

## Project on Nuclear Issues Capstone Conference

United States Strategic Command  
December 6, 2011

### Presentation Abstracts

#### Maintaining Nuclear Capabilities in the U.S. and UK

##### ***Overview of Weapons Enterprise Transformation and Mathematical Assessment Tools***

Dr. Carol Meyers, Mathematician, National Security Engineering Division, Lawrence Livermore National Laboratory

The US nuclear weapons complex has undergone considerable consolidation in the past decade. The National Nuclear Security Administration has been tasked with creating a smaller, safer and more secure nuclear weapons enterprise, while simultaneously experiencing a smaller budget than in years past. Complicating this task is the fact that infrastructure within the complex was largely built during the Cold War, and as such is aging dramatically. This presentation will provide an overview of some of the inherent challenges in weapons enterprise consolidation, as well as some of the plans that have been proposed to address these issues. Particular emphasis will be placed on mathematical tools that have been developed for assessing the relative benefits of different stockpile transformation scenarios, and the kinds of policy questions each of these tools can help to address. It will also contain a brief discussion of the types of results that can be obtained using such tools, and the resulting implications on policy analysis.

##### ***An overview of Nuclear Detonation Safety***

Mr. Raymond Wolfgang, Member of Technical Staff, Sandia National Laboratories

How does the United States ensure that its nuclear weapons are safe to store, handle and transport – for multiple decades? The Walske criteria requirements for weapon safety are robust – one in a billion chance of failure in normal environments (e.g. day-to-day storage, maintenance and transport) and one in a million chance of failure in abnormal environments (e.g. fire, plane accident). This brief will explain how, at a high-level, the United States weapon laboratories verify that weapon designs meet these stringent safety requirements in both types of environments. This talk presents the three design principles of the Enhanced Nuclear Detonation Safety (ENDS) theme – Isolation, Incompatibility, and Inoperability – and focuses on the non-nuclear part of nuclear weapon safety. The brief also shows how the concept of using independent subsystems allows a producible design. The brief concludes with how this theme allows the labs to assert that weapons in the current stockpile meet safety requirements in both normal and abnormal environments.

##### ***The UK-France Nuclear Agreement in Context***

Mr. Matt Harries, PhD Candidate, King's College London

In November 2010, the United Kingdom and France signed a treaty providing for cooperation on a limited range of nuclear weapons matters, as a subsidiary to a wide-ranging bilateral defense

agreement. Although the nuclear treaty is relatively limited in scope, it reflects broader strategic shifts. Three changes have allowed UK-French collaboration to gain a foothold: certain obstacles to cooperation have been removed, new areas for cooperation have emerged, and acute economic pressures (and chronic deficiencies) have driven the UK and France to look for defense partners. This paper outlines the factors that led to the UK-France agreement, identifies its key features as well as its immediate practical implications, and explores the options for future cooperation in the technical, policy, and operational fields. The paper concludes that, although there remain limits to strategic nuclear cooperation between the UK and France, there are a number of avenues for future collaborative work (with the additional possibility of trilateral cooperation including the United States).

### ***Management of Key Technologies in the UK Naval Nuclear Propulsion Program***

Mr. Christopher Palmer, Assistant Chief Engineer, Astute Program, Rolls Royce (UK)

Maintaining a viable UK NNPP has necessitated the management of several key technologies; typically these are unique or highly specialized to the naval reactor with little or no independent support within the UK. The UK NNPP has engaged academic and industrial organizations in order to leverage external capability and capacity. A number of academic institutions are used to undertake fundamental scientific research, the results of which are then incorporated into the NNPP technology base. Similarly, the UK NNPP has developed and supported key technical capabilities in industrial organizations to ensure their availability to the program when required. Also, in recent years, the UK NNPP has collaborated with the US NNPP to a far greater extent than has historically been the case since the inception of the 1958 mutual defense agreement. As the PWR3 design for SSBN Successor matures and enters production and service, the challenge of maintaining the UK's capability in order to own the design basis and the underpinning key technologies through the life of the platform will continue. Development and adoption of common or complementary policies across the UK nuclear sector on issues such as waste management, fuel cycle management and health & safety and environmental regulatory drivers provides the potential for lowest risk and best effective management of these challenges.

## **Strategic Stability Challenges in Asia**

### ***The Threat that Leaves Something to Chance in U.S.-China Relations***

Mr. Vincent Manzo, Research Analyst, Institute for National Strategic Studies, National Defense University

Thomas Schelling's "threat that leaves something to chance" illuminated how a state might achieve its foreign policy objectives by manipulating shared risks in dangerous circumstances. Because confrontations between nuclear weapon states would be unpredictable and difficult to control, Schelling argued, leaders in both countries could perceive an incentive to threaten an outcome—full-scale nuclear war—that they would be unlikely to choose in order to gain strategic advantages from having demonstrated a willingness to risk disaster. Though influenced by the U.S.-Soviet competition, Schelling's strategic concept applies to contemporary U.S.-China relations. Both countries' diverse strategic postures create a multitude of strike options, vulnerabilities, and opportunities for miscalculation and misinterpretation that would increase the potential for unwanted escalation in crises. In particular, concerns about non-nuclear first-strike vulnerability, ambiguous thresholds in space and cyberspace, and blurring of nuclear and conventional thresholds would make it more difficult for U.S. and Chinese officials to control escalation. Schelling's lesson for U.S. policymakers, therefore, is that they should cultivate China's appreciation of the potential for uncontrollable and unintended

consequences in military confrontations with the United States. A strategy to do this would include both competitive and cooperative measures.

***Cruise Missiles in Southern Asia: Strategic Implications for China and India***

Mr. Kalyan M. Kemburi, Associate Research Fellow, S. Rajaratnam School of International Studies

This presentation endeavors to demonstrate how cruise missiles would increasingly affect the strategic calculus between China and India, and why this influence warrants the two countries including this weapon system in any strategic discussion and assessment. Through an evaluation of various technical, operational, and doctrinal aspects related to cruise missiles, this presentation identifies three capabilities that these missiles would endow China and India: strengthening nuclear deterrence; negating the effectiveness of ballistic missile defenses; and providing conventional strike options for counterforce operations and strategic targeting. The presentation will also involve a discussion of why confidence building measures associated with cruise missiles are difficult to implement and verify.

***Are Conventional Weapons a Viable Option for Damage Limitation Operations against Medium-sized Nuclear-armed Adversaries?***

Mr. Tong Zhao, PhD Candidate, Sam Nunn School of International Affairs, Georgia Tech University

The ability to control escalation and reduce damage in conflicts with nuclear adversaries has been an important component of American military strategy. The option of preemptive use of nuclear weapons, however, has become increasingly unpopular in recent years; it is morally indefensible and militarily impracticable. As a result, the ability to conduct conventional preemptive strikes as a means of damage limitation against nuclear-armed adversaries looks increasingly attractive to military strategists. However, the feasibility and wisdom of conventional counterforce strike has not been tested by rigorous research. In the context of a hypothetical U.S.-China conflict in the Asia-Pacific region, previous studies have assumed that the U.S. will focus on and target China's intercontinental ballistic missiles (ICBMs). This presentation points out that, contrary to previous analysis, if the U.S. ever considers a first strike for the purpose of escalation control, it is more likely to target China's theater nuclear forces than its ICBMs. Accordingly, this presentation provides a comprehensive analysis on the probability that American conventional strikes might destroy China's theater nuclear forces. It concludes that using conventional global strike capabilities against medium-sized nuclear adversaries for purposes of damage limitation is impracticable and will mostly likely lead to inadvertent escalation. It therefore also offers a number of policy recommendations to help mitigate potential negative impacts of the development of conventional global strike capabilities on strategic stability.

***Benefits of ICBMs to US Nuclear Posture and Global Stability***

Mr. Jerry Maxwell, Systems Engineer, Northrop Grumman Aerospace Systems

With the ongoing discussion of the implementation of New START as well as budgetary reviews, high-level decisions will be made that will affect the United States' nuclear posture, in particular decisions regarding the required nuclear force size. These decisions require an understanding of the characteristics and benefits of the ICBM System. This briefing will review ICBM history and benefits – both intended and unintended – and the ICBM's role in global stability today as well as in scenarios where the number of nuclear weapons worldwide is near or at zero. Finally, the briefing will touch on potential improvements for future ICBMs.

## Nuclear Arms Control and Force Reductions

### ***Next Steps in Arms Control: Restoring Consensus on Nuclear Policy***

Dr. Tom Karako, Assistant Professor of Political Science, Kenyon College

Whatever else is true about the ratification debate over the New START treaty, the experience brought renewed attention to the U.S. nuclear enterprise writ large and created a bipartisan awareness in and outside Congress about the importance of U.S. nuclear weapons activities. A path to weapons modernization has now been laid out, but much remains to be seen and done, and this will take over a decade. In November 2010, the Obama administration likewise laid out a detailed ten-year budget and plan for nuclear modernization, and in ratifying the treaty in December, the U.S. Senate affirmed the importance of following these steps. As our nuclear stockpile becomes both smaller and older, it becomes all the more important that it remain safe, secure, and effective, and able to support a credible deterrent. If this were not a sufficient challenge, the coming decades will also see a need to modernize or replace a number of U.S. strategic platforms, including bombers, dual-capable aircraft, ICBMs, SSBNs, and cruise missiles. This presentation will discuss how to sustain a sober, public, and bipartisan awareness of what it will take to sustain nuclear deterrence (for ourselves and our allies) in anticipation of potential deeper nuclear reductions and cuts to the defense budget.

### ***Qualitative Considerations of Nuclear Forces for Future Arms Control Negotiations***

Mr. Tom Devine, Policy Analyst, SAIC and Ms. Rebecca Gibbons, PhD Candidate, International Relations, Georgetown University

The brief will present the results of a year-long project addressing the challenge of attempting to reduce the overall *quantity* of U.S. nuclear weapons without compromising the *qualities* underpinning the U.S. arsenal's ability to meet policy and strategy requirements that currently rely upon nuclear options. Informed by the national strategic objectives for nuclear forces identified in the 2010 Nuclear Posture Review Report (NPR), this project studied the impact of quantitative reductions of U.S. nuclear forces on the qualitative requirements associated with deterring adversaries, prevailing over opponents (should deterrence fail), and assuring allies. The study team identified the key qualitative characteristics of U.S. nuclear forces and conducted a detailed analysis to determine which characteristics increase or decrease in relative importance to U.S. objectives to deter, prevail, and assure as it reduces its numbers.

### ***Contextualizing and Engaging Russian Nuclear Policy***

Mr. Alejandro Sueldo, JD Candidate, University of California at Berkeley

Drawing upon interviews with experts, this presentation examines the role nuclear weapons play in Russia's foreign and defense policy, with particular focus on their relation to arms control; the U.S.-led ballistic missile defense system; Russian military reform; and the role of the U.S., NATO, Iran and China. The presentation finds that Russia will, for the foreseeable future, continue to depend on its nuclear weapons for real and perceived status and security. It will therefore be reluctant to engage in both further strategic arms reductions and talks on tactical nuclear arms control, particularly without greater clarity on the near-term U.S. political climate and greater assurances that China will not jump to strategic parity and that NATO missile defense will not threaten Russia. Furthermore, nuclear weapons will likely play a greater role in a reformed Russian military and that reductions of Russia's tactical nuclear weapons will largely depend on assurances regarding China intentions, greater transparency on

U.S. prompt global strike, and efforts to revive talks on European conventional security. The presentation will therefore discuss how to engage with Russia on various nuclear policy issues and concludes by examining latent challenges and promising opportunities.

***The Duma-Senate Logjam Revisited: Actions and Reactions in Russian Treaty Ratification Debates***

Ms. Anya Loukianova, PhD Candidate, Policy Studies, University of Maryland

With an eye toward future nuclear reductions, this presentation seeks to elucidate some of the political dynamics and key themes of arms control debates and deliberations in the Russian legislature during the past twenty years. Russia scholars have observed that legislative politics have become “re-centralized” after Russia’s first president, Boris Yeltsin, left office. However, this observation obscures the impact of the internal debates in Russia’s legislature on the conditions placed on the implementation of arms control agreements and the paradox emerging from the seemingly enabling security concerns of conservative factions in lawmaking bodies in Russia and the United States. The presentation begins with an overview of the Russian legislative branch, its role in foreign policy and treaty ratification, and changes in political factions over time. It then offers a taxonomy of recurring themes based on an analysis of trends in factional politics in the parliamentary discussions about START I, CTBT, START II, SORT, and New START. The presentation concludes by highlighting both continuity and change in Russia’s lawmakers approach to arms control and the implications of these trends for the future.

## Exploring the History of the NPT and Nonproliferation Regime

***Superpower Collusion and the Nuclear Nonproliferation Treaty***

Ms. Jane Vaynman, PhD Candidate, International Relations, Harvard University

This presentation will offer a formal model of the origins and stability of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The model illustrates that the treaty arises from a shift in the superpowers' perceptions of the consequences of proliferation. Three tests of the model predictions, which will be discussed in the presentation, show that the superpowers did collude extensively in the design of the treaty, in pressuring other states to sign the NPT, and in responding to violations of the treaty. Growing worries over the autonomy nuclear weapons provide to other states lead the superpowers to collude in order to preserve the nuclear oligopoly and their influence over their respective clients. The notion that the treaty is enforced by the superpowers' threat of sanction or abandonment and their clients' fears of being “left out in the cold” is also discussed.

***The Cost of the Bomb: Security Trade-offs and Nuclear Forbearance***

Mr. Gene Gerzhoy, PhD Candidate, International Relations, University of Chicago

Why have so many states abandoned the pursuit of nuclear weapons? Nuclear deterrence virtually guarantees a country’s survival, yet among the dozens of states that pursued nuclear weapons, only nine currently possess them. This presentation argues that many states abandon their pursuit of nuclear weapons due to dependence on superpower patrons for critical goods and services. Superpowers use the provision of these goods and services as sources of coercive leverage to discourage nuclear armament. The presentation examines four sources of coercive leverage to explain when superpower coercion is effective: (1) dependence on a superpower ally for territorial defense against external

threats; (2) dependence on imports of critical military parts and scientific research components; (3) dependence on economic and military aid during periods of dire need; (4) vulnerability to the manipulation of domestic politics, including superpower support for coups and political upheavals. The presentation demonstrates how these mechanisms work using historical examples, and concludes by discussing the policy implications of its findings and avenues for future research.

### ***The Question of Nuclear Disarmament and the Enforcement Paradox***

Mr. Jonathan Snider, PhD Candidate, Political Science Department, University of California, Davis

Nuclear disarmament has reemerged as a major issue in international security. Advocates claim nuclear disarmament will provide two benefits: it will reduce the risk of nuclear terrorism, and make it easier to build international political support for measures to prevent nuclear proliferation. The perceived benefits of nuclear disarmament give impetus to efforts to create the conditions necessary to eliminate nuclear weapons. But there is substantial disagreement over which factors are most important in creating these conditions. Insights from the early history of disarmament provide a useful contribution to this debate. Official disarmament studies conducted by the U.S. government in the 1940s and 1950s were primarily concerned with a particular military threat: a nuclear surprise attack. This presentation contends that, minus nuclear weapons, effectively managing the surprise attack threat will likely require deep reductions in conventional weapons. However, this disarmament “solution” creates its own problem as deep conventional reductions will complicate efforts to police a nuclear weapons-free world. Therefore, disarmament will lead to an “enforcement paradox,” as the process of nuclear disarmament will require deep cuts to the conventional weapons required to enforce the rules in a nuclear weapons-free world.

### ***Transition to Zero: A Change Leadership Perspective***

Mr. Paul Higson, Organizational Development Specialist, Atomic Weapons Establishment

As a responsible nuclear weapon state and party to the NPT, the UK stated in the 2010 Strategic Defense and Security Review that it remains committed to the long term goal of a world without nuclear weapons. To achieve this world without nuclear weapons, irrespective of the various technological solutions, political agreements and preventative measures that will need to pave the way, leadership of change will need to be sustained over decades. This presentation does not judge whether a nuclear weapons-free world is either desirable or achievable, but takes articles VI & VII of the NPT to their logical conclusion and focuses on how to successfully lead such a change on the global stage. It describes a model for leading change and uses the model to assess the effectiveness of the transition to a nuclear weapon free world. The leadership of change over the last 60 years is evaluated and opinions expressed for successful leadership to zero nuclear weapons. (Note: The opinions contained in the presentation (and abstract) are those of the author only and do not represent UK policy, the views of AWE, or the UK Government.)

## Technical Aspects of Nuclear Security

### ***Multi-actinide Resonance Ionization Mass Spectrometry (RIMS) for Nuclear Forensics Applications and Rapid Response***

Dr. Brett Issselhardt, Post-doctoral Fellow, Chemical Sciences Division, Lawrence Livermore National Laboratory

Obtaining accurate actinide isotopic data is critical to the timely interrogation materials of nuclear origin. Dissolution and purification are necessary prior to attempting most U and Pu isotopic analyses by mass spectrometry, and are generally the time-limiting step in obtaining isotopic data. Multi-actinide resonance ionization mass spectrometry (RIMS) uses precisely tuned lasers to selectively excite and ionize atoms of an element of interest, permitting analyses of samples as collected, without complications from isobaric (same mass) interferences. RIMS can minimize or even obviate chemical separation and sample preparation steps for uranium isotope analyses in a variety of matrices, but as an analytical technique it is still in its infancy with respect to applications in nuclear forensics. However, we have been developing methods for U and Pu isotopic analysis by RIMS, working to optimize elemental selectivity, enhance background suppression, and minimize detection limits. Our initial experiments have provided several promising results, and we have demonstrated that we can easily move between RIMS schemes for two elements in samples of mixed actinides (U and Pu), as well as discriminating against interfering masses ( $^{238}\text{U}$  and  $^{238}\text{Pu}$ ). Rapid measurement of the isotopic composition of multiple elements in a mixed actinide sample without significant interferences lays the foundation for actinide isotopic analyses using state-of-the-art resonance ionization mass spectrometry. This presentation will also reflect on the journey from concept to demonstration of a developing nuclear forensic technique.

### ***Characterization of Uranium Oxyfluoride Particles for Nuclear Safeguards***

Dr. Ruth Kips, Research Scientist, Lawrence Livermore National Laboratory

When IAEA safeguards inspectors collect swipe samples from uranium enrichment facilities, their samples often contain uranium particles with a measurable amount of fluorine. These particles are typically produced when small amounts of uranium hexafluoride ( $\text{UF}_6$ ) gas, used for the enrichment of uranium, reacts with moisture from the atmosphere, forming solid uranium oxyfluoride ( $\text{UO}_2\text{F}_2$ ) particles. Somewhat surprisingly however, these samples were also found to contain uranium-bearing particles without a measurable amount of fluorine, suggesting  $\text{UO}_2\text{F}_2$  is unstable with respect to the loss of fluorine. Since nuclear safeguards often rely on the analysis of these chemically-sensitive compounds, it is important to understand how exposure to the atmosphere, prior to collection and analysis, may affect the particle characteristics. Given the small size of the particles, highly sensitive and selective instrumentation is required for their analysis. To that end, the presentation provides a review of research findings from Lawrence Livermore National Laboratory, where nano-scale spatial resolution secondary ion mass spectrometry (NanoSIMS) was used to measure the fluorine-to-uranium ratio in lab-synthesized  $\text{UO}_2\text{F}_2$  particles. The relative amount of fluorine was compared for samples that were freshly-prepared and samples exposed to different temperature, humidity and light conditions, and for various amounts of time. The NanoSIMS measurements were complemented with spectral data obtained by micro-Raman microscopy. Micro-Raman spectroscopy was used in a purely fingerprinting manner to identify changes in the Raman spectrum due to humidity exposure. The combined elemental and spectral information obtained from these measurements allowed differentiation of  $\text{UO}_2\text{F}_2$  samples with different exposure history, which may benefit the analysis of environmental samples for nuclear safeguards.

***Verification Challenges at Low Numbers***

Mr. Paul Booker, Mechanical Engineer, Pacific Northwest National Laboratory

President Obama announced in Prague that the reduction and ultimate elimination of nuclear weapons is a goal of the United States. This presentation will consider the arms control verification challenges associated with reducing stockpiles from 1,000 to 100 and ultimately 10 nuclear weapons per state. Verification of 1,000 weapons may be fairly straightforward and will most likely draw upon current bilateral treaty requirements; however, verifying the next order of magnitude reduction to about 100 nuclear weapons will be significantly more complicated. At that point multiple nuclear weapon states must convince each other, and the international community, that their respective stockpiles have been reduced to 100 weapons. Thus, the technical measures for verification must include tools to count and track weapons throughout the weapon's life cycle, as chain of custody to verify weapon dismantlement becomes crucial to build confidence between the parties of a multilateral agreement. Verification using remote monitoring methods will also be complicated due to the variations in technical sensing between signatories. And, of course, on-site inspections will be problematic if there is concern that such access would provide aggressors with targeting information for a disabling first strike. Furthermore, extreme challenges to treaty verification appear when states only possess as few as 10 nuclear weapons each. At this level, having accurate and reliable data on baseline inventories, past fissile material production, and global adherence to a nuclear material control regime will be paramount. These challenges, as well as possible solutions, will be discussed.

## **Building the Nonproliferation Regime to Address Contemporary Challenges**

***Iran's Nuclear Strategy: Understanding Tehran's Acquisition Pathway***

Mr. Patrick Disney, MA Candidate, International Relations, Yale University

Iran has possessed the basic technological capability to build nuclear weapons for a number of years, yet it has not done so. Why? Experts widely agree that Tehran's decision makers have yet to form a consensus on the matter because Iran stands to lose more than it would gain from openly declaring its intent to weaponize. In the absence of such a consensus, Tehran is content to keep the option open for the indefinite future. This presentation argues, however, that Western nonproliferation policy – marked by efforts at sabotage, assassination, sanctions and pressure – is built upon the assumption that Iran's leaders are irreversibly committed to weaponization. The overarching goal of Western policies is thus to hinder Iran's nuclear progress, yet this approach contains a serious risk of blowback. The Iranian regime's past decision making behavior has been highly reactive, responding to provocations with provocations of its own. The current dynamic, in which Western states constantly ratchet up pressure while Iran refuses to budge, risks fostering a consensus within Tehran in favor of weaponization. Thus, the current course of Western nonproliferation policy toward Iran runs the risk of encouraging – rather than discouraging – an Iranian push for a bomb.

***Strengthening the IAEA: the Double Track***

Ms. Sonia Drobysz, PhD candidate, Panthéon Sorbonne University; Junior Associate Researcher, Center for International Security and Arms Control Studies

Calling for wider application of the IAEA safeguards system and extended cooperation to ensure its implementation while insisting on the need to constantly strengthen its effectiveness and improve its efficiency, the last NPT review conference underlined that the verification tool of the non-proliferation regime is neither universal nor fully optimized. The IAEA's general conference itself recently called on its own member States to "give their full and continuing support to the Agency in order to ensure that [it] is able to meet its safeguards responsibilities." The international community's concern, or at least part of it, was also well expressed in the International commission on nuclear non-proliferation and disarmament report, which states that "the IAEA, while the bulwark of the safeguards system, has been insufficiently resourced, both in terms of authority and capabilities, to detect clandestine nuclear activities, and a number of serious violations have slipped through the net in recent years, giving both weapon and non-weapon states cause for concern about the foundations of the NPT bargain they signed up to." Insisting on the importance of preserving and promoting the institutional legitimacy of the IAEA within a regime which is often described as being in crisis, the presentation will explore a few aspects of a double track approach aimed at ensuring better achievement of safeguards objectives, and ultimately, non-proliferation ones.

***Transnational Networks and Nonproliferation: Strengthening the Multilateral Nuclear Export Control Regime***

Mr. Michael M. Lieberman, Associate, International Department, Steptoe & Johnson LLP, Washington D.C.; Fellow, Truman National Security Project

This presentation will offer a developing theoretical framework of the role transnational regulatory and enforcement networks play in preventing the proliferation of sensitive nuclear technology. As developers and enforcers of domestic and international laws to combat proliferation, these networks are vital to combating their criminal doppelgangers, the illicit procurements exemplified by A.Q. Khan, and the black markets used by nuclear aspirants. To combat these networks, concerned states have entered into a number of multilateral export control agreements. However, these pacts provide an incomplete basis for a comprehensive multilateral export control regime, as they are voluntary, vague, consensus-based, and lack institutionalized capacity-building assistance. Furthermore, in an era where the West and its allies no longer monopolize the production or dissemination of nuclear technologies, policy harmonization proves difficult. Even where common views regarding threats and priorities exist, vast gaps in state enforcement capacity often hinder the *de facto* harmonization necessary for effective control. The theoretical framework proposed could provide a basis for understanding how regulatory and enforcement networks operate, and how their activities might be better coordinated and improved.