PRECISION TECHNOLOGIES AS POSSIBLE ALTERNATIVES TO NUCLEAR WEAPONS

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THE ARGUMENT IN BRIEF

Nuclear weapon technology, and its related systems, doctrines, and strategies is based on what was the newest discovery of science in the 1930s, promising important capabilities in WW II. In the event, its major impact was in the following decades. The intervening seventy years have seen a number of new technologies applied to the protection of states and their populations. These new technologies include those enabling the precise and discriminate application of far smaller amounts of force to achieve militarily desirable effects than that delivered by even the lowest yield nuclear weapons. The question examined here is to what extent might these new technologies, and the demonstrated or potential capabilities of systems and doctrines based on them, substitute for what is currently offered by nuclear weapons.

The short answer is to a great extent but not entirely.

Certainly, the replacement of nuclear weapons with potentially equally effective ways of achieving military objectives has been underway for a number of years. During the period of nuclear arms limitation negotiations between the U.S. and Russia, conventional military capabilities have benefited substantially from developments in radar, stealth, precision navigation, unmanned vehicles, guidance, propulsion, computation, and networked communications linking target acquisition sensors to both national-level commanders and as well as to theater forces at the lowest organizational levels. The frequently expressed view is that if one can find a target and identify it, it can be dealt with quickly and effectively. In the light of such capabilities, consideration of the potential for the substitutability of conventional for nuclear weapons is appropriate.

On the other hand, nuclear and discriminate conventional technologies have quite different characteristics, each having advantages and disadvantages in various circumstances, substitutability implies trade-offs that need to be considered. In this regard, there are at least five relevant issues:

1. As the U.S. and Russia reduce their stockpiles in concert to very low levels, they enter the range where their stockpiles are numerically comparable to those of other nuclear states. The decrease in numbers of U.S. and Russian weapons is opposite to the upward trends in at least three nuclear states. Warhead numbers do not, of course, tell the whole story. Cold War strategic balance calculations on which U.S., and presumably Soviet, net assessments were based included such additional metrics as yield, range, accuracy, vulnerability, reliability,

readiness, warning, and command and control. None of these are addressed by warhead counts alone. Nonetheless, negotiating further reductions will require the participation of at least seven other states, each with very different agendas than those of the U.S. and Russia.

2. Understanding the substitutability between nuclear and discriminate conventional technologies depends on complex calculations related to a nation's perceived adversaries, the nuclear and conventional capabilities of each, how the lower collateral damage of conventional weapons is valued by each, and the number of aim-points to achieve a desired military and political effect. Nuclear weapons are judged on the basis of their presumed first and/or second strike destructiveness. Nuclear deterrent forces are not to be "used" beyond existing. Their cost derives from the cost of the production facilities employed, weapon maintenance and upgrades, and the cost of maintaining and exercising alert forces and their supporting systems. Conventional discriminate technologies are judged on the very different basis of their continuing use and by post-conflict outcomes. Thus they are judged by their failures under far different circumstances from that of a nuclear exchange. Thus the two classes of weapons are not directly commensurate.

3. As national goals evolve over time, and as national security needs change correspondingly, new technologies such as those noted above become important in assessing the ability of a nation to enforce its will on another. Substitution options are not equally accessible to all nations. They depend on sustained long-term investments in R&D, target acquisition and delivery systems, training, employment doctrines, and conventional warhead type and design. Not all states are equally endowed with the necessary economic, technological, and production capabilities to deploy and maintain weapons based on these advances.

4. The new discriminate technologies have practical limits not shared by the nuclear weapons they could be seen as replacing. Even small nuclear weapons have such large areas of destruction that errors in delivery accuracy, target identification, target vulnerability, and uncertainties in weather and visibility are relatively unimportant. These are, however, central for the effectiveness of conventional discriminate technologies. Thus nuclear weapons, whatever their financial and political cost, can provide more effective and reliable options for the delivery of military force under some circumstances and for some countries.

5. The number of aim-points on which one sizes precision forces does not tell the whole story. A defender builds aim-points for a number of reasons: the state of its industrial development, to disperse its capital assets, or as a matter of deception. The attacker builds forces sized to service aim-points. It must build enough weapons to deal with whatever contingencies it anticipates, plus it must maintain production capability to resuppply its forces for the precision weapons expended or lost. The issue is not simply one of the numbers on each side. The matter hinges on the assessments each makes regarding the relationships among aim-points. The defender will conceive survivable distributed aim-points having the greatest number of critical nodes that must be successfully attacked. The attacker must discern which set of aim-points constitute the minimum critical essential targets. These are not matters of simple counting. They are matters of detailed engineering studies and intelligence collection and analysis.

One must consider all the factors bearing on these tradeoffs to understand the potential for, and the limitations on, substitutability of precision conventional weapons for nuclear weapons. There is no simple yes-no answer to the question. It depends on which state is concerned about its strategic force balance vis a vis which other states. The answer may be that one or both types of weapons are valuable, with the choice of which to use situation dependent.

THE INHERENT EXCESS OF NUCLEAR FORCE

The non-use of nuclear weapons as deterrents implies they have certain characteristics: terrible existential consequences to a threat nation should they decide to attack, sufficient numbers of weapons on the part of the target to assure their survivability to be able deliver on that promise regardless of attacker actions; a varied mix of redundant platforms to deliver them; and continued upgrading in the light of changing technology, security threats, uncertainties, and threat nation actions. These characteristics imply "overkill," inefficiencies in the delivery of force on an enormous scale, and what seems to make national suicide inevitable. This power is justified on the basis their terrible potential will never be realized. They are intended to frighten. To be effective this fright must be internalized by the most obtuse and strong-willed, even "irrational," national leaders.

To constitute a credible threat, something more than sophisticated strategic balance calculations and psychology is involved. Such weapons have to work in an assured manner, in the light of uncertainties. Their *use* has to be demonstrably feasible. An adequate amount of force must be delivered as advertised, and not easily dismissed by adversaries of even the most optimistic bent. With nuclear weapons, such demonstrations have derived from their use in WW II, through continued development tests, especially atmospheric testing, and through aircraft and submarine operations and missile testing. Even military parades have been valuable. A photograph of the external configuration of a missile enables reverse engineering back to the warhead yield and range-payload tradeoffs.

There is a downside to these unmistakable demonstrations of power. Planes crash or weapons are accidentally released, accidents at sea occur, submarines sink, adventurism brings nations closer to a nuclear war than intended, and actions can be misread, all in the name of intelligence collection, realistic exercises, and assertions of national resolve. These are all part of their "non-use." Demonstrations of capability provide information on the expected performance of nuclear systems that allows their owners to be more confident of "success," and adversaries to calculate their odds of survival.

Were this the nub of deterrence, matters would be simple. Inevitably, political and military planners recognize that while large nuclear exchanges are to be avoided, the same forces, used in smaller number and with weapons of less than the maximum possible yield, might be just the thing. NATO adopted this view to deter a Soviet invasion of Western Europe and planning for possible tactical use of nuclear weapons occurred in Korea, twice in Vietnam, and in a number of other cases.[1] Some argue that nuclear use in Japan was critical to breaking the will of the government, thereby avoiding a costly land battle in Japan.

The Soviet military saw nuclear weapons as large bombs and missiles as artillery. So did President Eisenhower in Korea. A whiff of "nuclear grapeshot" can seem not unreasonable if available, needed, and one does not fully grasp the five order of magnitude difference between 200 lb of chemical explosive and 20,000,000 lb (20 kT) of equivalent TNT. Measuring nuclear capabilities in kilotons and megatons masks the very great differences between nuclear and conventional weapons by reducing nuclear yields to misleadingly small numbers. Putting people into situations where such large differences in scale must be accurately understood invites errors in judgment.

Other potential disasters follow from the accidents attending nuclear weapon deployment. It is difficult to handle nuclear weapons without something going awry, a state of affairs well-known to those dealing with reliability theory.[2] The issue in reliability is not the fact of unreliability *per se* but the consequences of reliability failures. Reliability and safety of weapons depend on details of design that will not be known to all concerned: quality and stability of the chemical explosive components, the number of detonation points and timing required to achieve the design yield, handling procedures, the training of operational and maintenance personnel, details of the arming, fusing, and firing circuitry, etc. Peacetime deployments of nuclear weapons in international space enables confrontations between nuclear-armed adversaries to occur.

An emergent characteristic of nuclear arsenals is that of hoaxes, rumors, and exaggeration. These are driven by perceptions, some created by a state wishing to inflate its capability to deter, others result from self-deception. Jenkins makes the case, in his provocatively-titled book, *Will Terrorists Go Nuclear?*, that al Qaeda *is* a nuclear power, not because it possesses nuclear weapons, but because we are as frightened of them as we would be if they did possess them.[3] An observation by Secretary of State Dean Acheson in 1951 also pointed to the perception vs. facts aspect of nuclear force when he noted, with regard to nuclear weapon use in Korea, “The threat represented by our stockpile of atomic bombs was not a political advantage or asset, but, rather a political liability. The threat of its use by us would frighten our allies to death but not worry our enemies.” The essence of nuclear weapons is only partly physics and engineering. For the most part it is what is in the minds of the beholders.

Recognizing that beliefs and fear are the essence of deterrence, note must be taken of the opportunities and instabilities of contemporary personal communication channels to propagate hoaxes, rumors, and thus the fears they enhance. These supplement the media,

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[1] See <www.npolicy.org/files/19961001-NWTWTW.pdf> For comments concerning some inaccuracies in this report, see <www.armscontrolwonk.com/2081/nuclear-weapons-that-went-to-war-case-studies>.
[2] Charles Perrow, *Normal Accidents: Living With High-Risk Technologies*, Basic Books, New York, 1984. An alternate body of thought holds that any desired level of reliability can be achieved, the issue being the amount of care and attention given to achieving reliability. Since investment in reliability is, of necessity, limited given other needs, the difference between the two viewpoints is quantitative, not qualitative. Add also Scott D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons*, Princeton University Press 1993.
[3] Brian Michael Jenkins, *Will Terrorists Go Nuclear?*, Prometheus Books, Amherst, New York, 2008.

with their need to fill airtime 24 x 7 with talk, images, and speculation, regardless of substance.

These issues bear on the many adversarial pairs in a multi-polar nuclear world. Substantial nuclear force is necessary to deter nuclear or conventional conflict with similarly large adversaries. Lesser levels of nuclear capability are sufficient for equally lesser pairs of countries such as India and Pakistan. The U.S. deterring Russia or China in either nuclear or conventional conflicts is quite different from the U.S. deterring North Korea or Iran in terms of forces needed or the acceptability of nuclear use by the U.S. Multiple nuclear states with multiple competing interests, global relationships across a range of economic and political domains, and the rise of both sub-state organizations and transnational institutions channel confrontations into local, limited, and specific directions. The practical value of nuclear forces in these various cases is unclear.

Thus qualitative and quantitative value of nuclear weapons must be viewed in terms of the specific threat nation whose actions they are intended to deter. Nuclear weapons only come in inconveniently large sizes. At any level of use they imply an excess of force whether against a large or small nation. For large adversaries their utility relies on the prospect of mutual assured suicide and the dangers they pose from normal accidents. Against a smaller adversary their excess leads one to look for more acceptably proportionate levels of threat to deter.

THE PROSPECT OF TRADING EXCESS NUCLEAR YIELD FOR PRECISION DELIVERY OF CONVENTIONAL FORCE

Sun Tzu said, “Generally in war the best policy is to take a state intact; to ruin it is inferior to this.” He further notes, “For to win one hundred victories in one hundred battles is not the acme of skill. To subdue the enemy without fighting is the acme of skill.”[4] The magnitude of nuclear force in even the smallest feasible weapons and the attendant uncertainties in the outcomes of its use makes industrial war, the focusing of a state’s total power to the application of force against an adversary, a high risk enterprise.[5]

Since a nation's resources are limited, prudence and efficiency suggest using minimum resources in conflict to maintain a capability to meet future needs. Efficiency in the management of force suggests not expending resources to destroy something of no military or economic value. Political considerations likewise argue for minimizing collateral damage to non-targets. Can these goals be satisfactorily achieved with post-nuclear technology that centers on maximum efficiency and discrimination for the delivery of minimum amounts of force?

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[4] Sun Tzu, *The Art of War*, Samuel B. Griffith translation, Oxford University Press, 1963, Chapter III, Offensive Strategy.

[5] Rupert Smith, *The Utility of Force: The Art of War in the Modern World,* Random House/Vintage Books, New York, (2007).

There are a number of technologies than can contribute to national security that were not on the horizon when the decision was made to develop nuclear weapons. These are not matters of speculation. They are available today and have been integrated into force structures since the mid-1980s for the purpose of achieving efficiency and discrimination in the delivery of force. They demonstrate there are alternatives to the delivery of huge amounts nuclear force.

The military and political and constraints on precision weapons emerged early. Eight years after the first Wright brothers' flight, the first "precision" air attack took place. On November 1, 1911, Lt. Gavotti, commander of the Italian air fleet directed his Bleriot X.1 fighter over a Turkish camp near Ain Zara as part of a campaign for control of Libya and Crete. He dropped four modified 4 lb Swedish hand grenades from his open cockpit. The attack was the first mention of collateral damage when the Turks complained that the bombs hit a field hospital.[6]

The pursuit of discriminate technologies to maximize delivery accuracy of the smallest feasible amounts of force sufficient to minimize collateral damage, while at the same time achieving military objectives, has become a central element of conflict.

> *Radar* to acquire targets precisely and to guide the application of force was first demonstrated in WW II. It can locate and track moving targets at long range, work through fog, darkness, and intentional obscuration, filter signals to match target characteristics and, in coordination with IFF, reduce targeting mistakes. Newer technology enables radar to operate with low probability of detection. Its companion technologies are electronic countermeasure and low radar cross-section platforms that can penetrate areas with less risk and thus provide better accuracy in weapon delivery.
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> *Space systems* enable platforms to know where they are and, with GPS coordinates of targets, enables weapons to be delivered accurately. Local GPS enhancements can fill reception gaps and increase accuracy further. Satellite based reconnaissance enables the location fixed targets.
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> *Unmanned air vehicles* can accomplish tactical objectives with timeliness and specificity. They can provide virtually continuous surveillance of areas at less risk than can manned aircraft or ground observers. Such platforms can have reduced observables and be configured to carry weapons.
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> *Cruise missiles*, aided by *GPS, inertial,* or *terrain matching guidance* technology, constitute another type of unmanned platform with longer range, larger payloads, and high accuracy.
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> A variety of *autonomous homing or manually guided warheads* enable relatively small warheads to attack targets effectively when directed to their points of greatest

[6] Personal communication from William C. Yengst as part of a study of the effectiveness of precision weapons and their effectiveness.

vulnerability. These include home-on-emitter and home-on-jammer warheads as well as those employing visual or IR image correlation.

Ballistic missile defense is a precise and discriminate technology if it is to work, and has little downside in collateral damage.

C*yber weapons* enable attack "packets" to be selectively delivered to locations that can be precisely known. While not usually considered in the panoply of precision guided weapons, they are potentially as precise as IP addresses can be related to physical locations.

Special forces provide the ultimate in accurately delivering warheads, or other devices, to targets by human eyes, hands, and minds.

Networks supporting software-enabled functionality provide new capabilities for information collection, collaborative analysis, distribution of information to forces for immediate use, as well as rapid and flexible command and control. An opposing technology is portable short-range emitters of high-power microwave energy that can couple to electronic circuits and disable or destroy them, again with little collateral damage.

With regard to the precise application of force, one must ask two questions. First, how well have precision weapons met their potential capabilities? The second is whether these technologies, employed by trained forces operating under tested operational doctrine, can achieve the same national objectives for security attributed to nuclear weapons.

The obvious, and the one technologists and military leaders enthuse about, is the precision delivery part. This is a matter of design, fabrication, testing, training, mission planning, and mission execution. All these facets of the problem are understood in principle, but they change in detail as technologies change. They are, however, highly situation-dependent. Targets can be mobile so one has response time considerations. Camouflage, cover, and deception defeat the effectiveness of precise delivery. Urban and insurgent warfare mix targets and non-targets inextricably, Finally, defensive actions by targets can damage the weapon delivery vehicle and deflect it from its intended target. Collateral damage is not entirely under the control of the attacker.

A frequently overlooked part of the task, is what point of the target to aim for precisely? This is in part technical: the matter of the most vulnerable points in a selected target that, when struck appropriately, will disable or destroy it. These are matters for the collection, analysis, and distribution of intelligence, both strategic and tactical. Without correct and timely intelligence, precision delivery degrades more rapidly than do nuclear technologies.

What does not come out of "one-shot-per-kill" sound bites is the large amount of supporting effort involved in getting the precision weapons to general area of the targets. Easily neglected are the additional aircraft for refueling, defense suppression, fighter escorts, naval force protection, air defense, and the like.

In terms of the utility of conventional weapons delivered with precision and with regard to the minimization of collateral damage:

1. The technology *can* deliver sufficiently high accuracy that relatively small amounts of destructive power can effectively destroy many targets when an adequate degree of maturity in technology and employment doctrine have been achieved.

2. The promise of control of collateral damage is less clear, though collateral damage will be significantly less than with nuclear weapons. Intelligence agencies and military planners need to devote as much effort to the study of non-targets as is currently the case for understanding and characterizing targets.

3. The delivery of conventional force for strategic purposes involves large numbers of supporting capabilities including intelligence collection and analysis, delivery systems, mission planning technology, command and control, damage assessment, media communication, and post-attack exploitation of the results of such operations.

4. However much one might wish the problem away, applying precision force under circumstances where targets and non-targets are in intimate contact is not simple. There are realistic limits to what can be done to control collateral damage. This circumstance diminishes the military utility of discriminate weapons in some situations, and increases their political downsides, especially when the use of civilian populations as a shield is adopted as a deterrent.

A new form of precision is provided if cyber force used in a strategic role. Societies depend on infrastructure to deliver essential goods and services: electric power, communications, information, natural gas, crude and refined fossil fuel through pipelines, transportation of raw material, goods, and people, water and waste purification and disposal, etc. These depend on rotating machinery, pumps, pipes, circuit boards, and other physical devices. They are managed by computers so they function as intended by their designers. Cyber attackers can hack into their computer-based command and control systems and instruct those systems to operate beyond their design limits, causing them to damage or destroy themselves
Thus cyber weapons can, in principle, be as destructive as missiles or bombs. Since strategic cyber attacks have not occurred, the extent of such threats is a matter of conjecture. Neither have strategic nuclear attacks, but the demonstrable consequences of nuclear weapons more readily support the fear they engender.

Achieving national objectives without physical force is the most desirable way for a nation to proceed. Non-zero amounts of force inevitably result in effects on both targets and non-targets. The technologies of precision are relatively new, with R&D having been started in the 1970s and with first use in the 1990s. The results are encouraging but the technology is in its infancy. The emergence of information networking offers new opportunities for strategic deterrence in some cases but it is a generation newer than precision conventional weapons and thus far from being adequately understood.

The Prospect for Substitution

The U.S. and Russia, having been reducing their nuclear stockpiles since the 1980's, and at the same time developing a wide range of conventional capabilities, are driven to precision for the obvious reason of greater efficiency and effectiveness in military operations. To what extent can precision weapons reduce nuclear stockpiles further, as they have already reduced the need for some conventional capabilities, or to what extent will they simply supplement nuclear capabilities by raising the nuclear threshold?

There are no general answers to these questions. The substitutability of precision conventional weapons for nuclear weapons is dependent on individual circumstances of nations' nuclear stockpiles, defense needs, and its goals for power and influence. The following summary is offered to illustrate the range of circumstances currently extant and to serve as a base for projecting possible future utilities of precision weapons for current nuclear states and for non-nuclear states considering their nuclear options.

In the following table, current nuclear states are listed in rough order of when they acquired nuclear weapon capability. The nuclear weapon acquisition process consists of basic scientific education, development of industrial capabilities, operation of research and power reactors, and weapon design and development in its many aspects. Iran is treated as a nuclear state, not as an intelligence conclusion but to see how a non-weapon state fits into the set of current nuclear states.

Nuclear State	Deter Nuclear Attack By	Deter Conventional Attack By	Political Nuclear Utility To Gain Influence	Utility of Precision Weapons vis a vis Nuclear Weapons
U.S.	Russia, PRC	Russia, PRC	global	will delay theater nuclear use
Russia	U.S., PRC	China	global	will delay theater nuclear use
U.K.		Russia	global	will delay theater nuclear use
PRC	U.S.	Russia, U.S.	global	will delay theater nuclear use
France		Russia	global	will delay theater nuclear use
Israel	Iran	neighbors	neighbors	immediately useful capability
India	Pakistan	Pakistan	bilateral	deter Pakistan; delay nuclear use
Pakistan	India	India	bilateral	deter India; delay nuclear use
DPRK		U.S.	neighbors	little
Iran			neighbors	little

There is a clear separation between the first five nuclear states and the next five. The first five have global agendas and any of them have reasons for concern with threats posed by some of the others. The issue for them is to balance their past and continuing nuclear investments and those for the new technologies of precision. The original five nuclear states will continue to see themselves in a modified, but still polar relationship, requiring nuclear deterrence vis a vis each other, and in this light they may continue to see missile defense as destabilizing to their mutual balances. But ballistic missile defense to protect themselves against threats from the newer nuclear states is likely to be seen as advantageous.

The second five states pose, and face, more geographically-limited threats to which nuclear weapons can be seen as providing necessary capabilities irrespective of the alternatives provided by precision weapons. These states are less likely to have embraced the idea of limiting collateral damage to their enemies, but all can appreciate achieving security without having to necessarily threaten nuclear use offers political flexibility.. Having more limited resources, they will face the same issues as the first five nuclear states, to balance nuclear and precision weapon investments, but the tradeoffs will be more difficult for them. Precision weapons require far greater changes in force structures, doctrine, and training than do nuclear weapons that can simply be added through an overlay of new organizational elements.

What emerges is that precision weapons have utility, not necessarily in substituting for nuclear weapons, but in delaying nuclear use in theater conflicts. Only the U.S. currently has precision weapon capabilities in the "shock and awe" class, but even that has proven to be a transitory advantage. The U.S. benefits as much, or more, from its economic strength, its potential for global leadership, and its cultural and political values. To the extent the U.S. succeeds in exploiting these advantages, its nuclear forces will diminish in relative importance. But given U.S. concerns over the global agendas of Russia and China, and in view of its sunk costs of its nuclear weapon establishment, complete substitution of precision forces for nuclear forces is unlikely in the near and mid-term.

There are two viewpoints at work. The balance between them is likely to vary from state to state and with continuing developments in precision technologies. One view to keep all military technology and to discard nothing, certainly not until adequate and proven replacement technologies are in place. This can be expensive, but adopting the latest technologies without careful consideration is imprudent also. The other viewpoint, driven by maximizing return on investments, is to move out of less valuable technology as quickly as possible and adopt more promising approaches quickly. The former values retaining what one does well. The latter is seen as technological surprise, suddenly changing the name of the game. The history of military technology is replete with examples of both views with results that have been both good and bad. The decision is as much a matter of a nation’s security culture as one of detailed analysis.

ABM deployments, designed to protect against a finite number of self-identified threat states, nuclear and non-nuclear, are being designed and deployed. They can be separate national systems, or a single system cooperatively operated based on agreements among the set of states concerned with particular nuclear threats. Such systems could be boost-phase systems, sea-based or based in territory of the parties to separate agreements, or they could be air attacks on soft facilities during launch preparations. Such ballistic missile defense systems could be viewed as enforcing a quarantine on space launches from threat states. Pre-launch payload inspections could assure that any nation’s peaceful access to space would not suffer interference.

A missile defense architecture consisting of separate systems to protect state group A from threat nation X, another to protect state group B from threat nation Y, etc. clearly does not scale. But when the number of nuclear threat states is small and is growing slowly, one can accept some inefficiency in favor of limited solutions tailored to particular circumstances.

The growing concerns with non-nuclear missile threats, long as well as short range, add further incentives for developing and deploying missile defenses.

Economies of scale need not be totally forgone since there will be, in such cases, a market for missile defense systems and subsystems. It is not unreasonable to believe that even with a small number of single-threat systems there will be commonalities among the threatened states. Furthermore separate single-threat systems could possibly be networked to achieve additional political and geographical coverage. The idea of systems of systems is one of long standing, ranging from the consolidation of separate public utility systems in the nineteenth century to the endless networking enabled by Internet protocols that have led to net-centric warfare.

There is reason to believe the need to threaten the delivery of massive amounts of nuclear force will recede in importance in the light of alternative means of exercising national power. While not necessarily a general proposition, it recognizes conventional alternatives can be more flexible and cost-effective and that nuclear force can become obsolescent. Multilateral negotiations can facilitate such substitution opportunities, recognizing that any serious departure from reliance on nuclear weapons will occur slowly and unevenly at best.