapons. Two or more tools can be combined so as to balance their strengths and weaknesses to a better national security outcome than any one tool used alone. In the U.S.-Russian case, key objectives of the first Strategic Arms Reduction Treaty were reached on the Russian side with the financial and technical assistance of the Cooperative Threat Reduction (CTR) program. CTR's "business model" combines national-level umbrella agreements with project-level implementing agreements, integrating international contractors, and local implementation that is monitored to check conformance to US business and accounting practices. In principle, the CTR model could be applied outside the former Soviet Union in states that possess fissile materials, WMD, and/or delivery systems; that are of security significance to the United States; that pose a risk of further proliferation; and that are prepared to cooperate in implementing such threat reduction measures.

ASCO also commissioned the development of a model to simulate a multi-actor strategic environment that would permit the testing of alternative assumptions about how third parties may respond to U.S. strategic policy choices in offensive forces, defensive forces, and threat reduction. The resulting model takes into account actors' threat perceptions, propensity to take risk, attitude toward alliances, and preferences as to nuclear strategy, offensive versus defensive forces, and cooperative versus unilateral action. Actors' decisions are constrained by user-set assumptions about economic growth, budget limits, rates of technological change and industrial capacity. The model, presently undergoing sensitivity testing within ASCO, measures outcomes in terms of expenditures and in terms of damage suffered by forces or society in the event of a nuclear war.

In addition to the studies summarized in this report, nine other nuclear-related studies were underway as it was completed. They include:

- Comparative Lethality of Ballistic Missile-Delivered Nuclear, Chemical, and Biological Munitions;
- Northeast Asia Stability Study;
- Deterring Iran and Iraq (a Strategic Personality follow-up study);
- Evolving the Nuclear Force Posture (force planning and exchange modeling);
- Minimal Deterrence in French, British, and Chinese Nuclear Doctrine;
- Evaluating Prospects for Non-nuclear Strategic Deterrence;
- Nuclear Deterrence Planning in the Face of Uncertainty (a Scenario-Based Planning study);
- Assessment of the DoD Nuclear Manufacturing Base; and
- Nuclear Deterrence Issues and Options (a multi-part study addressing DoD nuclear expertise and issues related to nuclear force reconstitution and the inactive U.S. nuclear stockpile).

The objectives of each study are outlined in the final sections of the report.

BACKGROUND AND STUDY FRAMEWORK

The mission of the Advanced Systems and Concepts Office (ASCO) is to develop and maintain an evolving analytical vision of necessary and sufficient capabilities to protect the United States (U.S.) and Allied forces and citizens from nuclear, biological, and chemical (NBC) attack. ASCO is also charged by the Defense Threat Reduction Agency (DTRA), the Department of Defense (DoD), and by the U.S. Government (USG) generally to identify gaps in these capabilities and initiate programs to fill them.

ASCO's research program addresses nuclear, chemical, and biological weapons threats and responses.¹ This paper encapsulates results from the nuclear weapons-related studies completed to date, and then highlights ongoing studies that are scheduled to be completed not later than the second quarter of fiscal year 2002.²

The nuclear research program responded to the need for a broad and well-informed debate on nuclear strategy and forces. That need reflects both the decade-long stalemate in strategic arms control and concerns that the basic skill sets and supporting infrastructure supporting U.S. nuclear forces were at risk of atrophy or obsolescence unless action were taken to adapt them to future U.S. security requirements. ASCO's contribution to the debate and to the reconfiguration of strategy and infrastructure has been a combination of analysis and modeling commissioned and conducted over the past 18 months to facilitate informed debate and to permit sophisticated "what if" excursions and more effective approaches to strategic and regional threats.

ASCO's focused on the creation of better policy-making and analytical tools and frameworks. However, an informed debate about near-term USG decisions on nuclear forces and strategy is not possible without weighing how technical and operational decisions fit into the larger security environment and are affected by the decisions, interests, and policy preferences of other actors. Presidents Bush and Putin have, for example, stated their respective desires to reduce strategic force levels below what had been contemplated for the third round of Strategic Arms Reduction Talks (START III). The aim of ASCO's nuclear studies is, in part, to assess the full range of options for reaching that goal, in the context of WMD proliferation, non-state threats, and the evolution of technologies allowing defenses to complement deterrence at the core of American strategy.

The following sections summarize results from studies completed as of summer 2001 and list the objectives of studies due to be completed between November 2001 and May 2002.

COMPLETED STUDIES

Elements of the ASCO nuclear study effort completed thus far address three major areas of U.S. security interests: proliferation, deterrence, and threat reduction. *Proliferation-related studies* included:

- analytical surveys of the open source and collateral classified literatures on proliferation, looking out ten to twenty years, and

¹ The chem-bio elements of ASCO's research program include a feasibility assessment for a national health surveillance and biodefense system ("Z-chip"); studies of advanced chem-bio threats and operations in contaminated environments; efforts to enhance attribution in bio-weapon attacks ("bio-forensics"); an ASCO-sponsored National Academy of Sciences study of bio-detector technology; assessment of the relative lethality of missile-delivered nuclear, chemical, and biological munitions; NBC-related training scenarios; and approaches to food supply assurance.

² ASCO has been able to commission and carry out such a wide array of study efforts due in large part to its Indefinite Deliverables, Indefinite Quantities (IDIQ) contracting arrangements with three contractor teams selected competitively in 1999. The IDIQ instrument facilitates rapid issuance of task orders under the umbrella agreement.

- evaluation of the potential threat posed by nuclear weapon and ballistic missile proliferation to commercial and civilian government satellites in low earth orbit.

Deterrence-related studies included:

- assessments of U.S. efforts to deal with asymmetric threats, of the potential impact of nuclear-armed adversaries on U.S. strategy in future regional contingencies; and
- the utility of scoping out the "strategic personality" of future adversaries before crafting deterrence strategies.

Threat reduction-related studies included:

- a detailed comparison of the strengths and weaknesses of different policy instruments—from unilateral initiatives to ratified treaties—in reducing threats to the United States;
- evaluation of the "business model" of the Cooperative Threat Reduction program and the prospects for its extension to new tasks;
- estimation of the impact of the erosion or collapse of multilateral nuclear weapons control regimes on U.S. security and global stability;³ and
- creation of an interactive, three-player model of tradeoffs amongst offense, defense, and arms control approaches to meeting national security objectives.

Proliferation-Related Study Results

Future Global Nuclear Threats⁴

At ASCO's request, SAIC surveyed open literature discussions of nuclear weapon and weapon delivery capabilities – current and potential – in 14 countries. The study summarized proliferation trends, as well as variation in projections and potential sources of bias in the roughly 220 open sources reviewed. These included the academic literature, foreign press, and reports by non-governmental organizations (NGOs), international organizations, foreign governments, the U.S. government and U.S. government contractors. The study assumed that the current nuclear non-proliferation regime, nuclear testing moratoria, and related measures remained in place for the foreseeable future.

Positive trends include:

- major reductions in active weapon stockpiles in Russia, France, and the United Kingdom;
- a relatively low, stable number of willfully proliferant countries (North Korea, Iran, and Iraq); and
- seemingly limited prospects "for sudden and drastic nuclear build-ups" (that is, rapid *vertical* proliferation).

Negative trends include:

- a growing expectation of WMD use by transnational terrorists;
- incentives for regional powers to turn to WMD as counters to U.S. conventional military superiority;
- increased reliance on nuclear weapons and brinkmanship by Pakistan and India;

³ In a related but classified effort, ASCO provided analytical support to Gen. John Shalikashvili (USA, ret'd), in his capacity as Special Advisor to the President and the Secretary of State for the Comprehensive Test Ban Treaty. Copies of the resulting studies are available from ASCO upon request for parties with the appropriate clearances and need to know. Contact Dr. Tony Fainberg.

⁴ Greg Giles, et al., "Future Global Nuclear Threats," a project for DTRA/ASCO by SAIC under contract No. DTRA01-00-D-0003, 4 June 2001. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

- development programs that may give the five main proliferants of both nuclear weapons and ballistic missiles the capability to target the United States sometime in the next ten to twenty years (depending on the amount of outside help these states are able to obtain and implying the importance of agreements and regimes designed to make such help harder to come by);
- increasing difficulty in forecasting proliferation developments as states become more proficient at deception and denial; and
- adversaries with strategic cultures/personalities that may make credible deterrent threats harder to craft and sustain.

Although the Russian Federation has sharply reduced its nuclear arsenal (with U.S. assistance), its capabilities remain an order of magnitude greater than those of any nuclear power save the United States itself, and concerns about the long-term reliability of nuclear command and control arrangements are a continuing theme in the sources reviewed. Potentially weak command and control in India and Pakistan is also stressed as a source of accidental or unauthorized use of nuclear weapons in a future South Asian crisis.

Large nuclear weapon stockpiles are shrinking, only a few states are willful proliferants, and most need outside help to complete the task. BUT: Terrorists may turn to WMD, as may regional powers seeking counters to US military superiority, and deception/denial practices cloud proliferation predictions.

The study concludes that there are a number of actions that the United States could take to help to discourage nuclear proliferation and reduce the risk of nuclear war:

- keep the Agreed Framework with North Korea on track (so that the economic incentives of cooperation exceed what Pyongyang derives from missile and/or nuclear proliferation and political/economic isolation);
- continue to work with Russia to improve controls over nuclear weapon materials, essential to fostering closer ties with Russia and closing off opportunities for rogues/terrorists to obtain such materials;
- expedite deeper reductions in Russian that could bring other nuclear powers into a framework of restraint and encourage continued non-proliferation on the part of near-nuclear states that have up to now refrained from building nuclear forces;
- engage India and Pakistan in crisis management activities, facilitating political-military dialogue;
- address international concerns that U.S. deployment of missile defenses would have ultimately destabilizing consequences;
- recognize that "U.S. abstinence from the Comprehensive Test Ban Treaty erodes U.S. non-proliferation leadership and sets a poor example for countries like India and Pakistan," and that maintaining current testing moratoria is a minimum requirement for maintaining that leadership.

Nuclear Testing Scenarios and the Future of the Nuclear Non-Proliferation Regime

An ASCO-sponsored study by DFI/SPARTA examined the likely consequences of the continuation or collapse of the current, de facto nuclear testing moratorium; of the entry or non-entry into force of the Comprehensive Test Ban Treaty (CTBT); and of the continuation or collapse of the nuclear Non-Proliferation Treaty (NPT) regime, over the period 2006-2020. The study developed a qualitative methodology for assessing the potential effects of these alternative strategic environments on sixteen countries' policies and force structures, starting from a present-day base case for each and moving through five alternative scenarios (see table 1). The study estimated each scenario's impact on each state's threat perceptions and sense of the adequacy of its defense strategy and forces. Three

variations on scenario C assumed that the United States, China, or India/Pakistan were the first to resume nuclear testing.⁵

Table 1: Alternative Proliferation/Testing Environments

	Scenarios				
		B	C	D	E
NPT	Intact	Intact	Intact	Breakdown	Breakdown
CTBT	Entry into Force (EIF)	Fails EIF	Fails EIF	Fails EIF	Fails EIF
Testing Moratoria	Replaced by CTBT	Intact	Breakdown	Intact	Breakdown

Source: DFI/Sparta, "Future Integrity of the Global Nuclear Non-Proliferation Regime."

The study derived scenario responses for each state that appeared technically, economically, and politically feasible, and suggested a most likely response in each case. Table 2 summarizes these for the worst-case scenario (E), in which breakdown of the NPT regime and resumption of testing are assumed to arise from some combination of decaying US-China or US-Russia relations, an end to strategic arms reductions, deployment of robust NMD despite Chinese/Russian opposition, or "eruption of regional conflicts into sustained crises or war." The study found that the status of current nuclear testing moratoria is of greater near-term consequence to the non-proliferation regime than is the legal status of the CTBT. States' perceptions of the global security situation and of their particular regional situation, and not international treaty arrangements, are the principal drivers of state behavior and policy choices. Current nuclear states (the "P-5," plus Israel, India, Pakistan) are unlikely to deviate significantly from current plans and policies in most foreseeable nuclear environments, *unless* a P-5 state resumes sustained nuclear testing, or unless the United States decides to build a strategic missile defense system capable of stopping more than a handful of incoming warheads.

Non-nuclear states will also likely maintain their current policies barring a major deterioration of the non-proliferation regime. *However*, a breakdown of the non-proliferation regime will likely permit rogue states to accelerate nuclear weapons programs, since those states tend to depend heavily on foreign assistance regime collapse could facilitate that assistance.

Maintaining current nuclear testing moratoria is more important to non-proliferation than is entry-into-force of the CTBT. Current nuclear states are unlikely to alter current policies unless one of the P-5 resumes sustained nuclear testing. But collapse of the non-proliferation regime would accelerate rogue states' nuclear programs by opening the gates to international technical assistance.

⁵ "The Future Integrity of the Global Nuclear Non-Proliferation Regime: Alternative Nuclear Worlds and Implications for US Nuclear Policy," a study for DTRA/ASCO by DFI International and SPARTA, Inc., under contract DTRA01-00-D-0001, Task Order 0001. March 2001. Available online at: http://www.dtra.mil/about/-organization/ab_pubs.html. The sixteen countries in the study were the original five declared nuclear powers (the five permanent members of the UN Security Council, or "P-5": U.S., China, France, Great Britain and Russia); four "developing" nuclear states (China, Israel, India, Pakistan); three rogue states (North Korea, Iraq, Iran); and six states generally considered nuclear-capable (Argentina, Brazil, Egypt, Japan, South Africa, and South Korea).

Moreover, other near-nuclear, decidedly non-rogue states may eventually feel pressure to go nuclear in an international environment of growing numbers of nuclear powers.

Table 2: Summary of Likely State Responses Given NPT Collapse and Resumption of Nuclear Testing (Scenario E)

Groups of States		Likely Responses to Scenario E
Mature Nuclear	France	Resume nuclear testing; moderately expand nuclear arsenal.
	Russia	Resume nuclear testing; freeze dismantlement efforts
	United Kingdom	Moderately expand nuclear arsenal.
Developing Nuclear	China	Adopt more aggressive nuclear posture.
	Israel	Expand force structure.
	India, Pakistan	Pursue aggressive expansion of nuclear arsenal.
Rogue States	North Korea	Nuclear opacity.
	Iraq, Iran	Accelerate nuclear program; transparent nuclear policy.
Other Nuclear-Capable States	Argentina, Brazil, So. Africa	Pursue diplomatic options.
	Japan	Enhance defensive forces; deploy missile defenses; strengthen alliance with US.
	South Korea	Enhance defensive forces; build alliance with US.
	Egypt	Pursue nuclear option

Source: DFI/Sparta, "Future Integrity of the Global Nuclear Non-Proliferation Regime."

Assessing Nuclear Threats to Low-Earth-Orbit Satellites

Commercial and unclassified governmental satellite constellations in low earth orbit (LEO – 150 to 1,500 kilometers orbital altitude) are likely to be of growing importance to government, commercial, and military users over the next decade.⁶ LEO applications include communications, high resolution meteorology, earth sciences support, and terrestrial imaging, plus the International Space Station. Over the same ten-year period, proliferation of nuclear weapons and longer-range ballistic missile capabilities is likely to continue.

The confluence of growing use of LEO and proliferation of nuclear missile capability pose a unique potential threat, because the electromagnetic geometry of LEO space is such that radiation from a relatively low-yield nuclear weapon (equivalent to or somewhat larger than the bombs detonated over

⁶ John Parmentola, et al., "High Altitude Nuclear Detonations Against Low Earth Orbit Satellites." Annotated briefing. Ft. Belvoir, Virginia: Defense Threat Reduction Agency, Advanced Systems and Concepts Office, April 2001. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

Hiroshima or Nagasaki) exploded at 120–150 km altitude would increase ambient radiation density throughout LEO space for a period of months, only gradually dissipating. Radiation density could increase by a factor of one thousand or more.⁷ Satellites designed to withstand the natural radiation levels of low earth orbit for several years would likely degrade rapidly in this "pumped" radiation environment, in some cases in a matter of weeks.⁸

Such a situation could be incidental to a regional nuclear war involving one or more very high-altitude nuclear warning shots. It could also result from:

- high-altitude intercept of a ballistic missile whose nuclear warhead was fuzed to detonate upon impact or interference (so-called "salvage fuzing");
- exoatmospheric detonation of a missile interceptor that was itself nuclear-tipped; or
- an accidental missile launch.

A 10-50 kiloton nuclear weapon detonated at 120–150 km altitude would pump up radiation levels in LEO space by 3-4 orders of magnitude. Satellites designed to survive for years at natural LEO radiation levels could degrade in this radiation environment in a matter of weeks.

Finally, a high-altitude detonation could also be a deliberate attempt by a rogue state facing economic strangulation, or imminent military defeat, to cause economic damage to industrial economies in a manner less likely to generate nuclear retaliation than would a direct attack on enemy forces or territory, that is, without causing direct human casualties or visible damage to economic infrastructure.

The geometry of LEO space is such that only 5–10 percent of a given satellite constellation would be destroyed by direct exposure to prompt radiation (especially X-rays) from a nuclear explosion at 120–150 km altitude. The remaining satellites in the constellation would gradually accumulate ionizing radiation damage in key electronic components from gamma rays, x-rays, neutrons, debris gamma interactions, and beta decay electrons trapped in the Earth's magnetic field.

Modeling indicates that military or civilian applications heavily dependent upon vulnerable classes of LEOs would begin to hurt two weeks to two months after a high-altitude detonation. The degree of hurt in, say, communications, would depend on the redundancy in a user's communications bandwidth (i.e., the availability of substitute geosynchronous satellites, relay aircraft, or land systems). The period of greatest risk for military forces that use LEO assets is likely to be 1-2 months following a detonation, as LEO systems fail and replacements are sought or brought on line.

By comparison to long-lived geosynchronous satellites that must be able to absorb some 100 kilorads of natural ionizing radiation, LEO satellites need only be able to withstand 1–30 kilorads in their natural environment, the amount varying with their precise orbital altitude and inclination, and their designed life span. Were LEO satellites further radiation-hardened, a low-yield nuclear explosion in LEO, while still posing a prompt radiation threat to the 5–10 percent of LEO satellites within line of

⁷ Radiation density or flux = electrons/cm²/sec, while fluence = calories/cm²/sec, and absorbed dose = fluence x exposed area x time. The computer models used to estimate satellite radiation exposure are based on limited high-altitude nuclear testing done mostly in the early 1960s. Uncertainty of post-explosion radiation density *at any given point* in LEO space is a factor of 4-10 but "orbital averaging" reduces the uncertainty because satellites pass repetitively through "hot" bands and patches of space over days, weeks, and months.

⁸ Total dose degradation and failure occurs in electronic systems exposed to both natural and nuclear ionizing environments. The primary source of natural total dose is from the protons and electrons trapped in the Earth's radiation belts.

sight of the explosion, would no longer substantially threaten the other 85–90 percent of satellites in LEO.⁹

The potential threat posed by nuclear weapons to LEO constellations could be substantially mitigated by advance planning and satellite (re)design to increase resistance to radiation damage. Such hardening has been estimated to add perhaps three percent to the cost of a new system. If the U.S. government considered LEO survivability to be a national security priority, it could subsidize hardening, make it a condition of government use of U.S.-based companies' LEO satellites, or use only higher-altitude satellites for critical support functions. Comparable hardening of international satellite consortia (e.g., Skybridge, based in the UK) would likely require intergovernmental action.

Were LEO satellites further radiation-hardened, a low-yield nuclear explosion would still pose a prompt radiation threat to the 5–10 percent of LEO satellites within line of sight but would no longer substantially threaten 85–90 percent of satellites in LEO. Such hardening has been estimated to add three percent to the cost of a LEO constellation.

Deterrence-Related Studies

Dealing with Asymmetric Threats

Weapons of mass destruction are attractive equalizers for states such as Pakistan that have little hope of balancing the military power of one or more threatening neighbors by conventional military means. The conventional military capabilities of the United States are also essentially unstoppable by the conventional military means available to most third parties, leading to present concerns about asymmetric threats—nuclear and otherwise—that seek leverage against the "critical weak points" of the United States and its allies.

A brief study by the Institute for Defense Analyses (IDA) for ASCO looked at the asymmetric threat/response "community" and found considerable progress in implementing the Counterproliferation Initiative but also considerable intellectual disarray. Because the threat itself is ill-defined (and seems destined to remain so as technology becomes more sophisticated and adversaries seek to "work around" U.S. defenses), the community of interest has focused more on reducing vulnerabilities and building generic capabilities than on meeting specific threats. But "success" in counterproliferation remains largely undefined and there is disagreement as to the proper focus of vulnerability reduction efforts. One camp emphasizes "defending the homeland," or reducing civilian vulnerability to covertly-delivered WMD; a second worries about U.S. sensitivity to "casualties and quagmires," such that small but sustained U.S. military losses *without* recourse to WMD could produce big results for bad guys; a third

Because the threat is ill-defined, US planners have focused more on reducing vulnerabilities. There are four distinct "camps" that focus on domestic vulnerabilities, on US sensitivity to "casualties and quagmires," on limited wars with nuclear-armed major powers, and on major war with a WMD-armed aggressor. The events of September 11th highlighted the worries of the first camp, reduced those of the second, but left the concerns of the other two unchanged.

⁹ These percentages would vary for larger weapons detonated at higher altitude: a larger weapon would emit more of everything, and a larger fraction of near-earth space would be within sight of a higher altitude burst, but many potential targets would be quite distant, and radiation density dissipates as the square of the distance to the target.

seeks to reduce U.S. vulnerability in "limited wars against a major power with significant nuclear capability," for example, in protecting Taiwan; and a fourth focuses on vulnerability in a "major theater war against a WMD-armed regional aggressor," for example, a Gulf War II or Korean War II.¹⁰ The four camps, the study argues, interact but little yet carry very different implications for resource investments and political-military strategy. The events of September 11, 2001 have highlighted the worries of the first camp. The resulting national resolve has perhaps reduced the concerns of the second. However, those events leave the concerns of the third and fourth camps *unchanged*, something important to appreciate as the 11 September response unfolds.

This study concluded that U.S. interests may best be served by emphasizing a defense-heavy damage limitation strategy coupled to "conventional rather than nuclear replies to rogue aggression," and to threats that place at risk the survival of the rogue's ruling regime. Despite the conventional weapon emphasis, however, such regimes could not rule out U.S. nuclear retaliation in response to "asymmetric overreach," that is, a case where executing an asymmetric threat generated greater than anticipated damage or casualties.

Nuclear Multipolarity and International Stability

A second study done at IDA on nuclear "multipolarity" and regional stability tied nuclear weapons issues in the emerging "tripolar core" of the United States, Russia, and China to issues of regional stability and nuclear proliferation. These links are especially strong in the US-Taiwan-China relationship, where the ultimate concerns of a nuclear-armed challenger and a nuclear-armed protector clash directly: "For the United States, that ultimate concern is the forward progress of a liberal world order based on the democratic revolution. For China, that ultimate concern is territorial integrity and national sovereignty. Any leader that backs down could well be seen as selling out not only the interests at stake in Taiwan, but also the larger national mission."¹¹

Assuming, moreover, that the United States cannot be dissuaded from deploying missile defenses – regional or national – and that worst-case Chinese planning cannot assume a continuing ability to saturate such defenses, then Beijing, the study argues, has some incentive to act against Taiwan before defenses narrow a window for intimidation that is, at present, widening. A US-PRC offense-defense race could "spell an end to the effort to reduce nuclear threats and risks set in motion by the end of the Cold War."¹²

Beyond the Taiwan issue, there are several countries, in an arc running from the Middle East to Northeast Asia, that either seek or currently own nuclear weapons and/or medium range ballistic missiles. There is substantial risk of catalytic proliferation (where one country's programs stimulate another's) involving other near-nuclear powers, and subsequent risk of the escalation of conventional conflicts to nuclear weapons use.

If the United States cannot be dissuaded from deploying missile defenses, and worst-case Chinese planning cannot assume continuing ability to saturate such defenses, then Beijing has some incentive to act against Taiwan before defenses narrow a presently widening window for intimidation.

Although American experts tend to view such a world in terms of very specific "arms race" or "crisis" stability issues, non-Americans tend to embrace broader concepts of "strategic" stability,

¹⁰ Brad Roberts, "Asymmetric Conflict 2020," prepared for DTRA/ASCO under contract DASW01 98 C 0067, DC-6-1743. IDA Document D-2538, November 2000, pp. S2-S3. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

¹¹ Brad Roberts, "Nuclear Multipolarity and Stability," prepared for DTRA/ASCO under contract DASW01 98 C 0067, DC-6-1743. IDA Document D-2539, November 2000, pp. 15, 17. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

¹² Ibid., p. S-2.

defined largely in terms of the predictability of state behavior. Such predictability is a function of stable relations among the major powers, their collaboration to protect the peace, and their support for the rule of law. America's tendency to shift political course abruptly (and unilaterally) diminishes predictability and thus, from this perspective, strategic stability. Allied concerns about such tendencies were evident at a June 2000 experts symposium convened at IDA in connection with this study and thus predated the change in US administration.

Non-Americans tend to embrace broader concepts of "strategic" stability, defined largely in terms of the predictability of state behavior. Such predictability is a function of stable relations among the major powers, their collaboration to protect the peace, and their support for the rule of law.

Deterrence and Cooperation in a Multi-tiered Nuclear World

If a WMD-armed regional power threatened or actually used nuclear, chemical, or biological weapons against U.S. forces, U.S. allies, or the U.S. homeland, how should the United States respond? Equally important, how should it characterize its *likely* response so as to reinforce the deterrent value of its policies? DFI International and SPARTA, Inc., addressed this question for ASCO, building from what is known about the requirements of deterrence.¹³ Successful deterrent threats give the target a convincing incentive to comply, and such incentives come from evidence of *capability* and *commitment* to carry out a threat that *resonates* with the target's strategic culture, that is *effectively conveyed* to the target's leaders, and that *registers as serious* once conveyed. A threat may not register as serious if leaders survived previous U.S. attacks or, worse, bluffed their way past earlier threats.

Possession of WMD may make such rulers harder to deter—much less compel to act as we would wish after hostilities have commenced—suggesting a need for threats that are carefully tailored and perhaps more explicit than U.S. policy has supported to date. The 1990s strategy of "calculated ambiguity" in defining the U.S. response to use of WMD might not pose a sufficient deterrent to future WMD-armed regional adversaries, for the reasons laid out above. Moreover, should deterrence fail, the strategy might force the United States to retaliate with nuclear weapons against *any* use of WMD. Yet resort to nuclear weapons merely to avoid future loss of U.S. credibility could, in many circumstances, be wildly disproportionate to damage suffered and blow back on the United States politically. To escape this dilemma, the study suggested that decision makers focus on the *type* of weapon used by the adversary, on the *targets* struck, and on the *damage* done, which together would define the significance of the attack. The greater the significance, the stronger the reply, with strategy focused on the results we would like to achieve with that reply, rather than the means employed to achieve them.

U.S. threats and responses should be calibrated so that nuclear attacks, high-damage WMD attacks against U.S. forces or allies, or WMD attacks against the U.S. itself, would be known to risk immediate U.S. military efforts to destroy the offending regime... Such a strategy could leave all retaliatory means on the table but not emphasize one over the other.

¹³ "Deterrence and Cooperation in a Multi-tiered Nuclear World," a project for DTRA/ASCO by DFI International and SPARTA, Inc., under contract No. DTRA01-00-D-0001, 23 February 2001. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

This logic suggests that U.S. threats and responses should therefore be calibrated so that *nuclear attacks, high-damage WMD attacks* against U.S. forces or allies, *or WMD attacks against the U.S. itself*, would be known to risk immediate U.S. military efforts to destroy the offending regime. Lesser attacks would invite lesser responses aimed, for example, at destroying the attacker's WMD capabilities or its military forces. Such a strategy could leave all retaliatory means on the table but not emphasize one over the other, so that the choice of one option would carry no implications for the choice of others in future scenarios. Such a strategy implies the need for a robust theater defense capability to minimize the risk of high damage to U.S. allies and forward-deployed forces; a robust, precision-guided, non-nuclear retaliatory or operational denial capability; and flexible nuclear delivery systems as backups or, in some circumstances, alternatives to conventional strike forces. Such a combination of strategy and capabilities, the study argues, would reduce damage to U.S. forces or interests in the event of WMD attack and, by reducing pressure for a nuclear reply, permit the United States to deal with an array of potential WMD attacks in ways that would neither undermine the norms of nuclear non-use that have evolved over the past half-century nor make nuclear weapons seem a necessity to borderline proliferant countries.

Using Concepts of "Strategic Personality" to Inform US Strategy and Decision Making

In the post-Cold War world, it is sometimes said, rationality is at a premium; that the United States now faces more "irrational" adversaries (and friends!) than it did ten, twenty, or fifty years ago. A third study done by IDA argues that irrationality is not necessarily on the rise, and that deterrence and other rationally-based strategies can work if one understands the underlying foundations of other actors' interests and decision making style.

This study used the concept of "strategic personality" – or typical cognitive patterns that grow out of national history, culture, and founding myths – to generate insights into how a country's leaders translate dominant, long-term interests (or "ultimate concerns") into current national interests, how they calculate risk, and the implications of these interest-risk calculations for U.S. strategy and action.¹⁴ Borrowing terminology from the Meyers-Briggs psychological evaluation literature, the study assessed strategic personality on three dimensions:

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how a leadership orients to the outside world (that is, whether it is, on balance, "introverted" or "extroverted"); how it selects and gives credence to information (whether it is "sensing" or "intuitive"); and how it analyzes information and makes decisions to act ("thinking" or "feeling"). These three pairs of categories are, of course, bookends for three complex ranges of behavior, but the objective of the methodology is not to calculate incredibly fine gradations of difference but to flag dominant tendencies and, in so doing, help U.S. decision makers avoid counterproductive policies and unexpected, adverse crisis outcomes. Table 3 defines the characteristics of each category, the ultimate concerns that are typical of states that fall into each category, and the states highlighted in the study's case histories.

The study applied its methodology to U.S. and Japanese behavior leading up to Pearl Harbor; to Anglo-German rivalry in the late 19th and early 20th centuries; to Egyptian and Israeli interactions on the eve of the October 1973 War; and to contemporary Indo-Pakistani relations. (Follow-on work will apply the methodology to Iran and Iraq.)

¹⁴ Caroline F. Ziemke, Philippe Loustaunau, and Amy Alrich, "Strategic Personality and the Effectiveness of Nuclear Deterrence," prepared for DTRA/ASCO under contract DASW01 98 C 0067, DC-6-1743. IDA Document D-2537, November 2000, p. ES-2. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

Table 3: Defining "Strategic Personality"

Dimensions of Strategic Personality	Characteristics of Each Dimension	Typical "Ultimate Concerns"	Case Study States
Orientation to the Outside World			
Introverted [fears outsiders]	Looks "inward to identify national interests," sees international system as loose collection of autonomous actors with self-contained histories; acutely boundary-sensitive.	Defending the nation against external stresses.	Egypt India Iran Pakistan Iraq China Israel Japan
Extroverted [dominates outsiders]	Looks "outward to identify and consolidate national interests"; has a "progressive, linear view of history"; sees the international system as an integrated whole; grows/advances by adapting to change; see boundaries as more subject to change.	Engaging, resolving, or adapting to external stresses.	Germany UK United States
Orientation to Information			
Sensing [fact-oriented]	Focuses on observable & measurable data; strongly oriented to the present; Golden Age is in the past; history shaped by isolation or acute exposure to invasion; identity rooted in land, ethnicity, language.	Maintaining territorial or social cohesion (via, for example, ethnic or linguistic homogeneity).	Egypt Germany UK Iraq China Japan
Intuitive [trend-oriented]	Focuses on <i>patterns</i> of current events; strong visionary strain, oriented toward <i>future</i> Golden Age; national myths built on shared ideas or doctrines.	Reaching utopia.	Iran Israel India Pakistan United States
Orientation to Action			
Thinking [rule-oriented]	Historical challenges overcome by the imposition of order on chaos; order sustained by state action or by rigid social norms. "Left brain" states "whose judgment stresses analysis and logical reasoning."	Maintaining the proper order of things; maintaining international respect.	Germany China Israel Iraq India Pakistan
Feeling [value-oriented]	Historical challenges overcome by cooperative action, guided by sense of common purpose. Order sustained by common value hierarchy (religious or secular). "Right brain" states that judge evidence against that value hierarchy; actions less predictable than logic-driven states.	Defending the value systems that are considered key to social stability, harmony, and cohesion.	Egypt Iran UK United States Japan

Source: Ziemke, Loustaunau, and Alrich.

Each of these pairings has its own, historically-based dynamic but the cases permit a few basic generalizations to be drawn, as illustrated in Table 4 . The table discusses the implications of several generic pairings of "defenders" and "challengers," with the defender's personality type being consistent with that of the United States – extroverted, intuitive, and feeling – and with states matching each challenger type listed for purposes of illustration only.

Since, following the disastrous conflicts of the 20th century, the Extroverted, democratic states of Europe seem to have put intramural war behind them, most political-military challengers that the United States will encounter in the new century will be Introverted, and as a result, U.S. actions may push up directly against these states ultimate concerns. If they are also Sensing states, credible deterrent threats must be consistent and the "will to defend" must be unambiguously communicated; if they are Intuitive states, threats to their core values or self-image may backfire. If they are Thinking states, deterrent threats must be specific and coherent, lest the target "hear" the wrong message; if they are Feeling states, such threats should aim to influence overt behavior rather than to change core values, because such efforts, too, may backfire.

In the end, argue the authors, what counts most in a deterrent relationship is the balance of ultimate concerns and how the engaged parties (and any party trying to function as mediator) understand all of the ultimate concerns at stake. Such understanding will "point to where compromise is possible and where the conflict of ultimate concerns is irreconcilable." Further understanding the strategic personalities of the engaged parties will result in the sending of messages (whether threats, payoffs, or offers to disengage) that the other party "is likely to notice and can understand, and that make sense in terms of his own ultimate concerns."

Applied to the United States, the strategic personality methodology suggests that for the foreseeable future, the United States will continue to pursue a national strategy of international economic and political engagement, with isolationist periods "unlikely to be extensive or sustainable." Such engagements lie "at the very heart of the US strategic personality, [and] are key to US ultimate concerns" that include the promotion of economic liberty throughout the world and of the political liberty that

rationally accompanies it—what Theodore Roosevelt called a policy of "power with high purpose." "The United States sees its power as a sign of its righteousness... and if it stops following its higher purpose..., it risks losing that power." Moreover, since much of what the United States seeks to export is "inherently threatening to repressive or culturally conservative regimes," it will find itself confronting disaffected or insecure challengers whether or not it maintains current levels of overseas military commitments. It is not so much the commitments themselves but what the country stands for that generates the challenges.¹⁵

International economic and political engagement lie "at the very heart of the US strategic personality." They are key to US "ultimate concerns," which include promoting economic and political liberty—what Theodore Roosevelt called a policy of "power with high purpose."

¹⁵ Ziemke, Loustaunau, and Alrich, pp. 134-137.

Table 4: Policy Implications of Different Strategic Personality Pairs

Defender (U.S.)	Challenger (samples)	Implications
Extroverted	Introverted (Serbia)	"Virtually all of the likely challengers that the United States will face in the years ahead will be Introverted states.... [M]ost future conflicts between the US (or NATO) and an Introverted state will center on the...attempt to narrow the Introverted state's prerogatives and freedom to pursue what they see as their legitimate Ultimate Concerns." In such confrontations, "international pressure can, and often does, have the opposite of the desired effect." [viz. NATO vs. Serbia over ethnic cleansing in Kosovo] (pp. 122-123.)
Intuitive	Sensing (China)	"Last minute deterrent threats are unlikely to make a convincing impression... [and] a Sensing state is likely to generalize from one experience of flagging resolve...." Sensing states (or groups, like Osama bin Laden's) in turn "have a very difficult time judging an Intuitive defender's threshold of pain...this normally leads them to underestimate that threshold." The challenge for Intuitive defenders...is to "maintain sufficient consistency ...that there is no ambiguity regarding the will to defend" so that a Sensing state opts "not to challenge rather than to miscalculate, challenge, and lose." (pp. 124-126)
	Intuitive (Pakistan)	"A determined Intuitive challenger can be difficult to deter if their vision is directly threatened" but easier to deter "when the interests at stake are primarily material." Where national visions are weak, threatened, or in flux, "the most valuable threat reduction strategy may be thinking about ways to mend, reinforce, or rebuild viable national visions" if only by not "pressuring them to adopt policies that conform to the U.S. vision" but violate their own. (pp. 126-130)
Feeling	Thinking (Iraq)	"Thinking states...do not understand the vocabulary of values that Feeling states employ," find their deterrent threats "bafflingly open-ended and imprecise," and "often find it difficult to anticipate which values are supreme at any given point." When they hear mixed or contradictory messages, Thinking states focus "on the one that makes the most sense to them," which may not be the message that the Feeling state most wanted to convey. (pp. 130-132)
	Feeling (Iran)	"The message must be that the United States wants a [Feeling state] to do something different, but not that it must become something different. It is much easier to shape actions than to reshape values." And it is important to be clear as to which one is the U.S. goal. In the case of Iran, U.S. containment objectives are "open-ended," and what the Iranian regime must do to satisfy U.S. demands is unclear. The Iranians thus "perceive...an unspoken objective: to overthrow the Islamic Republic, or at least pressure it to collapse...." (pp. 132-134)

Source: Ziemke, Loustaunau, and Alrich.

Threat Reduction-Related Studies

The ASCO projects summarized thus far focused on boosting the effectiveness of deterrence and

Table 5: Complementarities in a Sample of Threat Reduction Tools

Tools:	Treaties	Interagency Agreements	Parallel Unilateral Actions
Measures:			
Adaptability and Flexibility	Low-Moderate	Very High	Very High
Timeliness and Responsiveness	Low-Moderate	High	Very High
Irreversibility	High	Moderate	Low-Moderate
Verifiability	High	Moderate	Low-Moderate
Support for Compliance Diplomacy	High	Moderate-High	Low
Political Insulation	Low/High	Low/Moderate-High	High
Institutionalized Cooperation	High	High	Low
Ease of Implementation	Low	High	High
Limited Legislative Action Required	Low	Low-Moderate	High
Implementing Costs	High	Low-High	Low

Source: Lewis A. Dunn, et al., "An Assessment of Preventive Threat Reduction."

reductions under START I, in some cases making those reductions economically feasible. START, in turn, gave CTR a firm legal and political framework against which to operate. In other cases, experience with one approach can smoothe the way for another: The CSBMs established under the Conference on Security and Cooperation in Europe (CSCE), for example, were useful precursors to and experience-generators for the on-site inspection regime established under the later Treaty on Conventional Forces in Europe.

¹⁶ Lewis A. Dunn, et al., "An Assessment of Preventive Threat Reduction," a report prepared for DTRA/ASCO under contract DTRA01-00-D-0003, Task Order 0003. February 2001. Available online at: http://www.dtra.mil/about/organization/ab_pubs.html.

Evaluating Cooperative Threat Reduction: The "Business Model" and Its Future Potential

DTRA's Cooperative Threat Reduction Directorate invited ASCO to evaluate the CTR "business model" and to assess its future potential. The resulting study assessed two components of the business model: its strategy and its process.¹⁷

The CTR *strategy* is to provide U.S. assistance to states to facilitate secure storage, dismantlement, and/or destruction of weapons of mass destruction and their delivery systems. Prerequisites for success include:

- compatible US-partner state interests;
- transparency in program execution; and
- partner state political and bureaucratic support for the program.

CTR has an effective business model that combines national-level "umbrella agreements" with project-level implementing agreements, integrating international contractors, and local implementation, monitored to check conformance to US business and accounting practices.

US-partner state interests need not be identical, but they must be sufficiently compatible as to encourage active, voluntary compliance with the objectives of the program. Implementation must be sufficiently transparent that such compliance can be independently confirmed. Lack of political support can stymie a program, as happened in Belarus, and inadequate local bureaucratic support has delayed implementation of some projects in Russia.

The CTR *process* begins with a government-to-government "umbrella agreement." This agreement establishes a political and legal framework for the program that is supportive of U.S. contract law and standards and facilitates follow-up audits. Under the umbrella agreement, CTR sets up:

- interagency implementing agreements for each project within a country program;
- U.S.-based "integrating contractors" who sub-contract project implementation to local firms where possible but maintain on-site presence to oversee execution; and
- an audit/examination process to verify the proper use of funds and equipment transferred.

The CTR program benefited from the framework of arms control agreements between the United States, Russia, and the other successor states of the Former Soviet Union (FSU). Projects that facilitated the execution of such agreements—especially dismantlement of large, visible weapon systems—have not only enjoyed great success but can readily be *seen* as successful by observers outside the CTR program. Measures of effectiveness for such projects are intuitive: see system, cut up system, photograph pieces, add up number of systems destroyed. Any issues relate not to *whether* the task has been executed but how *efficiently*.

Measures of effectiveness for other program elements are harder to implement. In some instances, a task (e.g., equipment delivery) may be completed but access limitations may obscure whether it contributes as intended to overall program goals; or it may contribute as intended but the links between the particular task and overall CTR objectives may be indirect. In the case of projects that entail major construction, such as the Mayak fissile material storage facility or the Shchuche chemical weapons destruction pilot facility in Russia, effectiveness may be undermined by shortfalls in host nation matching funds or by growing environmental consciousness on the part of local populations long subject to the casual and wholesale environmental damage inflicted under the former Soviet regime. Where projects aim to secure fissile materials from dismantled weapons, it must be clear that materials sent to secure storage in fact derive from those weapons and not from some other source (e.g., from

¹⁷ DFI International and SPARTA, Inc., "The Future of the Cooperative Threat Reduction Program," a project for DTRA/ASCO under contract DTRA01-00-D-0001, Task Order 0004. January 2001.

reserve weapons, from fissile materials stockpiles, or from materials production reactors). Such "chain of custody" monitoring is feasible but complicated by both sides' desires to keep secret from one another the design details of their weapons.

This study developed criteria for applying the CTR model to countries outside the FSU. Candidate countries would be those that possessed fissile materials, WMD, and/or delivery systems; that posed a risk of further proliferation (as a matter of national policy or a function of lax security measures); that were of security significance to the United States; and whose cooperation in threat reduction could be anticipated either in the near term (within five years) or medium term (six-plus years).

Of the eight states that met the expansion criteria, the most promising near-term candidate appeared to be Yugoslavia, where the program might focus on fissile materials security or on chemical weapons destruction in support of the country's obligations under the Chemical Weapons Convention. Such efforts could be one facet of a new, comprehensive program of peacetime engagement with post-Milosevic Yugoslavia and could be undertaken in collaboration with U.S. allies. Such multilateral efforts entail both pluses (cost sharing) and minuses (diminished U.S. control). Like the Korean Energy Development Organization that helps to implement the Framework Agreement with North Korea, multilateral arrangements can sometimes open doors or keep them propped open better than can unilateral American initiatives. The study lays out a number of options for CTR-like programs that, in principle, could be led by a variety of actors, from non-governmental groups to international organizations.

Candidates for CTR-like programs outside the FSU would be states that: possess fissile materials, WMD, and/or delivery systems; pose a risk of further proliferation; are of security significance to the United States; and are prepared to cooperate in threat reduction in the near to medium term.

Modeling Tradeoffs Between Offense, Defense and Threat Reduction for Three Actors

Strategic offensive force reductions and defensive force buildups are the twin elements of U.S. strategic policy. Russian nuclear weapon capabilities still far outshadow those of other nuclear powers other than the United States, but U.S. and Russian force reductions will increasingly level out the nuclear playing field, especially if third powers choose to build up long range nuclear forces. Strategic missile defenses are intended to counter "rogue" states expected to acquire long-range, WMD-armed missiles within the next decade, but the Asian orientation of initial U.S. missile defense deployments inevitably engages Chinese strategic interests as a matter of geography and geometry.

To date, China has apparently been satisfied with a strategy of guaranteed retaliation supported by relatively few strategic nuclear warheads on long-range missiles. An ongoing ASCO study is looking into Chinese nuclear strategy in more detail, but Chinese nuclear forces modernization programs and a growing economy give Chinese leaders a certain amount of flexibility in how they respond to Russian and American force structure changes, and especially to U.S. deployment of missile defenses oriented toward Asia. In this arena as in others, China will play a growing role in America's strategic calculus.

Having at least three players in that calculus complicates strategic planning, making the net security impacts of any given policy or force structure initiative harder to predict and potentially much different from those intended by U.S. decision makers. At present, there do not appear to be good decision and simulation tools capable of addressing the many dimensions of such a multi-actor environment, where actors can choose among offensive, defensive, and arms control/

There is great need for good decision and simulation tools able to address a multi-actor environment. Those actors should be able to choose among offensive, defensive, and threat reduction within constraints of technology and budget, and to estimate the international knock-on effects of their decisions.

threat reduction options to meet their strategic objectives, and where the knock-on effects of their respective decisions — made within constraints of technology and budget — can be projected over a period of years. Without such tools to support U.S. decision making, the unanticipated or poorly predicted reactions of third parties may negate U.S. strategic choices or make them unnecessarily costly. With such tools, U.S. planners and decision makers could not only game out others' reactions to U.S. choices but evaluate the most cost-effective approaches to achieving U.S. objectives.

To help fill this gap, ASCO commissioned the development of a model to simulate a multi-actor strategic environment and permit the testing of alternative assumptions about how third parties may respond to U.S. strategic policy choices. The resulting model takes into account actors' threat perceptions, propensity to take risk, attitude toward alliances, and preferences as to nuclear strategy, offensive and defensive forces, and threat reduction measures. Actors' decisions are constrained by user-set assumptions about economic growth, budget limits, rates of technological change and industrial capacity. The model measures outcomes in terms of expenditures and in terms of damage suffered by forces or society in the event of a nuclear war.

The model's logic has been implemented in a spreadsheet, using a Visual Basic engine, and is undergoing sensitivity testing at ASCO. The model currently permits its actors to respond to choices made by other actors but not to anticipate them, as a well-informed, real-world planner might do, extrapolating from past choices and reactions. Although the current implementation has produced useful insights into three-party interaction, the database, decision engine, and user interface need further refinement before they are suitable for larger release, and ASCO will be pursuing those refinements in fiscal year 2002.

STUDIES TO BE COMPLETED NOT LATER THAN FIRST QUARTER FY 2002

- **Comparative Lethality of Ballistic Missile-Delivered Nuclear, Chemical, and Biological Munitions**, underway at SPARTA, Inc., looks at the "source terms," or starting assumptions, for models of the impact of nuclear, chemical, or biological weapons delivered by ballistic missile, in response to a request from the Ballistic Missile Defense Organization. The study is classified Secret.
- **Northeast Asia Stability Study**, at the Institute for Defense Analyses (IDA), is unclassified and has three components. The "Northeast Asia Strategic Security Environment Study" focuses on intra-Asian bilateral ties and regional threat perceptions of China, North Korea and the United States (where "threat" is a function of capability as much as intent). "China-US Nuclear Relations: What Relationship Best Serves US Interests" looks at the implications of Chinese efforts to build a secure nuclear second-strike capability and likely willingness to maintain that capability in the face of US countermeasures, with emphasis on missile defense options and their implications. Finally, "East Asia's Nuclear Future: A Long-term View of Threat Reduction," examines regional trends in nuclear forces, strategy, and proliferation, and measures to reduce the threats to US interests and regional stability that they may pose.
- **Deterring Iran and Iraq**, also underway at IDA, applies the Strategic Personality framework to the issue of deterring leaders of these two very old and very different cultures, which tend to be viewed in Washington through the same "rogue state" lens.
- **Evolving the Nuclear Force Posture**. Since government analysts, academics, and think tankers presently use different analytical tools to evaluate nuclear forces and strategy, government has difficulty responding to outsiders' arguments and recommendations because, classification issues aside, the decision metrics and weapon effects measures buried inside various outside models may not be commensurate with those used in government models. ASCO is funding improvements to two sophisticated, unclassified models to facilitate dialogue about the assumptions and strategies

driving nuclear forces and doctrine. Two models, minus weapon/effects databases, are to be released to academic analysts through normal DoD security review channels. An exchange modeling tool, "Multiple Engagements of Strategic Arsenals, with Stability Metrics" (MESA/SM), developed at Los Alamos National Laboratory, is a three-party exchange optimization model.¹⁸ ASCO is funding the addition of defensive forces and other improvements. A second model, the "Force Operational Readiness Combat Effectiveness Simulator" (FORCES), addresses operational requirements for weapon delivery. Development work is to be complete by late December 2001.

- **Minimal Deterrence in French, British, and Chinese Nuclear Doctrine**, a study underway at SAIC, is reviewing the sources and evolution of the nuclear doctrines and strategies of these three states. As US and Russian nuclear arsenals are substantially reduced, "minimal" or "sufficient" deterrent strategies may gain greater relevance to US and/or Russian nuclear planners, especially in conjunction with deployment of strategic defenses. It will produce brief doctrinal summaries and an annotated database of published materials as a ready reference to minimal/sufficient deterrence history, logic, and force structure requirements.
- **Evaluating Prospects for Non-nuclear Strategic Deterrence** is a project at DFI International to assess the viability and feasibility of emphasizing non-nuclear weapons to deter state and non-state actors who may be contemplating use of WMD; to develop a deterrence and warfighting strategy using such weapons; and to identify future technology, hardware, intelligence, organizational, and doctrinal requirements for a credible non-nuclear deterrent and warfighting strategy.

STUDIES TO BE COMPLETED NOT LATER THAN THIRD QUARTER FY 2002

- **Nuclear Deterrence Planning in the Face of Uncertainty**, undertaken by Systems Planning and Analysis, will employ a "scenario-based planning" methodology for estimating US nuclear force requirements in the 2015-2020 time frame. Political-military scenarios that might require recourse to nuclear forces will be developed for each of several plausible alternative worlds, with emphasis on "core" requirements for a nuclear force structure in all cases examined. The project will also develop decision making guidelines for meeting, in a timely fashion, the force structure requirements of more stressing future worlds, such as the emergence of an aggressive Soviet successor state, or the proliferation of rogue states. The study should be completed by March 2002.
- **Assessment of the DoD Nuclear Manufacturing Base**, Westinghouse Safety Management Solutions, will identify gaps in U.S. capability to design, produce, test, and support nuclear delivery vehicles. Starting with a survey of previous studies on this subject, the study will examine current support capabilities and document future support capabilities already in the planning or implementation stages. Study results are intended to provide input into DoD's Nuclear Mission Management Plan. (WSMS) will complete the study by May 2002.
- **Nuclear Deterrence Issues and Options**, undertaken by SAIC, includes four sub-tasks. In *sub-tasks one and two*, the contractor will develop issue papers and hold tailored workshops to address critical nuclear policy issues regarding Russia and China, which will help frame choices facing the United States and define the continuum of options available. *Sub-task three*, complementing the study on the future nuclear manufacturing base, will assess trends and make recommendations regarding future DoD staff nuclear expertise, focusing on the risk that staff directors (needing to hire officers and civilians with requisite nuclear expertise) may, in future, find the personnel "cupboard" disturbingly bare, leading to improper nuclear program oversight or poor advice to national-level leaders. *Sub-task four* will address two aspects of nuclear hedging: (a) steps that the U.S. may need to take in the future to reconstitute a larger—or different—nuclear force in response to strategic warning and (b) the rationale and strategy for the US inactive nuclear stockpile. The

¹⁸ Models *with* data will be offered only to qualified government users.

first three sub-tasks and sub-task four (a) are to be completed by November 2001; sub-task four (b) is to be finished by May 2002.