AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

SPACE-BASED COUNTERFORCE IN THE SECOND NUCLEAR AGE

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A Research Report Submitted to the Faculty

In Partial Fulfillment of Graduation Requirements for the Degree of

MASTER OF OPERATIONAL ARTS AND SCIENCES

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Maxwell Air Force Base, Alabama

April 2015

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ABSTRACT

Some scholars argue that the world has entered the "Second Nuclear Age" in which nuclear proliferation has invalidated traditional deterrence assumptions. Air Force leaders believe this new "multipolar, proliferated world requires new ideas, concepts, and analyses." To address this concern, this paper explores the possibility of limited nuclear wars and how the United States may respond to them. In doing so, it reopens the debate between Thomas Schelling and Herman Kahn regarding the nature of deterrence and reconsiders one of Strategic Air Command's boldest strategic weapons system proposals.

The paper combines modern nuclear scholarship with recently declassified Air Force documents from the 1960s to argue that the Second Nuclear Age will require a more Kahn-like "escalation dominance" deterrence posture rather than the Schelling-inspired "balance of terror" deterrence that guided Cold War postures. Further, the old nuclear Triad may no longer be sufficient. The paper concludes that space-based nuclear deterrence may be the only method to establish true dominance and that Project Orion, an audacious plan championed by SAC General Thomas Power to develop advanced spaceships propelled by nuclear explosives, may be a vital strategic capability to ensure the United States can reliably deter adversaries in the Second Nuclear Age.

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SECTION I: INTRODUCTION

The *Flight Plan for the Air Force Nuclear Enterprise* (26 June 2013) identifies as one of its five strategic vectors: "Develop and foster Air Force critical thinking on deterrence and assurance."[1] Elaborating further, the *Flight Plan* explains "Deterrence will grow increasingly complex in the multi-domain environment of future conflict and our thinking needs to anticipate this new environment. A multi-polar, [nuclear] proliferated world requires new ideas, concepts, and analyses."[2] This work is meant to help address the *Flight Plan*'s call for critical thinking on deterrence in such a world. It challenges the expressed need for *new* ideas or concepts to succeed in the future. This paper argues that the best way to deter aggression and assure allies in the 21st Century is to return the classic concept of nuclear escalation dominance to mainstream military thought and, concurrently, to resurrect perhaps the boldest plan ever to emerge from the supremely confident United States Air Force (and championed by the Strategic Air Command) of the 1960's – space-based counterforce using nuclear pulse driven spacecraft.

A radical claim such as this requires exceptional evidence to persuade an audience. While the author does not believe that either escalation dominance or nuclear pulse propulsion are particularly bizarre concepts, to convince the public to embrace them would admittedly require above average effort. Accepting the former would require the United States to accept that nuclear weapons are not only political, but also warfighting weapons with practical utility. Developing and deploying the latter would require nothing less than amending or withdrawing from both the Outer Space Treaty of 1967 and the Limited Test Ban Treaty of 1963, and (perhaps more psychologically difficult) committing to the detonation of small atomic devices in the atmosphere and space for purposes of propulsion. Many of these propositions at first glance may seem too outlandish to consider, even wistfully. However, the the potential dynamics of

this future multipolar and proliferated world may change so fundamentally that current views on nuclear weapons and these "unthinkable" concerns above may quickly emerge as merely minor considerations of the "Second Nuclear Age." What's more, the actions that may propel these fundamental changes will not likely be taken by the United States. Indeed, America may be forced into a reaction it may not like in order to adapt to the new nuclear environment. This paper builds a case for escalation dominance and space-based counterforce should America be forced by circumstances to fundamentally alter its nuclear policies.

The first section explores the small but growing literature surrounding the emerging multipolar nuclear environment often dubbed the Second Nuclear Age. Central to understanding the dynamics of this new age are Paul Bracken's *The Second Nuclear Age* (2012) and *The Spread of Nuclear Weapons: An Enduring Debate* by Scott Sagan and Kenneth Waltz (2013). Bracken introduces the key problems, concerns, and dynamics behind the rapidly emerging new nuclear landscape and explains the reasons why the new nuclear environment is significantly different from the older one. Bracken's work serves to ground the definition of the Second Nuclear Age and assist in developing scenarios that may occur in it that may force significant changes in the American nuclear enterprise. Sagan and Waltz' debate between proliferation 'pessimism' and 'optimism' is important to identifying the nuclear "tipping point that may emerge from one of the scenarios that will fully close the First Nuclear Age and cause the Second Nuclear Age to come into full fruition. Here, we will be forced not just to think about, but react to the "unthinkable" by discarding the First Nuclear Age logic of "minimum deterrence" in favor of a "new" logic of warfighting in the Second Nuclear Age.

The second section will then examine what a warfighting nuclear logic for the Second Nuclear Age may look like. Destined to become a foundational work, the various contributions

in *On Limited Nuclear War in the 21st Century*, edited by Jeffrey Larson and Kerry Kartchner (2014) will frame the requirements of a new logic and provide evidence that the Second Nuclear Age will require a nuclear warfighting perspective in order to secure effective deterrence. It also suggests that the multipolar environment will limit the power of crisis management techniques in favor of escalation dominance. We will then review Herman Kahn's *On Escalation* (1965) to develop the classical theory, assumptions, and requirements of escalation dominance in order to understand what characteristics an escalation dominance nuclear force structure may look like.

The third section reintroduces Project Orion, the Air Force's nuclear pulse propulsion spacecraft project (1957-1965). Its military utility was explored in Frederick Gorschboth's recently declassified Air Force study *Counterforce From Space* (1961) and his unpublished manuscript *Man, Space, and Modern War* (1961). Combined, these studies present a model of counterforce-based warfighting deterrence centered on the Orion spacecraft. The characteristics of Gorschboth's Orion vision and the current American nuclear arsenal will then be compared with the "ideal" counterforce weapon and assessed for their individual suitability to support an escalation dominance nuclear doctrine. The results of this assessment will determine whether changes in the current nuclear force structure will be necessary, and if Orion can fill any identified gaps.

Lastly, this study concludes that the dynamics of the Second Nuclear Age may "break the nuclear taboo" and cause nuclear weapons to be used in limited wars (and not by America's choosing). If such a tipping point is reached, the United States will be forced to abandon its First Nuclear Age logic of nuclear weapons as primarily "political" devices and accept that their use on the battlefield will drive a shift to warfighting deterrence postures predicated on escalation dominance. However, as distasteful as a re-emergence of limited nuclear warfare may be,

eliminating the nuclear taboo also opens the possibility to capture some of the dormant promise of nuclear energy, one of which is the nuclear pulse propulsion (Orion) concept which not only may provide a superior weapon with which to keep peace in the Second Nuclear Age, but also open wide the gates of the solar system to large-scale human exploration and development. Instead of offering only a dark age of prospective nuclear warfare, the Second Nuclear Age may also usher a golden age of exploration and prosperity. Indeed, embracing the paradoxical duality of nuclear energy may be the key to America's -- and humankind's – victory and survival in the Second Nuclear Age.

SECTION II: THE SECOND NUCLEAR AGE

Nuclear weapons may have been born in WWII but they are children of the Cold War. Hence, most of what we "know" about the utility of nuclear weapons was discovered during this "First Nuclear Age," where from 1947-1991 the United States and the Soviet Union faced off in a bipolar nuclear environment in which the nuclear weapons of one side were overwhelmingly poised to threaten the other. There were other nuclear powers (Britain, France, China, etc.) but the age was determined by the two major players. When the Cold War ended many argued that the need for nuclear weapons did also. In the United States especially, strategic and tactical nuclear forces were deemed unnecessary or at least of secondary importance.[3] Their numbers were significantly reduced and whole categories of weapon were eliminated.

However, over two decades into the post-Cold War world, nuclear weapons have not disappeared. Instead, Paul Bracken argues, "atomic weapons have returned for a second act… In the past two decades, new nuclear powers have emerged from 'natural causes,' the normal dynamics of fear and insecurity that have long characterized international affairs."[4] China's strategic forces are technologically beginning to rival the major Cold War nuclear powers of the United States and Russia, and all three are being joined by smaller nuclear powers such as India, Pakistan, and North Korea, among others, forever altering the Cold War nuclear calculus. Moreover, this act is also producing new regional nuclear "dyads" such as Pakistan-India, Iran-Israel, and potentially others to add to the classic US-Russia competitive pairing, making security dynamics much more complicated. Calling this act the Second Nuclear Age, Bracken continues:

> A multipolar nuclear order is taking shape. It will have its own interactions, and as it matures it will undergo dynamic changes…

> Understanding this system of major and secondary nuclear powers and groups is critical to averting a security disaster and big shocks that the international system may not be able to absorb. Regional arms races, crises in the regions, and nuclear competition among major nuclear powers are likely parts of the second nuclear age.[5]

One of the major problems Bracken identifies is that "the second nuclear age is much more decentralized than the first nuclear age, with many independent nuclear decision centers. Moreover, there is nothing comparable to the discipline of the Cold War blocs to keep countries in line."[6] With the breakdown of the Cold War nuclear monopoly, the First Nuclear Age's "circuit breakers have been pulled out of the global wiring system for nuclear war and peace."[7]

In response to the end of the First Nuclear Age, American policy sought to prevent the spread of nuclear weapons, but despite these efforts these weapons have proliferated across South Asia and into East Asia, causing the birth of the Second Nuclear Age. This limited proliferation hasn't deterred the US from continuing its counter-proliferation efforts, but it has caused some to reconsider Cold War (First Nuclear Age) nuclear strategy under the new multi-polar and multi-regional Second Nuclear Age environment in order to formulate American policy.

In his book *The Great American Gamble* (2008), Keith Payne argues that two major nuclear deterrence schools of thought emerged from the Cold War: a "stable balance of terror" theory attributed to Thomas Schelling, and a "US Advantage" school championed by Herman Kahn. Understanding each school's basic tenets is critical to this study.

According to Payne, both schools emerged from the same dynamic of the Cold War, but followed "different trails of logic and judgment" that ultimately concluded with significantly different recommendations for policy and strategic force development.[8] The differences between these schools were based in large part on their disagreements regarding the behavior of rational

actors, the mechanisms behind deterrence, and ultimately, which types of strategic forces are most effective.

Schelling argued that a "stable" balance of terror between the United States and the Soviet Union was the best deterrence policy, where no country would be dominant in strategic capability, and no population would be safe from the other. Mutual vulnerability would ensure that both sides acted prudently and cautiously in international relations. A side benefit (attractive to some politicians) would be that the size of the American nuclear deterrent would simply be that adequate for threatening Soviet society with destruction. Schelling maintained that "in the absence of the 'reciprocal fear of surprise attack' that might ignite a nuclear war, a 'stable balance of terror could be established to provide reliable, predictable mutual deterrence."[9] Therefore, Schelling advised that anything that would incite fear of a possible surprise attack in the enemy (such as missile defenses or civil defense aimed at minimizing the destructive potential of the enemy's deterrent forces) was "destabilizing," and worked against deterrence.

Schelling's "stable balance of terror" was contested by the second main deterrence theory of the Cold War. Kahn presented an alternative view of deterrence based on fundamentally different assumptions from Schelling's. Diametrically opposed to a stable balance of terror, Kahn advised the United States develop any and all strategic capabilities – both offensive and defensive in nature - necessary to establish an "asymmetric and advantageous imbalance of terror" against the Soviet Union.[10] Kahn rejected Schelling's belief that a system which gave the US superiority was "destabilizing." Indeed, for Kahn the only "stabilizing" force in deterrence was a clear and obvious American strategic superiority that conferred real advantage. Kahn advocated more expansive offensive and defensive US strategic force requirements that would

both be able to deter Soviet aggression and protect the American population in case deterrence failed.

Andrew Ross described the functional differences between Schelling and Kahn as "an intellectual struggle between the proponents of a punishment-based deterrent posture [Schelling] and the proponents of a denial-based deterrent posture [Kahn]."[11] Kahn's denial-based deterrent posture was not simply deterrence, but "deterrence plus" the ability to prevail in a nuclear war while defending the population from catastrophic loss. To Kahn, the ability to wage nuclear war enhanced deterrence because "deterrence requires the capability to fight, survive, and win along the entire spectrum of nuclear conflict, from limited to total."[12] To Schelling and his fellow punishment-centric theorists, of course, such a war-winning nuclear capability would increase Soviet fears of an impending American nuclear first strike and could cause the war both Schelling and Kahn wanted to prevent.

Schelling won the debate and the "stable balance of terror" became the dominant school of the First Nuclear Age when secretary of defense Robert McNamara adopted the theory to develop American strategic forces under both Kennedy and Johnson administrations.[13] Payne credits Schelling's victory for his theory's simplicity (its tenets were understandable by the majority of the population), relative affordability (stressing a small number of offensive weapons rather than expensive and complicated offensive and defensive systems), and agreeableness to the anti-war mood of America in the middle Cold War, and the avant-garde sophistication of balance of terror thinking among elites, among other reasons.[14] In fact, both political parties held to Schelling's basic outline of the "stable balance of terror" throughout the Cold War and beyond, and it appears to have worked. The Cold War never erupted into nuclear warfare of any

kind. Therefore, it was natural for many to argue that the lessons learned from the First Nuclear Age should naturally be the correct policy prescription for the Second Nuclear Age.

Perhaps the most well-known example of Schelling's First Nuclear Age thought applied to Second Nuclear Age problems is in *The Spread of Nuclear Weapons* by Scott Sagan and Kenneth Waltz. Sagan argues that nuclear proliferation would result in a more unstable world, but Waltz posits that the world will become more stable as nuclear weapons spread based on the principles of First Nuclear Age (Schelling) deterrence. Arguing against adopting a more Kahnian view, Waltz channels Schelling by claiming that "in the nuclear business deterrence is cheap and easy while defense is costly and difficult."[15] However, Waltz makes plain the fundamental underpinning of Schelling's deterrence by calling nuclear warheads the absolute weapon:

> Nuclear defense attempts to pose an absolute defense against an absolute weapon. The logic of nuclear defense is the logic of conventional warfare. Conventional war pits weapons against weapons. This is exactly what nuclear defenses would do, thereby recreating the instabilities that plague countries armed with only conventional weapons. We know the dangers of offensive/defensive races from centuries of experience with conventional weapons. The major mischief of American defense effort is not only that they may sharpen the efforts of a few countries to make their own nuclear weapons but also that they may recreate the contest between offense and defense with all its unfortunate consequences. *Why should anyone want to replace stable deterrence with unstable defense?*[16]

Kahn would argue, of course, that defense is preferred because Schelling's deterrence is not stable at all, or at least that Schelling's deterrence simply ignores the problem of *what if deterrence fails*? In the Cold War, the thought that deterrence could fail was either too difficult or too alarming for politicians and most academics to contemplate and, because anything else would be "unthinkable," Schelling's deterrence became First Nuclear Age deterrence.

However, not all academics agree with Waltz that First Nuclear Age thought can be simply applied to the Second Nuclear Age. One manifestation of this uneasiness with First

Nuclear Age thought is *On Limited Nuclear War in the 21st Century* (2014), a collection of essays on limited nuclear war with a foreword written, amusingly but impressively, by Thomas Schelling. In Kahnian fashion, Schelling offers that policy makers "must tackle the problematic but urgent question of 'what if nonproliferation fails, and nuclear weapons are actually used?' During the Cold War, this question was in the province of the 'unthinkable…' [but now] there is a greater than zero possibility that a limited nuclear war may one day occur, and any nuclear war is likely to be limited, rather than apocalyptic, as was often the assumption in Cold War analyses."[17] Schelling concludes that "the United States has neither the right weapons nor the right doctrine to wage such a conflict if one were thrust upon it… War is inevitable. Limited nuclear war is possible."[18]

Here is the critical difference between the First and Second Nuclear Age: where in the First Nuclear Age nuclear warfare at any level was "unthinkable" and Schelling's deterrence assumptions appeared viable, the Second Nuclear Age is one where nuclear war is very possible. Waltz' defense of First Nuclear Age logic in the Second, then, is not a defense at all but rather a plea to continue to assume away the possibility of nuclear war by claiming that to consider nuclear warfare on any scale is to make nuclear weapons "conventional." However, the "tipping point" between the First and Second Ages is not to think of nuclear weapons as "conventional" and approve of their widespread use, but rather to entertain that Schelling's deterrence may fail and that nuclear warfighting may become necessary as Kahn predicted. This paper will now explore what the right doctrine and the right weapons for the Second Nuclear Age might be.

SECTION III: NUCLEAR WARFIGHTING

After reviewing the new and potential nuclear states likely to emerge in the Second Nuclear Age, Kartchner and Gerson observe that "given the range of potential opponents the United States may face, each with its own strategic culture and risk-taking propensities, there is even greater uncertainty than in the Cold War about the ability to reliably and effectively control escalation through traditional crisis management tools."[19] The traditional management tools used in the Cold War included institutionalized channels of communication, including unofficial back channels, a shared understanding of "red lines" that allow for "signaling" and clear communication of intent, and supporting alliance structures. These tools were developed over decades between two belligerents. Similar tools simply do not exist among all competitors in today's nuclear environment. Kartchner and Gerson conclude:

> For these reasons, traditional [First Nuclear Age] approaches to escalation control cannot be solely relied upon to manage the risks of nuclear escalation in the 21st century. When reciprocity and shared interests are lacking, *escalation dominance must come into play*… Whereas escalation control depends upon some element of cooperation between the belligerents, *escalation dominance relies purely upon superior brute force and war-winning strategies, coupled with the credible threat to employ those forces and strategies if necessary*.[20]

Katchner and Gerson argue that the sheer diversity of nuclear actors in the Second Nuclear Age may make local crises very difficult to manage due, in part, to a lack of cultural awareness. US difficulties in the Middle East in conventional conflict lend credibility to their line of thinking. If these cultural difficulties make successful de-escalation negotiations suspect, then they argue that deterrence based on brute force – escalation dominance – must be developed. Interestingly, escalation dominance is a concept developed by Herman Kahn. In *On Escalation*, Kahn defines escalation dominance as:

> A capacity, other things being equal, to enable the side possessing it to enjoy marked advantages in a given region of the escalation ladder. Escalation dominance thus is a

> function of where one is on the escalation ladder. It depends on the net effect of the competing capabilities on the rung being occupied, the estimate by each side of what would happen if the confrontation moved to other rungs, and the means each side has to shift the confrontation to these other rungs. One variable affecting escalation dominance is relative fear of eruption [to maximum effort nuclear warfare]. That side which has least to lose by eruption, or fears eruption the least, will automatically have an element of escalation dominance.[21] [22]

Lawrence Freedman describes two asymmetries between belligerents that can cause one to achieve successful escalation dominance. The first is a favorable *asymmetry of capabilities*. That is, escalation dominance tends to accrue to the belligerent with the most effective capacity to operate at the current crisis level as well as those levels that would generally tend to escalate the crisis. The second asymmetry tends to give escalation dominance to the side that *fears eruption the least*, the side that has technical advantages if a general war breaks out, or to a more aggressive attitude in the crisis.[23] Thus, escalation dominance accrues to the side that has the best equipment with which to fight as well as the side with the least concern for avoiding general war.

Kahn's escalation ladder (see Appendix 1) provides a workable model of the many ways a nuclear war may take shape and indicates that there are many nuclear options short of civilization-ending "spasm" warfare. In the model, the majority of nuclear options are concerned with demonstration, exemplary, and "counterforce" (aimed at destroying military fielded forces) attacks, bypassing cities and populations entirely. These will probably comprise the bulk of Second Nuclear Age nuclear strikes. Common to all of these limited nuclear options is a desire to minimize collateral damage and avoid further escalation. Indeed, Bruce Bennett, in an independent study of US responses to nuclear attack, stressed that in almost all conceivable scenarios US responses will be limited to demonstration, exemplary, and counterforce attacks.[24] Since all three attack missions would seem to stress similar characteristics of nuclear weapons,

and to be consistent with stated US nuclear employment doctrine, let's assume that limited nuclear war requires "counterforce" weapons to be most efficient, effective, and humane.[25]

Suppose that the United States is forced to initiate a "justifiable counterforce attack" (Rung 19) against a rogue nation's nuclear capability after absorbing an "accidental" nuclear strike (Rung 15).[26] What capabilities must the US have to accomplish this strike? Dr. Barry Schneider identifies six key attributes of an ideal counterforce capability. The first is to have highly *accurate target information*, far more than simply knowing where the target is. It would also include the precise location of the weapons, production and storage facilities, and launchers, and the vulnerabilities of each. Post-attack, targeteers would also need to know how to assess strikes on WMD targets as well as determine whether WMD agents were released in the environment and if they present any danger.[27]

These information requirements are very detailed and difficult because they span the entire Find, Fix, Track, Target, Engage, Assess "kill chain." Post-strike assessment is particularly troublesome but vitally important for a counterforce strike on nuclear targets so the repercussions of the strike can be quickly known (fallout hazards, contamination dangers, etc.). However, accurate target information is only the first requirement of an ideal counterforce capability. Schneider continues: "In addition to ascertaining precise target coordinates and characteristics, the ideal counterforce fighting force should be able to *deliver their blows with great accuracy*. Counterforce units will need precision guided munitions (PGMs) to hit the bulls-eye when the balloon goes up."[28]

Highly accurate nuclear weapons allow explosive yields to become much smaller than they might otherwise need to be in order to maintain effectiveness. The smaller the nuclear weapon used, the less likely that use will cause unwanted escalation. Therefore, increasing

accuracy is a very high priority for effective limited nuclear warfare weaponry. With high accuracy attained, the next three requirements for an ideal counterforce capability can be developed. Schneider believes the final requirements is a force capable of applying *discriminate lethality* (to tailor effects by matching appropriate weapons to targets and minimize collateral damage), *significantly reduced sensor-to-shooter-to-target times* (through all-weather precision, extended range, and/or continuous presence over target sets), and *minimize dangers to air crews* engaged in counterforce operations.[29]

Counterforce weapons must be able to apply discriminate force mindful of collateral damage risks, reduce the "kill chain" time, and minimize the danger to crews mounting the attack. But even with these five key requirements met, the ideal counterforce capability needs one more element: "Finally, for counterforce operations to be optimally employed, the United States needs a *strategy and military doctrine* that guides when, where, and how such counterforce actions should be triggered by top U.S. decision-makers."[30]

Weapons are only as good as the techniques developed to use them, and the techniques for fighting a limited nuclear war are as necessary as weapon systems with the other five ideal counterforce requirements (accurate target information, precision, discriminate, short kill chain, minimum danger to crews) as listed by Schneider. With these six requirements identified, we can now analyze current United States nuclear forces for their suitability in this new limited nuclear war context.

Bruce Bennett's analysis of the current US nuclear force structure in terms of limited nuclear war requirements is insightful. Bennett argues for three critical criteria in determining whether the US is prepared for limited nuclear war. First, can the US deliver a devastating

nuclear attack? Second, can the US avoid nuclear accidents and horizontal escalation? Three, can the US deliver these attacks in a limited, distinct manner with precision effects?[31]

The requirements for a successful nuclear counterforce campaign are significant. Bennett asserts that a devastating counterforce attack "against countries with even modest nuclear force capabilities… could require up to about 50 nuclear weapons, and hundreds of conventional force sorties.[32] Large sortie requirements are not simply a matter of multiple targets. Not every nuclear attack may reach its intended target, and the possibilities of hitting every adversary nuclear weapon in an initial strike may be prohibitively remote. Bennett describes the difficulty:

> This concern about attack effectiveness would be particularly true with counterforce attacks. Consider a case where the adversary has five nuclear weapons storage facilities each containing four nuclear weapons. If the United States sends one nuclear weapon against each, and the US weapons have an 85 percent delivery probability and a 90 percent probability of destruction if the warhead arrives, then the expected number of surviving adversary warheads would be 4.7, enough for a fairly devastating adversary response. Even if two warheads were assigned to each target, 1.1 adversary warheads would be expected to survive…[33]

Because of the unique requirements of limited nuclear war operations, current US systems face a number of problems not faced by the Cold War deterrence mission. Beyond the simple kill probability of the nuclear weapons used, Bennett says that these forces need to have sufficient range and penetration capabilities to reach their targets, as well as have overflight, launch location, and booster impact characteristics that can be manageable.[34] If an American ICBM is launched in combat, it's first stage booster will likely impact Canada, an event that may complicate ICBM use in any manner not resulting from a "spasm" war. Warhead packaging (i.e. placing multiple warheads on a single missile) might also be problematic if we want to strike only one target with an ICBM or SLBM.[35] Any strikes must also be prompt, timely, and exhibit a great deal of simultaneity in order to prevent dispersal of an adversary's nuclear capability before all sites can be hit. Also, any contemplated nuclear strike must minimize collateral

damage and fallout.[36] Concerns about collateral damage and fallout have always been the main worries behind nuclear weapons actually being used, leading many to openly question whether nuclear weapons are needed for deterrence, much less warfare.[37] If nuclear weapons are indiscriminate (too high of a yield) or too dirty (high fallout), then they will not be useful to limited nuclear war aims. Finally, in order to use even a high quality limited nuclear warfare weapon, the US must correctly attribute the attack it absorbs in order to retaliate against the proper nation responsible for the attack. Limited nuclear war forces must have favorable characteristics in all of these areas to prosecute a limited nuclear war. Can current US nuclear forces (ICBMs, SLBMs, and bombers) satisfy these high requirements? Bennett assesses the current nuclear force structure as marginally adequate. Overall, Bennett concludes:

> The United States clearly has sufficient high-quality nuclear weapons to cause devastating damage to any adversary, using multiple limited attacks if necessary. But US forces face some challenges with overflights and achieving attribution of adversary attacks. And the United States appears to face a number of challenges in delivering limited, precise nuclear attacks. Some of these challenges are associate with nuclear attack criteria that do not vary across the nuclear force types, including intelligence and major elements of simultaneity and timing. Simultaneity and timing appear to be significant constraints on the efficiency of any US response other than demonstration and EMP attacks.[38]

Bennett identifies a number of gaps in each leg of the US nuclear triad. ICBMs are problematic in limited nuclear war because their boosters would tend to land in the United States or Canada and even strikes into many rogue nations in the Middle East would tend to overfly Russia, a very dangerous and problematic issue that could lead to an unintentional full retaliation by Russian strategic forces.[39] These problems with overflight alone would tend to limit the ICBM's role in limited nuclear warfare. The SLBM can mitigate some of the ICBM's geographic and overflight issues, but problems still remain. Even with an ability to move launch positions around, overflight over China and other nations if attacking some targets in the Middle

East and Southeast Asia may be prohibitively dangerous. SLBM warheads are also relatively large and dirty and their targeting systems relatively imprecise. Also, SLBMs might have some timing and simultaneity problems if launch orders are received late.[40] Finally, nuclear bombers and fighters may be able to eliminate many overflight problems, carry much more tailored weapons, and act as very useful limited nuclear warfare platforms. However, aircraft may be very slow to deliver their weapons on target compared to ICBMs/SLBMs, especially if they and their nuclear weapons are not deployed in close proximity to the theater.[41] Bennett's assessment of the current US nuclear force to prosecute limited nuclear warfare operations is presented in Table 2.

Overall, Bennett concludes that the US must make fundamental improvements to the nuclear force in six areas in order to become a force capable of fighting limited nuclear wars: improving intelligence, quickening timing and execution of nuclear strikes, increasing capabilities to assign attribution, closer basing and less overflight, improved nuclear weapons packaging, and minimizing collateral damage/fallout.[42] However, these improvements should be expected because our current force structure was based on First Nuclear Age thinking.

As stated earlier, Defense Secretary McNamara favored Schelling's deterrence theory rather than Kahn's in the critical early 1960's when the classic nuclear triad became fully operational (the B-52 nuclear bomber in 1955, the George Washington class ballistic missile submarine in 1959, and the Titan ICBM in 1962). With the triad in place, the US nuclear force was sufficient for Schelling's deterrence and strategic force development for nuclear war fighting was curtailed significantly. Under Secretary McNamara, the Defense Department emphasized "assured destruction" and rejected "destabilizing" strategic programs, including defenses aimed at defending the American population during a nuclear exchange. As Payne explains,

"Declassified documents covering the 1960s – including Secretary McNamara's progression of classified [Draft Presidential Memorandums' on strategic forces from 1961 until 1968 – demonstrate conclusively that *he explicitly rejected the logic and strategic force goals recommended by Kahn in favor of those compatible with Schelling's definition of a stable balance of terror with the Soviet Union*."[43]

Since US nuclear forces adhered to Schelling's deterrence theory shortly after the classic nuclear triad became operational, it is no surprise that the First Nuclear Age US arsenal is ill-equipped to deal with a Second Nuclear Age where Kahn's deterrence theory may prove the dominant model. However, there were nuclear development programs in the 1960's that followed Kahnian logic cancelled by the McNamara Defense Department. Even if these programs did not prove necessary for service in the First Nuclear Age, they may find new purpose confronting the challenges of the second one.

Perhaps the most ambitious nuclear program proffered by the US Air Force and rejected by McNamara was the Strategic Earth Orbital Base. Written by the Commander-in-Chief of Strategic Air Command (SAC), General Thomas Power, in a 21 Jan 1961 Qualitative Operational Requirement (QOR) memorandum, the Base is described as:

> A strategic earth orbital platform capable of sustaining extremely heavy, composite payloads from low orbite [sic] to lunar distances and beyond… A long term strategic earth orbital capability, virtually unrestricted by propulsion or payload limitations, is required.[44]

Such a giant, manned spacecraft would serve as the space component of the SAC strategic deterrent force. General Power continues:

> A number of [space] vehicles in various orbital planes at progressively distant orbital altitudes will provide integrated facilities for unlimited surveillance, depth of force, secure command and control, and a high probability of delivering weapons to any terrestrial target… [It must also] be capable of accurate weapon delivery, with a variety of weapons… self-sustaining when confronted with enemy attack… capable of omni-

> directional detection of attack and surveillance [to include processing and interpretation of collected data to allow on-board planning and decision.[45]

It is noteworthy that of all the space-related QOR memoranda written by SAC under General Power's command, he personally wrote and signed only the one documenting the Strategic Earth Orbital Base. Unfortunately, General Power's description of the base is difficult to follow without context. Captain Frederick Gorschboth, an officer charged with developing doctrine for this new space weapon, provided a much clearer explanation of what the Strategic Earth Orbital Base was meant to be, nothing less than an individual warship (we will call it Orion) to serve as part of a "space force that… would look like, operate like, and fight like a three dimensional Navy."[46] Captain Gorschboth continues:

> [The space force] would consist of a number of capital ships (with the necessary auxiliaries), all of which would be shielded, armored, armed with a variety of offensive and defensive weapons [nuclear counterforce missiles and anti-ICBM missiles and mines], equipped with the complete spectrum of sensing equipment including infrared, radar, optics, and electronic intelligence-gathering, furnished with numerous decoys and electronic countermeasures equipment, and supplied with the energy potential for essentially unlimited (except at the low altitudes) mobility in space.[47]

Gorschboth envisioned a fleet of "perhaps fifty major [Orion] vehicles" placed in three general orbits (a low altitude fleet of perhaps 1000 mile altitude polar orbits, an intermediate altitude fleet in geosynchronous orbit, and a deep space fleet in highly elliptical orbits perhaps with apogees beyond the Moon) that would be able to provide a robust counterforce capability capable of both deterring and successfully fighting the strategic forces of the Soviet Union.[48]

Nuclear forces capable of both deterring and successfully fighting a nuclear enemy are forces that Kahn would approve, but to a Schelling-minded defense secretary, the Orion battleship would seem expensive and destabilizing, and perhaps also impossible (a claim which will be addressed later). However, let us consider a 10,000 ton payload Orion spacecraft either crewed or uninhabited with characteristics as General Power and Captain Gorschboth describe.

Imagine a two-ship squadron in the same highly elliptical Molniya-type orbit separated by 180 degrees in true anomaly (so that there is always at least one ship over a point of interest, say North Korea). Each Orion would have a robust, modern sensor suite and associated processing with which to generate workable strategic reconnaissance capable of providing 100% target coverage between the squadron. In addition to having robust intelligence, the captain of each ship would also have effective command and control to be able to strike targets of his (or her) own volition once given proper authority from Earth. At his disposal would be dozens or hundreds of space-to-Earth missiles both conventional and variable-yield, fallout minimized nuclear weapons. Each ship would also have a robust loadout of space mines and anti-ICBM missiles or directed energy weapons capable of engaging low to moderate numbers of ICBM's launched from the target area simultaneously. Finally, each ship would have the ability to change orbits, including large plane changes. With a payload capacity of 10,000 tons, there is little doubt that the necessary equipment would fit. Thus, each ship would have robust sensors, offensive weapons that could attack any surface target with precise warheads ranging from conventional to perhaps megaton range, and a defensive weapons suite that can protect itself as well as provide robust missile defense for a low to moderate number of strikes, proper command and control and maneuverability. Would Orion satisfy the counterforce requirements needed for successful limited nuclear wars?

These Orion ships would go very far in addressing Bennett's six major necessary improvements to ensure a robust limited nuclear war capability. The comprehensive strategic reconnaissance and processing capabilities of Orion would excel in addressing both the need to improve intelligence (for constant pre-attack surveillance as well as post-attack assessment) and would also greatly improve the ability to attribute attacks from the squadron's area of interest.

Also, by placing all of the resources necessary to complete the Find-Fix-Track-Target-Engage-Assess (F2T2EA) kill chain, Orion could reduce the time needed to prosecute a counterforce attack dramatically. Also, with a large variety of weapons at its disposal, an Orion would be able to drastically improve the tailorability of counterforce strikes and minimize collateral damage as well. Finally, in perhaps its most novel capability, Orion could virtually eliminate basing and overflight issues by operating in the commons of outer space and by obviating the need to drop a booster on a neutral or friendly nation. Orion could, if properly equipped, offer the improvements necessary to prosecute a counterforce limited nuclear war effectively, according to Bennett.

However, Orion also seems to approach Schneider's characteristics of an ideal counterforce capability as well. In addition to Bennett's improvements, Schneider specifically adds that the ideal counterforce capability would also reduce the sensor-to-shooter-to-target times and minimizes dangers to crews. Again, by combining the sensor and the shooters in the same vehicle and basing the vehicle in orbits directly above a target area at distances of perhaps only hundreds of miles using hypersonic weaponry or directed energy weapons, the entire Orion kill chain could be conceivably cut to mere minutes from identification to nuclear engagement of a target. As for crew safety, aside from deploying the crews into space (not even as isolated as our submarine crews communications-wise), the Orion would have a great defensive weapons capability and many tons of armor, making the crew almost invulnerable – especially compared to a manned bomber. Thus, it appears that Orion would make an ideal delivery system for fighting limited nuclear wars. However, the question may be asked whether the operating requirements of launching a vehicle weighing thousands of tons of into orbit is beyond the realm

of technical feasibility. To answer this question we must return to General Power's QOR. The Strategic Earth Orbital Base must:

> Be placed in orbit by a nuclear pulse rocket (or other propulsion system of comparable performance) capable of orbiting extremely heavy useful payloads; (i.e. on the order to 5,000 tons by 1975 and 15,000 tons by 1985), or erected in space with components transported into orbit. In general, an operationally useful payload has been restricted by available propulsive thrust and monetary considerations. The nuclear pulse rocket, as employed in the "Orion" concept, appears to broaden these restrictions to the degree necessary for attainment of the capabilities described in this QOR.[49]

The Strategic Earth Orbital Base QOR was intended to serve as the military justification to enter the construction and test phase of Project Orion, the Air Force Special Weapons Center project (active 1957-1965) aimed at developing a nuclear pulse rocket. Project Orion scientist Freeman Dyson ably describes the vehicle in his 1965 article "Death of a Project":

> Orion is a project to design a vehicle which would be propelled through space by repeated nuclear explosions occurring at a distance behind it. The vehicle may be either manned or unmanned; it carries a large supply of [nuclear] bombs, and machinery for throwing them out at the right place and time for efficient propulsion; it carries shock absorbers to protect the machinery and the crew from destructive jolts, and sufficient shielding to protect against heat and radiation… The project in its 7 years of existence was confined to physics experiments, engineering tests of components, design studies, and theory. The total cost of the project was $10 million, spread over 7 years, and the end result was *a rather firm technical basis that vehicles of this type could be developed, tested, and flown. The technical findings of the project have not been seriously challenged by anybody. Its major troubles have been, from the beginning, political*.[50]

Indeed, Project Orion's use of nuclear detonations to achieve orbit (some flight profiles recommended up to 300 pulses per launch, with detonations ranging from a few hundred tons to perhaps a dozen kilotons – still very small by nuclear weapons standards) was from the beginning more politically than technically complicated. Orion's fate was sealed when the Limited Test Ban Treaty of 1963 forbid the detonation of nuclear devices in the atmosphere or in space, making illegal the entirety of Orion's flight profile. This treaty in conjunction with McNamara's distaste for Kahnian nuclear war fighting systems made Orion a poor political prospect regardless of its technical merits.[51]

A complete technical description of Project Orion is beyond the scope of this paper.[52] However, there is little disagreement in the scientific community that the nuclear pulse rocket is technically feasible and has far greater performance than any other currently envisioned space propulsion system by orders of magnitude. Indeed, most proposed self-contained interstellar (capable of flying to another star) propulsion systems have been some variation of the original Orion system, and interstellar propulsion expert K.F. Long favors nuclear pulse propulsion for interstellar missions because he has a "personal belief that nuclear pulse technology is nearly ready for use now, if not already available in some form, and is the most appropriate route for an interstellar flight. [Physical] Power is what will take us to the stars, and sending something there fast requires powerful engines as provided by the nuclear pulse options."[53]

If nuclear pulse propulsion engines can send spacecraft to other stars, they can certainly be used to power Orion craft such as General Power and Captain Gorschboth describe. These Orion craft offer superior capability with which to achieve escalation dominance (through overwhelming superiority in weaponry as well as decision superiority from Orion's ability to conduct anti-ICBM operations and other provisions for terrestrial defense) and deter or fight limited nuclear wars. Discussing Orion's greatest hurdle – politics – will be the subject of the last section.

SECTION IV: ORION ASCENDANT

With the potential military utility of Orion established and assuming that its technology is feasible, the major roadblock to developing and fielding nuclear pulse driven spacecraft is overwhelmingly political. How can launching and operating spacecraft propelled by external nuclear explosions be justified politically? We can begin by examining some recent guidance by both the Department of Defense and the US Air Force.

In the Chairman's Assessment section of the 2014 Quadrennial Defense Review, Chairman of the Joint Chiefs of Staff General Martin Dempsey prioritizes maintaining a secure and effective nuclear deterrent as his top priority of 12 total missions for the Department of Defense, followed closely by providing for military defense of the homeland (#2), defeating adversaries (#3), and providing a global, stabilizing presence (#4).[54] In accomplishing these missions, Dempsey argues:

> We will need capabilities that can operate effectively in contested environments and that can execute forced entry. This means capabilities that have greater operating ranges and are more interoperable with other systems and concepts and capabilities that will enable dispersed operations. We will need to continue to provide and enhance a network of systems that can defeat deeply buried and hardened targets and that can track and destroy mobile launchers. We need to begin to move away from traditional platforms and methods, without sacrificing the benefits of our current posture and capability set. Such a transition will be challenging and could be costly.[55]

Traditional platforms for maintaining and securing an effective nuclear deterrent include ICBMs, SLBMs on submarines, and manned bombers – all examples of First Nuclear Age deterrence thinking. In the QDR, General Dempsey appears open to new platforms that will better address emerging challenges. In *America's Air Force: A Call to the Future*, Air Force Chief of Staff General Mark Welsh echoes General Dempsey by declaring that providing effective 21st Century deterrence as the primary Air Force strategic vector for the future into the

middle of this century.[56] The document describes the Air Force's commitment to strategic deterrence:

> One of the Air Force's enduring contributions to national defense is maintaining credible and robust strategic deterrence. The sustainment and improvement of the individual nuclear weapons is critical to the success of this deterrent stance and warrants continued emphasis. Improvements in the weapons themselves may offer opportunities for better delivery capability, to include modernized bombers and missiles that will ensure our nuclear mission remains the bedrock of national security. The infrastructure that enables our nuclear mission is also a national treasure. It must be recapitalized where necessary and modernized when needed. The nuclear mission must remain the clear priority of Air Force leaders at all levels.[57]

Thus, both the Department of Defense and the US Air Force have placed 21st Century strategic deterrence as the top priority. As we have previously seen, the Second Nuclear Age may manifest itself as an age of limited nuclear war where Schelling's theory fails outright and successful deterrence will require a Kahnian strategy. Unfortunately, the shift from Schelling to Kahn in deterrence building will probably not be embraced until Schelling fails in a very public and tremendous way, for even official Air Force documents call Schelling's deterrence "one of the most successful deterrence strategies in history" that "ultimately delivered victory in the Cold War."[58]

However, the failure of Schelling's deterrence will also blow open the greatest obstacles to Orion development. Schelling's deterrence is based on the belief that mere possession of a nuclear weapon (suitably defended from a first strike) on each side is enough to ensure nuclear warfare between the belligerents cannot happen. Therefore, if a limited nuclear war does happen, such as a nuclear exchange between India and Pakistan or other hotspot, no matter how small (all will likely be very public and tremendous), most will be forced to accept that Schelling's original assumptions are invalid and that future deterrence will be based in part on the ability to fight a limited nuclear war – consequently adopting Kahn's version of deterrence.

But in addition to adopting Kahn, a limited nuclear exchange will also tend to invalidate the document that originally killed Orion, the Limited Test Ban Treaty (LTBT) of 1963.

Most countries have signed and ratified the LTBT (exceptions include China, North Korea, France, and Saudi Arabia) which declared space, underwater, and atmospheric nuclear detonations illegal. Of special note, many of the new nuclear powers (notably India, Pakistan, and Iran) are signatories and if one of these signatories engages in a limited nuclear war they will violate the treaty in a very overt way.

One limited nuclear exchange may cause the international community to clamp down hard on nuclear weapons and proliferation, but if two or more limited nuclear wars occur, the "nuclear taboo" against using these weapons may be broken. If so, the LTBT may dissolve as the world erupts into a large round of nuclear testing (perhaps including above ground) as both mature and new nuclear powers develop a new set of nuclear capabilities to address the challenges of a Kahnian Second Nuclear Age. With limited nuclear wars a fact of geopolitics, the LTBT in tatters, and its promise of superior nuclear war fighting capabilities far exceeding any other known platform, Orion may prove too attractive to the US to resist developing to achieve escalation dominance and re-establish deterrence under the Second Nuclear Age Kahn framework. With the LTBT gone, opposition to Orion from the Outer Space Treaty of 1967 (outlawing the deployment of weapons of mass destruction – including nuclear weapons – in space) may likely dissolve as well. It is important to note that the United States may not desire any of these outcomes, but may nonetheless be forced into developing Orion against its will in order to secure 21st Century deterrence in the Second Nuclear Age. Indeed, the US may have no choice since most foreseeable limited nuclear war scenarios do not involve the US as a belligerent. Circumstances and international events may themselves invalidate many of the

political objections to Orion in the United States. The US choice will be whether or not to re-establish strategic deterrence in this more dangerous Second Nuclear Age by embracing a Kahn-inspired space-based counterforce deterrence through Orion platforms.

Fielding Orion platforms would impact the Department of Defense far more than simply gaining escalation dominance and re-establishing credible deterrence in the Second Nuclear Age. A handful of Orion spacecraft could provide a truly global forward presence similar to a Carrier Strike Group by placing a great deal of American firepower in a theater with two major advantages – Orion is not limited to operating off an adversary's coast (making even inland targets reachable to US combat power), and being far more responsive to a crisis by redeploying to a combat area across the world in a matter of minutes or hours rather than weeks. Adversary Anti-Access Area Denial (A2AD) strategies could be rapidly overcome through an Orion capability. Orion vessels would also serve as robust intelligence, surveillance, and reconnaissance (ISR) platforms with capabilities that may be far in excess of our current satellite systems. Mating sensors to shooters and associated command and control would also shorten the F2T2EA kill chain enormously for both nuclear and conventional strikes from space. Such a robust combination in an Orion vessel may far exceed the capabilities of the more conventionally-minded satellite-based space-to-ground attack systems envisioned like "rods from God." Indeed, space based missile defense would be far easier to achieve through Orion platforms than classic "Star Wars" killer satellite concepts for reasons of spacelift cost (nuclear pulse propulsion is orders of magnitude more efficient than high thrust chemical boosters) and operability (human crews can perform routine maintenance and repair of onboard systems unlike a satellite weapons system). Orion vehicles may even allow for rapid reaction troop insertion and extraction similar to the short-lived US Marine Corps SUSTAIN program.[59] Regardless of

specific use, developing Orion would be a brave new challenge to the nation's nuclear industrial enterprise, perhaps leading to an era of greater discovery and prosperity than the Cold War itself. The addition of an Orion capability to the US military would take its place among the invention of the satellite, steam engine warship, or even the airplane as a historic strategic revolution. Orion would be perhaps the ultimate response to achieving stability in the increasingly dangerous world of the Second Nuclear Age.

However, Orion would not be simply a dangerous but necessary response to an infinitely darker world. Indeed, the danger associated with limited nuclear wars and the dissolution of the LTBT may paradoxically lead the Second Nuclear Age into a new Golden Age. Orion is fundamentally a new space lift and space transportation system, one that holds the possibility of launching massive payloads into orbit for a few cents to a few dollars a pound, orders of magnitude cheaper than space transportation is now.[60] Also, because Orion nuclear pulse units need only small yields for propulsive purposes, the explosions can be designed to minimize fallout and electromagnetic pulse (EMP) that could dramatically curtail the negative consequences of their nuclear power source. If Orion provided cheap lift and robust in-space maneuverability as envisioned, it would literally open all of the solar system (and with later improvements, perhaps beyond) to human travel and immediately make currently cost-prohibitive space projects economically viable. Strategic materials such as platinum group metals, volatile chemicals, and even water could be economically harvested from space *for use on Earth*, which may significantly lessen the risk of great power resource wars warned of by some defense analysts.[61] Potentially cheap and plentiful power could be distributed around the world – to include the rapidly growing economies of China and India – using space-based solar power.[62] Orion could also serve as a planetary defense platform, able to quickly intercept

incoming asteroids or comets which could impact Earth carrying whatever deflection technique deemed appropriate to the threat, potentially saving the planet from mass extinctions. Lastly, Orion could open the entire solar system to large-scale exploration and colonization, potentially offering humankind access to not only the final, but also permanent frontier of deep space.

From this study we have learned that Cold War deterrence based on the theories of Thomas Schelling may no longer be relevant in a proliferated Second Nuclear Age and that limited nuclear wars may be likely. In order to provide successful deterrence in an age of limited nuclear warfare, a deterrence approach based on Herman Kahn's theories may be necessary. Kahn advocated an approach to deterrence that would stress both massive retaliation capabilities to deter wars as well as the capability to successfully fight and win a nuclear war should deterrence fail. The Orion nuclear pulse propulsion spacecraft was designed by the US Air Force as a nuclear delivery system that could fight and win a nuclear war through both offensive and defensive capabilities in true Kahn fashion. Orion was cancelled because its nuclear propulsion system was deemed unstable under the Schelling-minded Defense Secretary McNamara. If the Second Nuclear Age results in limited nuclear wars much of the rationale for the original political opposition to Orion will be invalidated, and Orion's strategic deterrence capabilities may make it the only system capable of re-establishing deterrence using the Kahnian concept of escalation dominance. If fielded, the Orion system would not only revolutionize the American military but could also provide untold benefits to all by opening space to human settlement.

Even if the benefits of Orion are great, the United States will probably not take the necessary steps of abrogating the LTBT and OST treaties before the Second Nuclear Age delivers the world's first nuclear war in over 70 years. However, the United States must be prepared for the day when First Nuclear Age deterrence fails and we enter the Second Nuclear

Age. The best preparation is to be ready to proceed with developing the Orion weapon system as envisioned by General Power and Captain Gorschboth as soon as it appears that the "nuclear taboo" is irreparably smashed. In order to be ready, the United States military should proceed to collect all of the relevant data on Project Orion generated from 1958-1965 and continue to build upon it. Defense theorists should study the strategic implications of Kahn deterrence theory and the literature of limited nuclear war in order to develop new theoretical approaches for the Second Nuclear Age. Military analysts should develop the concepts of operation and associated doctrine for an Orion-like capability. Scientists and engineers must continue to explore design issues significant to Orion and develop as much necessary technology as possible short of actual nuclear testing. This includes assessing other power sources potentially suitable (technically *and* politically) for pulse propulsion such as nanoenergetic explosives (which may offer conventional yields in the kiloton range) and clean compact fusion devices.[63] Finally, all actors must develop a mature Orion development plan capable of execution immediately after the geopolitical situation sufficiently alters to allow Orion development to proceed politically.

Jeffrey Larsen and Kerry Kartchner end the preface to *On Limited Nuclear War in the 21st Century* by concluding "US policymakers and combatant command commanders have not really thought through the implications of [limited nuclear wars]. As a result, the United States has neither the right weapons nor the right doctrine to wage such a conflict if one were thrust upon it… War is inevitable. Limited nuclear war is possible."[64]

By re-opening Project Orion and embracing the study of Kahn's escalation dominance deterrence theory as described in this paper, even if the United States may not have the best tools to respond to the first limited nuclear war of the Second Nuclear Age, it will be armed to dominate the second.

APPENDIX A

Civilian Central Wars	44. Spasm or Insensate War 43. Some Other Kinds of Controlled General War 42. Civilian Devastation Attack 41. Augmented Disarming Attack 40. Countervalue Salvo 39. Slow Motion Countercity War
City Targeting Threshold	
Military Central Wars	38. Unmodified Counterforce Attack 37. Counterforce – with – Avoidance Attack 36. Constrained Disarming Attack 35. Constrained Force-Reduction Salvo 34. Slow – Motion Counterforce War 33. Slow-Motion Counter-"Property" War 32. Formal Declaration of "General" War
Central War Threshold	
Exemplary Central Attacks	31. Reciprocal Reprisals 30. Complete Evacuation (Approximately 95 per cent) 29. Exemplary Attacks on Population 28. Exemplary Attacks Against Property 27. Exemplary Attacks on Military 26. Demonstration Attack on Zone of Interior
Central Sanctuary Threshold	
Bizarre Crises	25. Evacuation (Approximately 70 per cent) 24. Unusual, Provocative, and Significant Countermeasures 23. Local Nuclear War – Military 22. Declaration of Limited Nuclear War 21. Local Nuclear War - Exemplary
No Nuclear Use Threshold	
Intense Crises	20. "Peaceful" World-Wide Embargo or Blockade 19. "Justifiable" Counterforce Attack 18. Spectacular Show or Demonstration of Force 17. Limited Evacuation (Approximately 20 per cent) 16. Nuclear "Ultimatums" 15. Barely Nuclear War 14. Declaration of Limited Conventional War 13. Large Compound Escalation 12. Large Conventional War (or Actions) 11. Super-Ready Status 10. Provocative Breaking Off of Diplomatic Relations
Nuclear War is Unthinkable Threshold	
Traditional Crises	9. Dramatic Military Confrontations 8. Harassing Acts of Violence 7. "Legal" Harassment – Retorsions 6. Significant Mobilizations 5. Show of Force 4. Hardening of Positions – Confrontation of Wills
Don't Rock the Boat Threshold	
Subcrisis Maneuvering	3. Solemn and Formal Declarations 2. Political, Economic, and Diplomatic Gestures 1. Ostensible Crisis
Disagreement – Cold War	

Herman Kahn's Escalation Ladder (*On Escalation*, 39.)

APPENDIX B

US Total Strategic Forces Capability to Execute Limited Nuclear Attack Options 2014						
	Response Options					
Criteria	Pure Demo	EMP	Ground Forces	Other Mil Targets	Counterforce	Strike Leaders
Devastating Attacks						
Yield, Accuracy	Good	Good	Good	Good	Good	Good
Delivery Probability	Good	Good	Good	Good	Good	Good
Range, Penetration	Good	Good	Good	Good	Good	Good
Altitude	-	Good	-	-	-	-
Net Capability	Good	Good	Good	Good	Good	Good
Avoid Accidents, Horizontal Escalation						
Attribution	Good?	Good?	Fair	Fair?	Fair	Fair
Overflight, Location	Good	Good	Good	Good	Good	Good
Net Capability	Good	P -> Good	Fair	Fair?	Fair	Fair
Limited, Precise Effects						
Intelligence	Good	Good	F -> Good	F -> Good	Poor?	Poor?
Doctrine, C2	?	?	?	?	?	?
Simultaneity, Timing	Good	Good	Poor	P -> Fair	Poor	Poor
Packaging	Good	Good	Good	Good	Good	Good
Collateral Damage	Good	Good	Fair	Fair	Fair	Fair?
Fallout	Good	Good	Fair	Fair	Fair?	Fair?
Net Capability	Good?	Good?	Fair?	Fair?	P -> Fair?	P -> Fair?

US Total Strategic Forces Capability to Execute Limited Nuclear Attack Options, 2014
Derived from "On US Preparedness for Limited Nuclear War" by Bruce W. Bennett *On Limited Nuclear War in the 21st Century* (2014), pgs 236-9.

END NOTES

[1] *Flight Plan for the Air Force Nuclear Enterprise* (26 June 2013), pp. iv.

[2] Ibid., pp 25.

[3] Tactical nuclear weapons are generally considered to be weapons for use on the battlefield (counterforce) that are of relatively low yield that destroy adversary military forces or formations. Alternatively, strategic nuclear weapons are higher yield weapons meant for use on cities or factories (countervalue) that destroy an adversary's ability to make war.

[4] Paul Bracken, *The Second Nuclear Age* (2012), 1

[5] Ibid., 3.

[6] Ibid., 95.

[7] Ibid., 11.

[8] Keith B. Payne, *The Great American Gamble* (2008), 5.

[9] Ibid., 5.

[10] Ibid., 6.

[11] Andrew L. Ross, "The Origins of Limited Nuclear War Theory." *On Limited Nuclear War in the 21st Century (*2014). Jeffrey A, Larson and Kerry M. Kartchner editors, 21.

[12] Ibid.

[13] Payne, 140.

[14] Ibid., 65.

[15] Scott Sagan and Kenneth Waltz, *The Spread of Nuclear Weapons: An Enduring Debate*, 3rd ed. (2013), 108, emphasis added.

[16] Ibid., 109.

[17] Jeffrey A. Larson and Kerry M. Kartchner (eds.) *On Limited Nuclear War in the 21st Century (*2014), xx-xxi.

[18] Ibid., xxv.

[19] Kerry M. Kartchner and Michael S. Gerson, "Escalation to Limited Nuclear War in the 21st Century," *On Limited Nuclear War in the 21st Century* (2014). Jeffrey A. Larsen and Kerry M. Kartchner, eds., 165.

[20] Ibid., 165-6. Emphasis Added.

[21] Herman Kahn, *On Escalation*. (1965), 290.

[22] Embedded in Kahn's treatment of escalation dominance, however, is his concept of the escalation ladder. The escalation ladder, "a linear arrangement of roughly increasing levels of intensity of crisis," was a metaphor Kahn used to display the many options available to a belligerent to escalate a crisis between two nuclear powers (Kahn, 38). The escalation ladder was not meant to be a theory of escalation or a predictive model for all crisis escalations, but rather a heuristic tool that attempted to capture as many options available as possible so that they may be analyzed. Kahn developed 44 rungs on his escalation ladder. Because Rung 15 involves the first use of nuclear weapons, Kahn's escalation ladder may also be used as a model that scopes the range of nuclear conflict from the most limited crisis between nuclear powers, through different levels of intensity of limited nuclear wars to a civilization-ending "spasm" or general nuclear war.

[23] Lawrence Freedman. *The Evolution of Nuclear Strategy*. Third Edition (2003), 206.

[24] Bruce W. Bennett. "On US Preparedness for Limited Nuclear War." *On Limited Nuclear War in the 21st Century*, Jeffrey Larsen and Kerry Kartchner, editors (2014), 223.

[25] Department of Defense, *Report on Nuclear Employment Strategy of the United States Specified in Section 491 of 10 U.S.C.*, Reference ID: 6-9963D19 (12 June 2013), 4.

[26] See Appendix A: Kahn's Escalation Ladder.

[27] Barry R. Schneider. "Counterforce Targeting Capabilities and Challenges." Future Warfare Series No. 22. Maxwell AFB, Alabama, USAF Counterproliferation Center. August 2004, 2.

[28] Ibid., 2-3. Emphasis added.

[29] Ibid., 3. Emphasis added.

[30] Ibid. Emphasis added.

[31] Bennett, "On US Preparedness", 224.

[32] Ibid., 225.

[33] Ibid., 227.

[34] Ibid., 228-9.

[35] Ibid., 232.

[36] Ibid., 234.

[37] David Trachtenberg, "U.S. Extended Deterrence: How Much Strategic Force is Too Little?" in Schneider, Barry and Patrick Ellis, editors. *Tailored Deterrence: Influencing States and Groups of Concern* (Maxwell Air Force Base, AL: USAF Counterproliferation Center, 2012), 291.

[38] Bennett, On US Preparedness", 235.

[39] Ibid.

[40] Ibid., 236.

[41] Ibid., 236-7.

[42] Ibid., 239-40.

[43] Payne, 100-1 emphasis original.

[44] Power, Thomas. "Strategic Earth Orbital Base", SAC QOR 21 Jan 61 (original classification SECRET, declassified 17 Apr 1987).

[45] Ibid.

[46] Gorschboth, Frederick F. *Man, Space, and Modern War*. Unpublished manuscript, Air Force Special Weapons Center, Kirtland AFB, NM, October 1960, 280.

[47] Ibid.

[48] Gorschboth, Frederick F. *Counterforce from Space*, TN-61-17, Air Force Special Weapons Center, Kirtland AFB, NM, 1 Aug 1961, (Original classification SECRET – RESTRICTED DATA; declassified 22 Jul 2014), 10. Declassified at request of author.

[49] Power, "Strategic Earth Orbital Base."

[50] Dyson, Freeman J. "Death of a Project." *Science*, 9 July 1965, 141. Emphasis added.

[51] Project Orion may have had more of a connection to Herman Kahn than simply fitting the requirements for his preferred method of deterrence. According to Fred Gorschboth, Herman Kahn wrote the preface to Gorschboth's classified version of *Man, Space, and Nuclear War* (interview with author, 13 March 2014). Unfortunately, the author's search for this classified document has been fruitless, and this document may be lost permanently.

[52] There are many sources for technical details on Project Orion. George Dyson's (Freeman's son) book *Project Orion* is the standard work on the subject and covers much of the program history and some technical details. K.F. Long devotes a chapter to the basic mathematics of nuclear pulse rockets in his *Deep Space Propulsion: A Roadmap to Interstellar Flight.* Detailed technical data can be found in the declassified General Atomics report *Nuclear Pulse Vehicle Study* GA-5009 (4 volumes) written for NASA's Marshall Space Flight Center Future Projects Office dated 19 September 1964.

[53] Long, K.F. *Deep Space Propulsion: A Roadmap for Interstellar Flight*, Springer, 2012, xi.

[54] *Quadrennial Defense Review 2014*, 4 March 2014, 60-61.

[55] Ibid., 62.

[56] *America's Air Force: A Call to the Future*, July 2014, 14.

[57] Ibid.

[58] Ibid., 15.

[59] The Small Unit Space Transport and Insertion (SUSTAIN) program was a US Marine Corps concept of operations to rapidly insert a squad to platoon-sized force from a home base into any area in the world in minutes using suborbital technology similar to that used by the Scaled Composites SpaceShipOne vehicle that won the Ansari X-PRIZE in 2004 or Virgin Galactic's space tourism vehicle SpaceShipTwo. It was active into the late 2000's.

[60] The Orion nuclear pulse propulsion concept's economic efficiency is derived from its high energy efficiency compared to chemical propulsion. The classic tradeoff in space lift engineering is between specific impulse (a vehicle's energy efficiency) and its generated thrust. Highly efficient space thrusters (such as electric propulsion) have very high specific impulses, in the thousands of seconds, but they produce only low amounts of thrust which make them unsuitable to lift objects into space. Chemical lift vehicles can produce high amounts of thrust (enough to place relatively large payloads into orbit) but are generally limited to specific impulses in the mid-400 seconds or lower. Orion, on the other hand, produces more thrust than chemical rockets can but also achieves specific impulses measured in the thousands of seconds in even its most rudimentary form. Therefore, Orion's economic efficiency is based on its energy efficiency matched with its ability to lift very large payloads into orbit.

[61] For a description of such resource wars see *Rising Powers, Shrinking Planet*, 2009, by Michael Klare.

[62] See *Space-Based Solar Power as an Opportunity for Strategic Study*, dated 10 October 2007 from the National Security Space Office for a Department of Defense-centric view of the utility of space-based power generation. It can be found at the National Space Society web site http://www.nss.org/settlement/ssp/library/nsso.htm (accessed 12 October 2014).

[63] Nanoenergetic explosives have been reviewed in the Air University's *Blue Horizons IV: Deterrence in the Age of Surprise* by Geis, Hammond, Foster, and Hailes (January 2014). The Lockheed Martin Compact Fusion effort wants to "Restart the Atomic Age." Information on the project can be found at www.lockheedmartin.com/us/products/compact-fusion (accessed 31 March 2015). Nanoenergetic explosives may be capable of substituting for nuclear pulse devices, eliminating the need for atmospheric nuclear detonations in small Orion-like spacecraft. Compact fusion technologies may either allow for self-contained nuclear thermal rockets

sufficiently powerful to propel Orion-like spacecraft or provide smaller, cleaner nuclear pulse units than the dirtier fission pulse units originally designed for Orion.

[64] Jeffrey Larsen and Kerry Kartchner, *On Limited Nuclear War in the 21st Century*, 2014, xxv.

BIBLIOGRAPHY

Bracken, Paul. *The Second Nuclear Age*. New York, NY: St. Martin's Press, 2012.

Department of the Air Force. *America's Air Force: A Call to the Future*. Washington, DC: Department of the Air Force, July 2014.

Department of the Air Force. *Flight Plan for the Air Force Nuclear Enterprise*. Washington, DC: Department of the Air Force, 26 June 2013.

Department of Defense. *Quadrennial Defense Review 2014*. Washington, DC: Department of Defense, 4 March 2014.

Department of Defense, *Report on Nuclear Employment Strategy of the United States Specified in Section 491 of 10 U.S.C.* Reference ID: 6-9963D19. Washington, DC: Department of Defense, 12 June 2013.

Dyson, Freeman J. "Death of a Project." *Science*, 9 July 1965.

Dyson, George. *Project Orion*. New York, NY: Owl Books, 2002.

Freedman, Lawrence. *The Evolution of Nuclear Strategy*, Third Edition. New York, NY: Palgrave, 2003.

Gorschboth, Frederick F. *Counterforce from Space*, TN-61-17, Air Force Special Weapons Center, Kirtland AFB, NM, 1 Aug 1961, (Original classification SECRET – RESTRICTED DATA; declassified 22 Jul 2014).

Gorschboth, Frederick F. *Man, Space, and Modern War*. Unpublished manuscript, Air Force Special Weapons Center, Kirtland AFB, NM, October 1960.

Kahn, Herman. *On Escalation*. New York, NY: Praeger, 1965.

Klare, Michael T. *Rising Powers, Shrinking Planet*. New York, NY: Metropolitan Books, 2009.

Larson, Jeffrey A. and Kerry M. Kartchner, editors. *On Limited Nuclear War in the 21st Century*. Stanford, CA: Stanford University Press, 2014.

Long, K.F. *Deep Space Propulsion: A Roadmap for Interstellar Flight*. New York, NY: Springer, 2012.

Payne, Keith B. *The Great American Gamble*. Fairfax, VA: National Institute Press, 2008.

Power, Thomas S. "Strategic Earth Orbital Base", SAC QOR 21 Jan 61 (original classification SECRET, declassified 17 Apr 1987).

Sagan, Scott D. and Kenneth N. Waltz. *The Spread of Nuclear Weapons: An Enduring Debate*, Third Edition. New York, NY: W.W. Norton and Co., 2013.

Schneider, Barry R. "Counterforce Targeting Capabilities and Challenges." Future Warfare Series No. 22. Maxwell AFB, Alabama: USAF Counterproliferation Center, August 2004.

Schneider, Barry and Patrick Ellis, editors. *Tailored Deterrence: Influencing States and Groups of Concerns*. Maxwell AFB, Alabama: USAF Counterproliferation Center, 2011.