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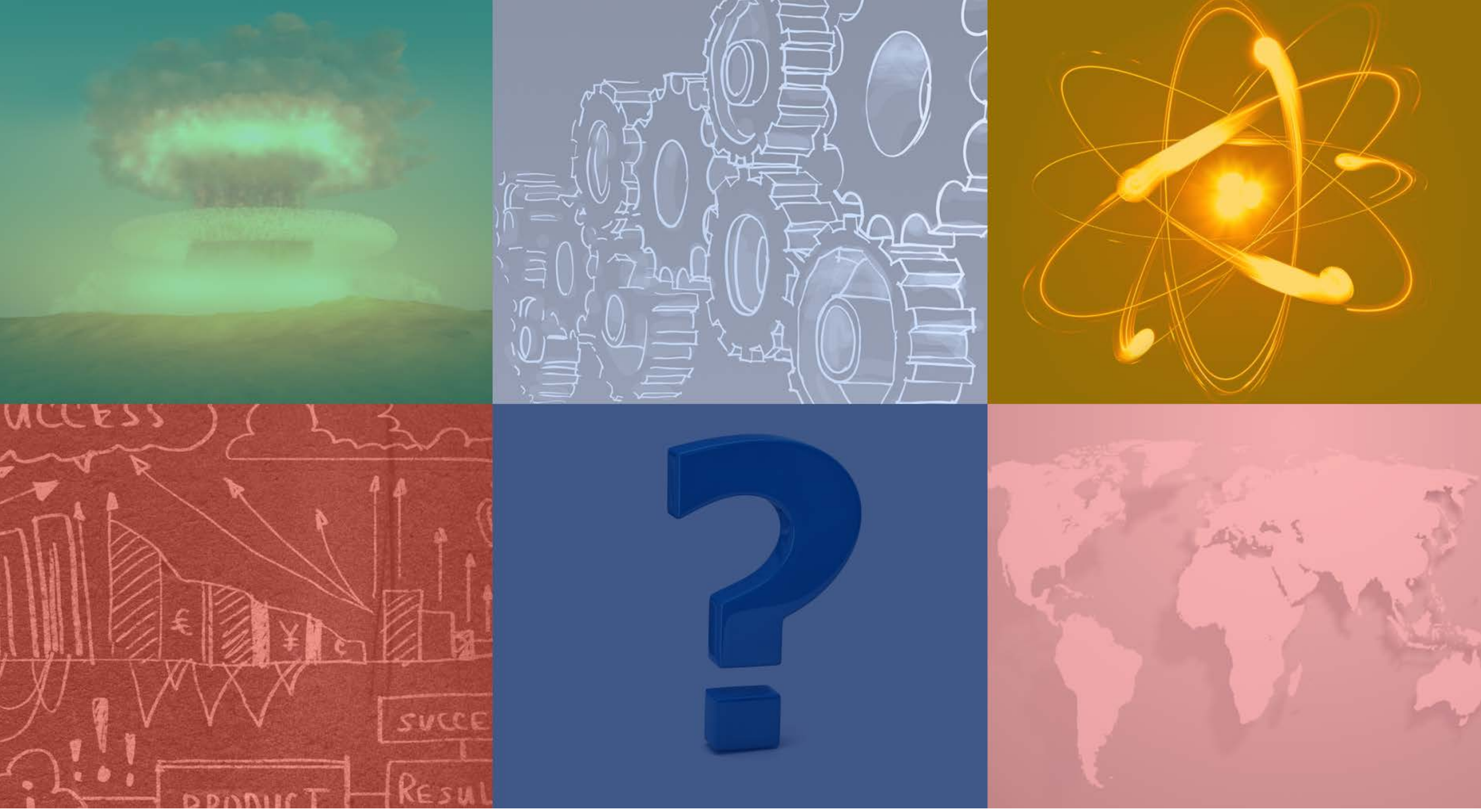
Nuclear Command, Control, and Stability Framework



NUCLEAR COMMAND, CONTROL, AND STABILITY FRAMEWORK

29 December 2015

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Executive Summary

This project investigates the topic of nuclear command and control (C^2) as a policy consideration for expressing and mitigating nuclear risks. The research was led by the Virginia Tech Applied Research Corporation (VT-ARC) with a sub-award to ANSER's Asia-Pacific Institute. The overall structure for the project revolves around two independent assessments of a stability framework proposed in the 2007 book chapter titled, "Nuclear Command and Control in the Twenty First Century: Trends, Disparities and the Impact on Stability."[1]

The first independent assessment was conducted by the Decision Support Red Team (DSRT) group at VT-ARC and focused on the functional design of the stability framework and the ease and accuracy with which it could be used by policy makers. This assessment was agnostic of specific regional and global characteristics and focused on the framework as a tool for expressing power dynamics.

The second independent assessment was conducted by a research team at ANSER and took a deeper look at the merit of the stability framework for expressing nuclear stability dynamics in a regional (bipolar or multi-polar) context.

A primary focus of both independent assessments was to determine the overall utility of the Framework for its application and use as a tool for constructive discourse by policy makers and non-technical personnel.

Key Findings & Recommendations

During the course of the assessments that were conducted by the VT-ARC Decision Support Red Team (DSRT) and the expert team from ANSER, the following observations, recommendations and findings were generated:

[1] Jerome M. Conley, "Nuclear Command and Control in the Twenty-first Century: Trends, Disparities, and the Impact on Stability," in Owen C.W. Price and Jenifer Mackby, Eds., *Debating 21st Century Nuclear Issues* (CSIS, Washington, DC: 2007).

- Nuclear command and control is often overlooked in policy/academic discussions. As a key overarching determinant of whether nuclear weapons are used (and how), this oversight is significant.

- The 2007 Framework/matrix is a simple way to categorize and think about the nuclear command and control systems in different countries and should enable more thoughtful discussions about the subject, especially among non-technical experts.

    - Subject matter experts may disagree about the relative weight assigned to the various control mechanisms, but the Framework gives them a common lexicon and visual with which to have that discussion.

- **"Bias" is a feature of one country's, while "stability" is a feature of the relationship between two or more countries.**

- The Framework may reveal biases in a country's nuclear C^2 which are different from its stated posture, thus providing a more nuanced view of stability/deterrence.

    - As an example, control measures to prevent unauthorized nuclear use – such as the separation of warheads from delivery vehicles during peacetime – may be negated if warheads and vehicles are mated during crises (thus elevating the potential for unauthorized use).

- It was determined that a complex control may contain characteristics that are both positive and negative. Given this possibility, a complex control (such as a submarine) may be divided and considered both negative and positive given the circumstances, or based on the operational environment.

- **The original Framework proposes that the synergistic and collaborative sum of all controls represents the bias and true intentions of a nuclear program.**

- The 2007 chapter uses the Framework to illuminate several policy recommendations:

    - It is unstable when countries shift to positive procedural controls (e.g. by mating warheads with delivery vehicles)

    - Steady-state actions, such as providing technical controls to Pakistan or ensuring U.S.-Russia data exchanges, may enhance stability.

    - Nuclear C^2 postures for multiple countries can be depicted on a single graphic, thus providing a visual tool for comparing capabilities and postures.

- The splitting of the bottom-right quadrant in the original 2007 Framework served a secondary purpose. That Framework argues that a C^2 system which has controls in the left two quadrants as well as the bottom-right quadrant is good/stable, while those in the top-right (reliant on Positive Procedural Controls) are more unstable or biased toward use. There is potentially merit in having two matrices – one that is blank for evaluating a country's C^2 and another with green and red for depicting the argument from the 2007 assessment that certain areas of the matrix are more "stable."

- **The original 2007 Framework is effective for expressing the individual "biases" of a country's nuclear capabilities, but it not an efficient tool for assisting policymakers in assessing nuclear stability dynamics between two or more countries (i.e. the interaction of each country's biases):**
  - The Framework provides a categorization/visualization, but not an assessment that would result in policy options and may therefore not be useful in crisis situations
  - The same policy recommendations could be made without the Framework.
- The Framework, in providing general categorizations for nuclear C^2 systems, may overlook key details unique to each country's C^2 system:
  - The Framework encourages people to make generalizations about countries and debate where a certain country (or a certain case study) falls on the Matrix.
  - This may be a useful academic exercise, but policymakers may prefer to have an in-depth analysis of each country's C^2 system since there are only nine with nuclear weapons.
  - For example, a DOTMLPF-P analysis could provide an alternative "framework" for analyzing and comparing each aspect of a country's C^2 system and then identifying gaps that could be filled. An example of this approach is provided in the Annex.
- The quantitative nature of the Matrix may lead to qualitative errors in determining biases.
  - For example, if an audience does not understand the value of one control over another, the quantity of controls visually represented in the Matrix may mislead an audience to disagree with the bias if specific controls carry more weight than other controls.
  - Moreover, if a nuclear program contains fewer, yet more impactful negative controls than positive controls, the bias will be viewed toward non-use. However, when depicted on the Matrix, the negative controls appear to be fewer than positive controls; the audience may disagree with a non-use bias and the Matrix could lose credibility.
  - Ultimately the value of the framework may be that it allows experts to have a meaningful discussion about C^2 and the potential for bias. SMEs may disagree about

where the bias falls on the matrix (there is no "right" answer), but they can use the framework to express their disagreements using the same lexicon.

- **C^2, although important, is only one aspect of nuclear stability dynamics.**
  - Presence or lack of positive/negative controls may contribute to a state's bias toward use, but so do its operational environment and defensive viability. A state's nuclear stability is more likely a reflection of its adversaries' intent, capability and means.
  - The Framework notes that a "use bias" in a country's nuclear C^2 system does not mean that nuclear weapons will be used. This point needs to be strongly emphasized so that observers do not get the impression that the Matrix determines how a country will react in a crisis.
  - Positive and Negative controls are only as effective as the underlying stability of the governing apparatus. The framework assumes a certain level of political stability and civil/military control as assertive or delegatory.

The following sections contain the detailed research results which were generated by the two independent assessment teams.

Decision Support Red Team Assessment[2]

This Assessment analyzes the Nuclear Command and Control (C^2) Framework proposed by Jerome Conley in 2007.[3] The critical aspects of the evaluation are twofold:

1) Determine the overall utility of the Framework for its application and use as a tool for constructive discourse by policy makers and non-technical personnel; and
2) Identify gaps within the original Framework and propose potential solutions to address those gaps which are uncovered.

Throughout the Assessment, the VT-ARC Decision Support Red Team (DSRT) was unable to identify a comparable, competing Framework that could be used in the context of expressing policy dialogue around nuclear C^2 and stability topics.[4] In the absence of a comparable, competing Framework, the DSRT determined the concept was a novel approach for assessing a nuclear program and its corresponding C^2 structure as it relates to nuclear stability.[5] Based on the determination of the overall potential validity of the Framework, the Team deconstructed and analyzed the various components within the Framework (terms, definitions, visualizations, parameters, etc…). The Team was then able to identify several pertinent gaps, however, which slightly deviated from its intended goal of providing a package that uses simple language and visuals to support non-technical bilateral discussion(s), while also being flexible enough to enable discussion from a wide subset of Subject Matter Experts (SMEs).

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[2] Most of the original content and findings from the DSRT are preserved within this section. In situations where there are potential opposing perspectives to points made by the Red Team, these alternate interpretations are called out.

[3] Conley, "Nuclear Command and Control in the Twenty-First Century: Trends, Disparities and the Impact on Stability", Owen C.W. Price and Jenifer Mackby, Eds., *Debating 21st Century Nuclear Issues, 2007*

[4] Although it may be technically correct that there are no known Frameworks which are dedicated to the expression of the role of nuclear command and control within stability dynamics, other methods of analysis could be applied to determine these relationships, such as DOTMLPF-P analysis. See the Annex for further details.

[5] A counter-point made by the ANSER team is that an assessment of stability dynamics surrounding a nuclear program must include other factors, such as non-nuclear capability, weapon reliability, declaratory policy, etc.

The major gaps identified include several key concepts that were either improperly defined or appeared to cause confusion when initially examined. Additionally, the original graphics (e.g. Matrices) were not robust enough and lacked clarity, especially when used to delineate certain cases where some positive controls can have a bias towards non-use, as an example. In order to address these issues, the Team proposed alternative definitions to the parameters based on information uncovered and gleaned from other resources so as to enhance matrix clarity.

Based on the results of this Assessment, the Team proposes that the revised Framework be applied to real-world nuclear stability scenarios to further assess the applicability of the Framework beyond a theoretical context. If then deemed applicable, this Framework will provide policy makers with an improved means by which to understand and place into proper context the complex nature of nuclear stability dynamics. Using commonly understood variables outlined in this Assessment, the Framework will also serve as a mechanism by which to discuss and assess policy options geared towards promoting greater nuclear stability.[6]

Background

In the wake of North Korea's third nuclear test, policy-makers and military strategists in the West and the Asia-Pacific region continue to explore options for halting or dampening the nuclear ambitions of the reclusive regime. With much focus on North Korean delivery vehicles and warheads, as well as defensive intercept options for those countries held at risk, little public attention has been given to safety and security options which address the North Korean C^2 system. Similar concerns over nuclear safety and security have also been raised in Pakistan – and recently in India – due to domestic insurgent threats and simmering bilateral tensions. In the absence of realistic methods to force the roll-back of these nuclear programs, all avenues must be explored to ensure *non-use of nuclear capabilities*, which is the same underlying purpose of

[6] In its review of this DSRT assessment, the ANSER team concluded that it was not convinced that the Framework is a useful tool for policy makers. There are only nine countries assessed as nuclear capable and each one of these countries is unique within its operating environment and the circumstances behind their need for nuclear weapons. Given the relatively small number of nuclear capable countries, the need for a general framework to determine nuclear command & control stability is better served by rigorous country analysis and not a generic matrix that likely tells a policy maker what he or she already knows. Instead, this framework may be valuable in facilitating dialogue within academia to discuss the attributes and characteristics of a nuclear C2 structure in a neutral OE.

"global zero" initiatives. Sitting at the nexus of all scenarios in which authorized and unauthorized use may occur, nuclear C^2 provides potential insight into the disposition and stability of these nuclear forces.

The academic and policy debates concerning nuclear deterrence theory and nonproliferation typically focus on the quantitative and qualitative aspects of the nuclear warheads and delivery vehicles possessed by countries. A potentially more important indicator of strategic stability and intent, however, are the C^2 systems that define, shape, and govern the actions and overall capabilities of the world's nuclear custodians. Specifically, the procedural and technical measures used to ensure nuclear weapon safety, security, and reliability must strike a delicate balance between guaranteeing weapon employment when properly authorized, and avoiding weapon detonation in all cases where proper authorization is not provided.

Nuclear weapons remain a critical – though often unspoken – component of the international security environment. Since the end of the Cold War and the post-9/11 focus on counter-terrorism and counter-insurgency operations, the role of nuclear weapons has been a topic held largely outside of the public dialogue in the United States and one mostly relegated to internal governmental reviews. This is not to imply, however, that significant changes have not occurred in the posturing of nuclear weapons around the world, nor that nuclear weapons do not hold larger political significance and public profile in other countries. Rather, the limited press coverage concerning nuclear weapons appears to center on the developing programs in North Korea and Iran, as well as periodic updates on the slow reduction of active nuclear stockpiles in the United States and Russia. In general, these discussions all focus on the existence and quantities of nuclear weapons in various countries. Absent from most discussions and analyses, however, is a deeper exploration and dialogue on the C^2 procedures, policies, and stability of these developing nuclear programs.

Deconstructing the measures and procedures which constitute a government's C^2 policy can provide considerable insight into the strategic positioning of that government's nuclear C^2 structure. From this, further insight can be gained into how C^2 can play into global nuclear stability dynamics. As a counterpoint to the majority of nuclear policy research that has typically quantified metrics based on quantity and quality of nuclear stockpiles, a Nuclear Command, Control, and Stability Framework (to be referred to therein as the Framework) was proposed in 2007 that focuses on the relationship between C^2 procedures and stability dynamics in "Nuclear Command and Control in the Twenty-first Century: Trends, Disparities, and the Impact on Stability," as published in *Debating 21st Century Nuclear Issues* (CSIS, Washington, DC: 2007). Therein, two (2) avenues through which a nuclear command and control system can be characterized are detailed: measures (either technical or procedural) and controls (either negative or positive). (See Figure 1).

	Negative Controls (-)	Positive Controls (+)
Procedural Measures	•Delayed retaliation posture •Adopt de-alert posture, NFU or LUA •Two-person rule, PRP, etc •Restricted access to launch codes •Separation of warheads & vehicles •Separation of warhead components •Personnel Reliability Programs, etc	•Airborne alert status •Launch on Warning (LOW) posture •Pre-delegation of launch authority •Final assembly of warhead •Mating warhead with delivery vehicle •Other
Technical Measures	•One-point safety warhead design •Mechanical / electrical locks •Fail safe weapon designs •Electrical exclusion regions •Weak-link designs •Environmental sensing devices •Other	•Fully automated launch system •Frequency diversity •Hardened communication systems •Sea-based delivery vehicles •Mobile command systems/posts •Jam / interference resistance •Environmental sensing device •Other

Figure 1. Example Technical and Procedural Negative and Positive Controls

The original Framework proposes that the synergistic and collaborative sum of all controls represents the biases and true intentions of a nuclear program. Accompanying this contention is a Nuclear Command, Control, and Stability Matrix (to be referred to herein as the Matrix) diagram that displays the four (4) possible controls (e.g. negative, positive, technical and procedural) which are depicted as potential drivers to the stability of a nuclear C^2 program through bias by favoring one type of control over another (see Figure 2).

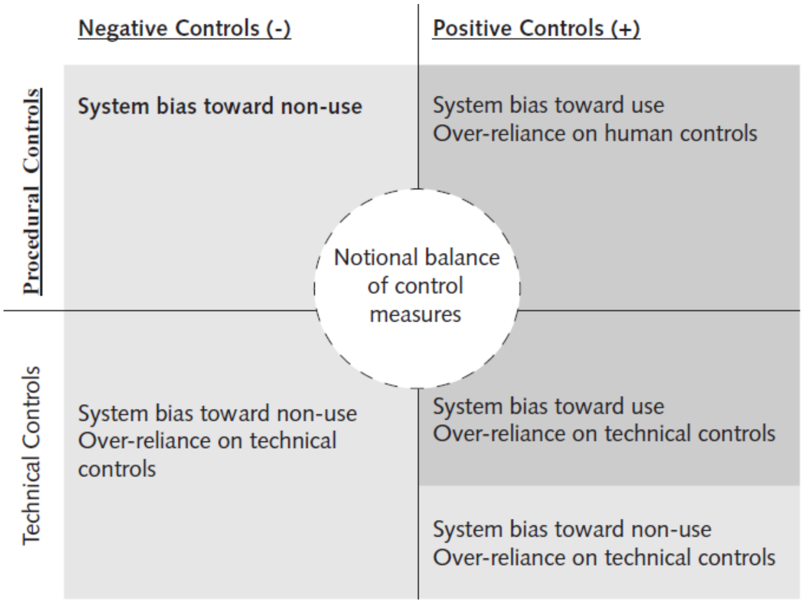

Figure 2. Conley's Nuclear Command, Control, and Stability Matrix (2007)

The purpose of the Framework serves to not only emphasize an alternative perspective to determine the stability of a nuclear C^2 system, but to also create a platform by which domestic and international experts from a wide range of non-technical nuclear backgrounds (e.g. policy, strategy, other governmental support personnel, etc.) can examine and discuss the ramifications and complexity of nuclear controls and measures.

DSRT Research Approach

The Nuclear Command & Control Framework was constructed as an enterprise to spur thought and bilateral (and multilateral) discussions regarding the dynamics of nuclear stability, strategic intent, and C^2 between policy makers and other non-technical experts across the domestic and global communities. Given the novelty of the ideas and concepts within the Framework, the Team conducted a critical review and analysis of the Framework by identifying/validating its assumptions and limitations to determine its applicability and viability as a tool for policy and strategy discussions. The four (4) goals of this Assessment are:

1. Synthesize information and comprehensively vet the Framework, the Matrix, and the complexity of nuclear bias and stability;
2. Adjust the Framework (if necessary) to support a broader multilateral, unclassified, and non-technical audience;
3. Test and evaluate the concepts of the Framework by applying the Matrix to the risks/trends of developing nuclear programs; and,
4. If necessary, identify and provide SMEs and/or additional expertise from the technical community to review and further vet the Framework.

DSRT Research Method

To meet the previously outlined goals, the Team conducted a critical review of the Framework from the perspectives of concept and application. The Team approached the concept review by identifying and analyzing the parameters and definitions of the Framework in order to discover gaps which may have existed in the language and concept. Next, the Team reviewed the Framework using case studies which tested and evaluated the value and applicability of the Matrix quad chart in scenario-based environments. Together, these perspectives served to provide a more holistic approach to the Team's task of evaluating the primary objectives of the original Framework by *challenging not only the design, intentions, and concepts of the Framework, but also its utility and practicality*. The Team used these findings to provide constructive technical feedback that could be used to improve the Framework's utility and ultimate acceptance from the larger potential user community.

Concept Review

To assess the Framework, the Team used a bottom-up approach to focus on the Framework's parameters, thereby developing a clear and concise understanding of the Framework's intentions prior to examining its complexity. By first isolating the concepts of the Framework, the Team could more clearly identify limitations in the logic and rationale behind the parameters put forth. Once these were defined, the Team compared the parameters to other references pertaining to the use and discussion of controls and structures in the context of a nuclear program. The Team identified, as applicable, potential gaps and points of misperception while reviewing the definitions of key terms for consistency of use and recognition within the larger nuclear policy and operational communities.[7] To reduce the potential for misinterpretation of terms, the Team further sought additional references, SMEs, etc., to help refine critical parameters to assure clarity. The following sections detail the parameters, definitions, and gaps the Team identified from within the Framework, and the actions proposed to improve the Framework.

Framework Parameters

The Team reviewed and analyzed the parameters within "Nuclear Command and Control in the Twenty-First Century: Trends, Disparities and the Impact on Stability," as published in *Debating 21st Century Nuclear Issues* (CSIS, Washington, DC: 2007) and compared these definitions with other well-known and published references. Upon review of the key terms, the Team identified language within the Framework which required clarity. The Team compared these definitions with other resources to identify gaps and provided alternative language to update or refine several key parameters. These references included books such as *Strategic Command and Control: Redefining the Nuclear Threat* by Bruce Blair, *Governing the Bomb: Civilian Control and Democratic Accountability of Nuclear Weapons* by Oxford University, and *C3: Nuclear Command, Control, Cooperation* by Valery Yarynich; and articles such as "A National Command and Control Network for India in View of Pakistan and China," by Bhushan, and "Command and Control Trends and Choices for the Next Decade in South Asia," by Clary. The Team used these secondary sources to clarify parameters of the original Framework where language may have been outdated and/or potentially unclear. The Team then proposed alternative language in Table 1 to improve clarity of meaning for the following definitions for the Framework. Finally, the Team used these proposed parameters and revisions to conduct the remainder of this Assessment.[8]

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[7] It is acknowledged, however, that terminology is not consistent between the operational and policy communities within the United States as well as internationally.

[8] Conley, "Nuclear Command and Control in the Twenty-First Century: Trends, Disparities and the Impact on Stability", Owen C.W. Price and Jenifer Mackby, Eds., *Debating 21st Century Nuclear Issues, 2007;* Blair (1985) *Strategic Command and Control: Redefining the Nuclear Threat*, Washington D.C.: The Brookings Institute; Born, Gill, Hanggi, (2010) *Governing the Bomb: Civilian Control and Democratic Accountability of Nuclear Weapons*, New York: Oxford University Press; Yarnich (2003) *C3: Nuclear Command, Control, Cooperation*, Center for

Table 1. C2 Parameters and Definitions

Command and Control (C^2)	Command and Control	Command and Control: The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission (JP 1-02).
	Negative Controls	Controls put in place that assure a nuclear capability is unavailable when not authorized. The prevention of unauthorized nuclear use.
	Positive Controls	Controls put in place that assure a nuclear capability is available when authorized.
	Procedural Controls	Controls put in place which are measures to govern operations, personnel, authority, communications, and strategy.
	Technical Controls	Controls put in place which are measures to govern equipment, facilities, systems, or any other non-human elements.
	Posture	A formal position for international awareness and deterrence that defines a country's nuclear weapon response strategy (e.g. no-first use posture, delayed posture, launch on warning posture). Can also refer to a deployment posture.
Bias	Nuclear Bias	A tendency or predisposition inherent to the C^2

Defense Information; Bhushan, "A National Command and Control Network for India in View of Pakistan and China," Clary, "Command and Control Trends and Choices for the Next Decade in South Asia", *Nuclear Learning: The Next Decade in South Asia;* The Naval Post Graduate School , 2012.

		infrastructure of a nuclear program.
	Nuclear Non-Bias	A lack of tendency or predisposition inherent to the C^2 infrastructure of a nuclear program.
	Nuclear Non-Use Bias	A tendency or predisposition to not-use nuclear weapons when negative controls are more numerous or significant than positive controls.
	Nuclear Use Bias	A tendency or predisposition to use nuclear weapons when positive controls are more numerous or significant than negative controls.
	Nuclear Stability	1. Internal to a country – a non-bias for nuclear use or non-use. A consistent, secure, reliable, prepared, enduring, flexible, and maintainable system to manage, organize, control, and command nuclear weapons.[9] 2. External to a country – a feature of the relationship between nuclear-armed states.
	Nuclear Stability Dynamics	1. Internal to a country – the rigidity or adjustment of a nuclear program's policies, controls, or bias due to internal, external, or international influences, to include the overall operating environment. 2. External to a country – a reflection of the interactions between two or more nuclear-

[9] This "internal" definition of nuclear stability was provided by the DSRT. Subsequent analysis by the ANSER team and other experts led to the determination that "stability" is best expressed as a feature of the relationship between two or more countries while "bias" is a feature of one country's internal nuclear structure and posture.

		armed states as well as the influence of the internal nuclear biases of those states upon the larger, external strategic environment.[10]
Policies	Nuclear C^2 Policy	Doctrine that formally dictates and governs personnel, authority, equipment, facilities, and communications within a nuclear program.
	Negative Procedural C^2 Policy	Doctrine that dictates and governs varying degrees of safety, security and management for personnel, authority, communications, and strategy to assure there is no unauthorized nuclear use.
	Positive Procedural C^2 Policy	Doctrine that dictates and governs personnel, authority, communications, and strategy for the rapid execution of authorized launch orders and the assurance of nuclear use.
	Negative Technical C^2 Policy	Doctrine that dictates and governs the varying degrees of safety, security and management for equipment, facilities, systems, non-human elements, and the sharing of technical innovations to assure there is no unauthorized nuclear use.
	Positive Technical C^2 Policy	Doctrine that dictates and governs equipment, facilities, systems, non-human elements, and the sharing of technical innovations for the rapid execution of authorized launch orders and the

[10] See previous note.

		assurance of nuclear use.
Influences	Nuclear C^2 Influence	A factor that stimulates a change in the balance of C2 within a nuclear program resulting in a shift of its bias.
	Internal Nuclear C^2 Influence	An influence that originated from within the nuclear program or country using appropriate channels (e.g. a policy written, approved, and put into action by the nuclear program, etc.)
	External Nuclear C^2 Influence	An influence that originated from within the nuclear program or country using inappropriate channels (e.g., a coup forces leaders to alter authority or chains of command etc.)
	International C^2 Influence	An influence that originated from outside the country (e.g. a regional crisis, a terrorist act, pressure from an international regulatory agency, change in the operating environment, etc.)
	Operating Environment	Factors that are taken into account for or impact the outcome of a nuclear bias/nuclear Stability Dynamics (SD)[11] that are not controls (e.g. geographical locations, lack of technical sophistication, internal disagreements etc.)
Nuclear	C^2 Elements	Subcomponents of C^2 infrastructure that support

[11] Conley, "Nuclear Command and Control in the Twenty-First Century: Trends, Disparities and the Impact on Stability", Owen C.W. Price and Jenifer Mackby, Eds., *Debating 21st Century Nuclear Issues,2007*

Infrastructure		and organize the system (e.g. equipment, facilities, strategies, communications, and personnel)
	C^2 Functions	The activities and objectives of C^2 infrastructure (e.g. force management, force direction, decision making, situation monitoring, and planning)

Framework Parameter Gaps

Throughout the analysis of parameters and subsequent review of reference materials, the Team identified several gaps in the 2007 Framework where language was dated, confusing, and/or appeared to conflict with other known terms. It should be noted, however, that the Team did not develop any new terminology or concepts while addressing the identified gaps. Rather, the definitions were combined and/or deconstructed in such a way as to clarify and focus already recognized and understood language. Specifically, the Team determined:

- The Framework did not contain formal definitions for several key concepts that should be defined in order to provide clarity, such as bias and stability. The Team provided proposed language to further refine the definitions for these parameters.
- Although procedural policies were specifically identified and defined by the Framework, technical policies were not. The Team provided proposed language to address the technical policy definitional gap.
- A gap in the Framework concerning how nuclear stability is impacted by C^2 bias, and specifically what impacts are. The Team identified three (3) influences with the potential to impact C^2 bias and stability: internal, external, and international.
- The Framework did not contain a system for categorizing, sorting, or defining C^2s beyond function. However, the functions discussed by the Framework were overarching and were not used to define or categorize controls. Thus, the Team proposed to better

define and arrange C^2 elements and C^2 functions within the Framework (See Figure 3). In doing so, the Framework could provide a consistent approach for classifying controls and provide language by which to define and differentiate parameters in a more concise manner.[12]

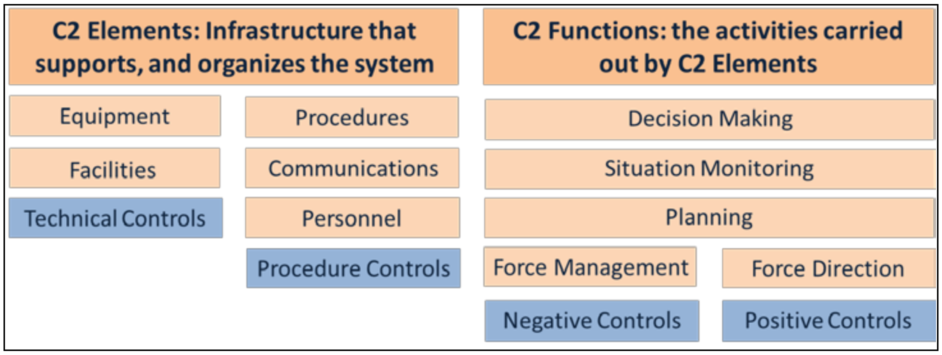

Figure 3. Suggested C^2 Elements and Functions[13]

- In the original Framework, a positive control could cause a nuclear program to be biased to use a nuclear weapon or biased to not use a nuclear weapon, given the circumstances and complexity of the control. The Framework cited the example of a submarine considered to be a positive control, yet has the characteristics of both use bias and non-use bias. The Team analyzed this circumstance and determined that the distinction of both biased to use and biased to non-use changed the intended definition of a positive control. The Team contends that as controls are measures enacted on purpose, the employment of a positive control is to ensure the authorized use of nuclear weapons. In doing so, a positive control cannot bias a nuclear program against the use of nuclear weapons. The Team aligned positive control with bias toward use of nuclear weapons, and aligned negative control with bias toward non-use. **However, the Team also**

[12] Bhushan, "A National Command and Control Network for India in view of Pakistan and *China*", 2012. See also DoD Nuclear Matters Handbook, http://www.acq.osd.mil/ncbdp/nm/nm_book_5_11/chapter_4.htm.
[13] A separate review of this DSRT-generated table noted that the definition of Force Direction in the Handbook encompasses negative and positive as well as technical and procedural controls. In addition, the distinction between elements and functions is useful for a more precise understanding of nuclear C2, but it may not be useful to try to force the four types of controls into this categorization as it is not a perfect fit and it does not add much to the understanding of the controls.

determined that a complex control may contain characteristics that are both positive and negative. Given this possibility, a complex control (such as a submarine) may be divided and considered both negative and positive given the circumstances, or based on the operational environment.

- The term "posture" can be misconstrued as it is used in two (2) separate contexts: in the Framework, posture describes a country's overall bias, but can also be used as a control. The Team deconflicted these terms by defining posture as a formal position that describes a nuclear program's weapon response strategy for international awareness and deterrence (e.g. no-first use posture, delayed posture, launch on warning posture). In doing so, a program's posture can be treated as a control because a posture is intended to alert and warn international adversaries of intentions and align other controls towards a common goal. **However, it should be noted that a posture is not a culmination of all controls in place, as this is defined as a bias because a nuclear program can say one thing (posture) but do something else (bias). In making this distinction, the Framework can serve as a possible litmus test to determine if a nuclear program is taking the necessary steps and controls to support the posture it claims to have.**

With these concepts defined, the Team then verified the orientation of each within the Framework. Figure 4 represents the core concepts of the Framework regarding the connection and relationship which exists between nuclear policies, nuclear C^2s, nuclear bias, and nuclear SD.

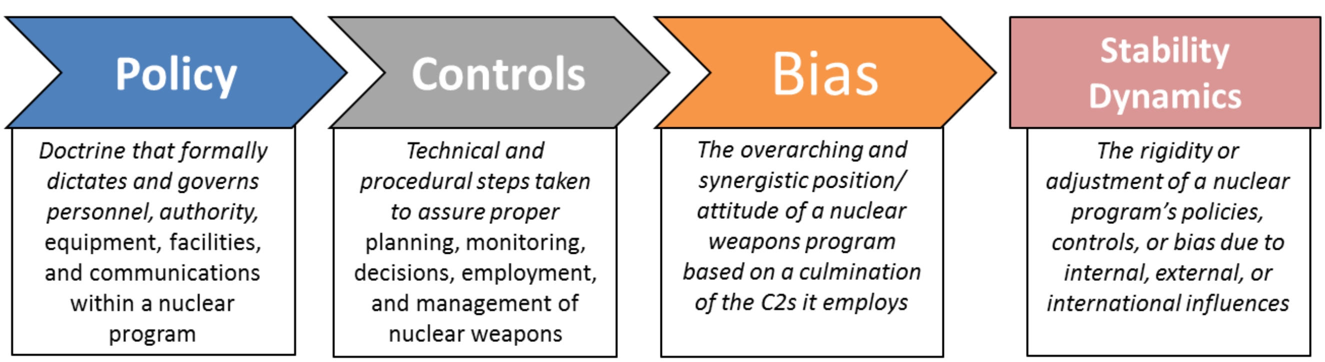

Figure 4. Framework Core Concept (original DSRT Graphic)

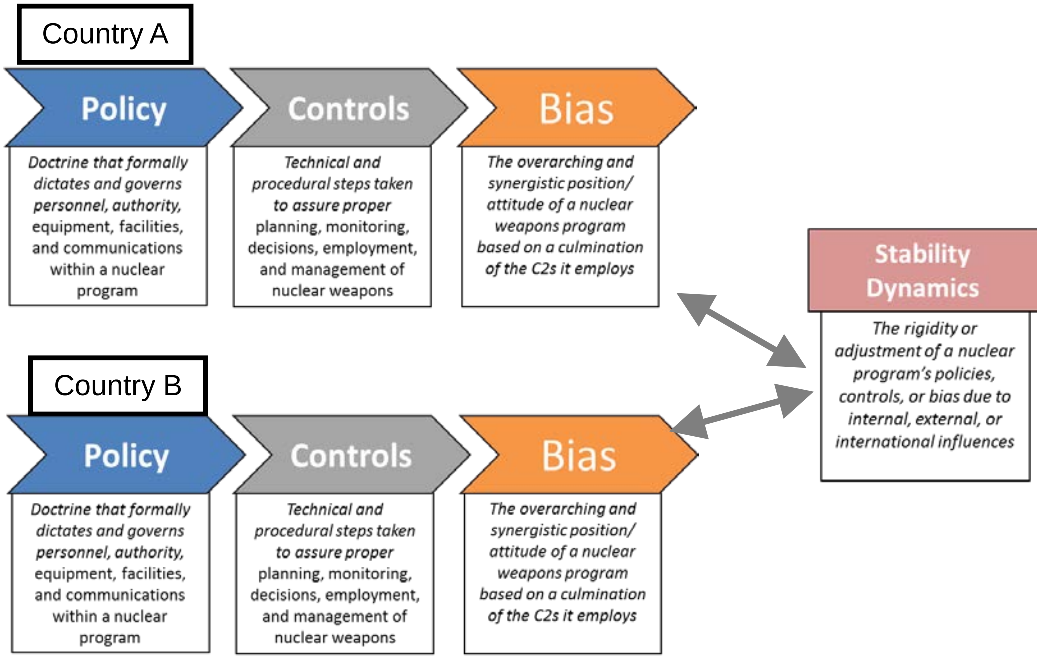

Figure 4a. Revised DSRT Framework Core Concept (based on ANSER Review)

Due to the fact that the analysis conducted in 2007 to define nuclear C^2 structure was new and untested in a real world setting, the Framework has the potential to present initial confusion to SMEs, particularly SMEs from the international community. The greatest risk, however, is that the complex and novel concepts of the Framework can be misrepresented when compounded with non-western-centric viewpoints which may lead to a disregard or rejection of the Framework upon initial review. To reduce this potential confusion, the Team proposed that a flow diagram, similar to Figure 4 above, be incorporated into the Framework to support a more straightforward understanding of the core concepts and methodology. In doing so, the Framework would provide a much simpler method to support constructive dialogue and discourse with SMEs.

Nuclear Command, Control, and Stability Matrix

The original Framework utilized a four (4) quadrant Matrix (See Figure 5) to represent the controls and measures of a nuclear control program. The Matrix visually depicts the ideas and concepts of the Framework in a flexible, yet constructive format representing the C^2, biases and stability of a nuclear program.

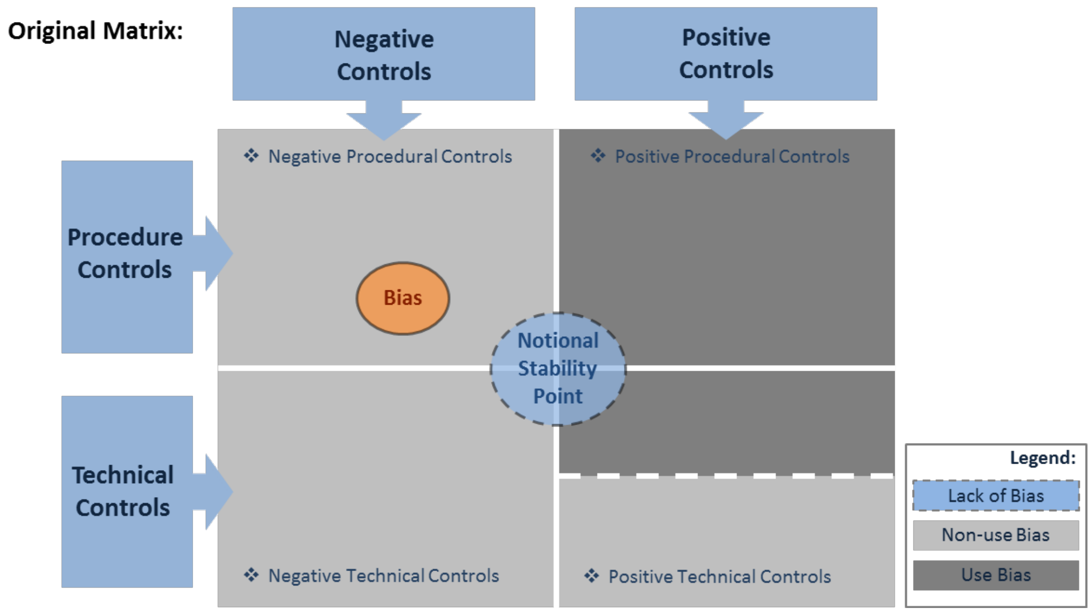

Figure 5. Rendering of the Original Matrix

The Team sought to apply the Framework to other analytic constructs, including a Venn diagram, to determine if the Framework could be represented in a different, and possibly more convincing, manner. However, the Team did not identify an alternative, more effective way to depict the concepts; thus, the proposed four (4) quadrant Matrix was determined to be the most suitable representation of the Framework and the core concept flow diagram. The Team therefore used several lessons learned from the identified parameter gaps (e.g. the alignment of use bias/non-use bias and positive/negative controls respectively, the use of posture as a control, etc.) to update and provide improvements to the Matrix in order to increase clarity and alignment with the core concepts.

The updated Matrix (Figure 6) maintains the four (4) quadrant design with negative/positive controls representing the X-axis and procedural/technical controls representing the Y-axis. Similar to the original Matrix, the updated Matrix also contains a notional stability point in the center where the negative/positive non-bias and technical/procedural non-bias intersect. This central point presents a non-bias that theoretically represents nuclear stability. While analyzing the diagram, the Team determined that orienting the negative controls on the left and positive controls on the right aligns and supports an basic exposure and understanding of an (X,Y) mathematics grid (as negative numbers are always extended to the left, while positive numbers extend to the right. The Team also determined that depicting the bias scale below the four (4) quadrants may allow SMEs to better discern and understand the Matrix as it presents a clearer understanding of how controls are linked to bias and stability.[14]

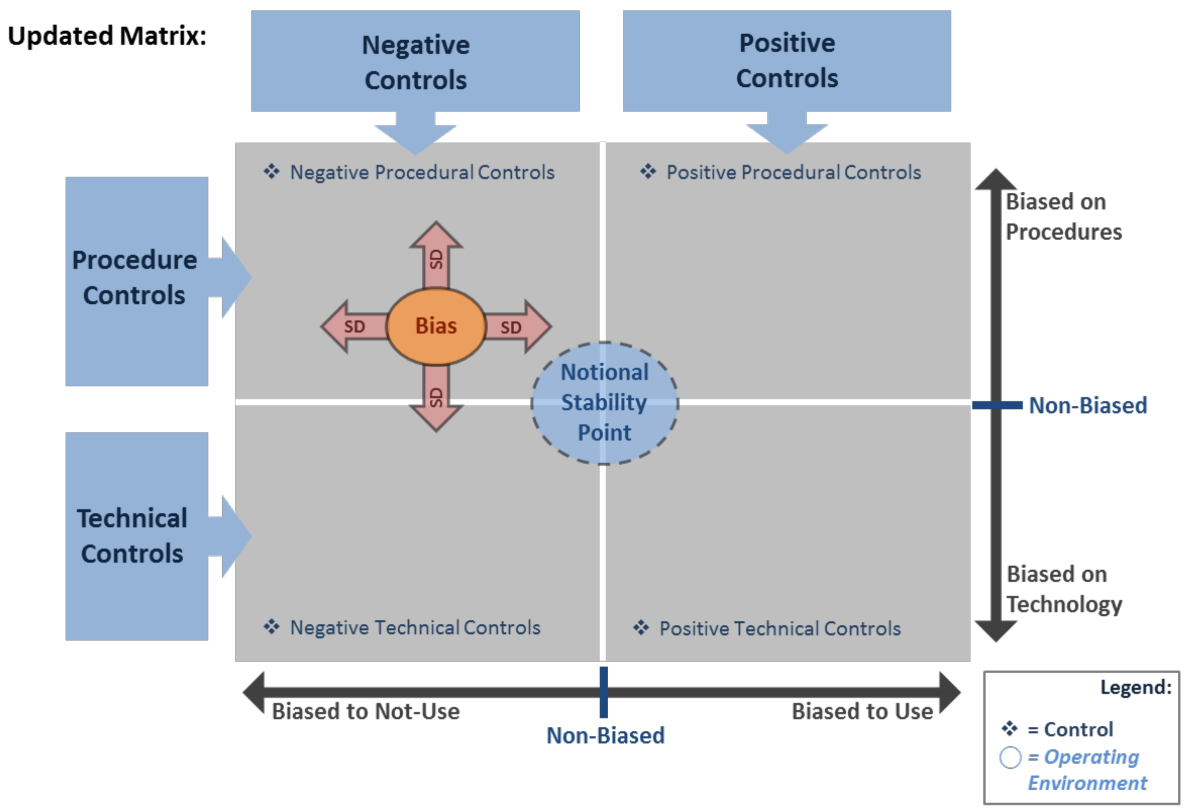

Figure 6. Updated Matrix

[14] Conley, "Nuclear Command and Control in the Twenty-First Century: Trends, Disparities and the Impact on Stability", Owen C.W. Price and Jenifer Mackby, Eds., *Debating 21st Century Nuclear Issues,2007*

Nuclear Command, Control, and Stability Matrix Gaps

Although the Team chose to maintain the four (4) quadrant Matrix design, there are several key differences and modifications to be made based on the findings uncovered during the parameter gap analysis to include:

- The submarine[15] use/non-use bias quadrant unnecessarily overcomplicated the Framework and should be broken apart to allow greater flexibility for all controls. Based on this, the Team decided to clearly define negative controls as being non-use biased and positive controls as being use biased. However, if the negative characteristics of a positive control (and vice versa) are significant enough to effect bias, they should be listed separately in whichever quadrant they represent.[16] This solution allows for greater clarity in deciphering the Matrix. For example, as the submarine is generally considered a positive control with negative characteristics, both the positive and negative characteristics of a submarine should be listed separately as positive and negative controls to allow a more complete understanding of the controls a nuclear program has put in place.
- The addition of a use/non-use bias scale to represent the predisposition of a nuclear program was necessary because the original Matrix appeared to display biases as an either-or construct. The Team discouraged this visual cue due in part to the fact that biases can have both negative/positive characteristics and technical/procedural characteristics.
- The original Framework lacked an identifiable formal representation of stability dynamics to influence a program's bias and controls. To connect stability dynamics to the visual, the Team portrayed stability dynamics on the Matrix as an arrow pulling the

[15] It is understood, however, that the capabilities and roles of submarines varies significantly among the various states possessing nuclear weapons as well as how launch authorizations are designated for those platforms.
[16] The splitting of the bottom-right quadrant in the original 2007 Framework served a secondary purpose, however. The Framework argues that a C2 system that has controls in the left two quadrants as well as the bottom-right quadrant is good/stable, while those in the top-right (reliant on Positive Procedural Controls) are more unstable. There is potentially merit in having two matrices – one that is blank for evaluating a country's C2, and another with green and red for depicting the author's argument that certain areas of the matrix are more "stable."

bias in a specific direction. Examples of destabilizing influences on a nuclear program's bias include: internal, external, international, political, policies, crises, and innovation.

- The original Framework listed only controls and postures on the Matrix to consider bias and stability. However, factors from the operational environment may also play a significant role in the bias or influence of a nuclear program. Therefore, the Team suggests that a legend be incorporated into the Matrix to differentiate controls and environmental factors to ensure that both can be accurately analyzed on the Matrix. For example, during the Cuban Missile Crisis, the Soviets in Cuba had limited communication with Moscow. This lack of communication was not a control, rather a factor of the operating environment.[17] Given this situation played a major role in the Soviets nuclear C^2 structure at the time, lack of hardened communication would be listed on the Matrix as a factor of the operational environment, and not necessarily as a control.[18]
- The quantitative nature of the Matrix may lead to qualitative errors in determining biases. For example, if an audience does not understand the value of one control over another, the quantity of controls visually represented in the Matrix may mislead an audience to disagree with the bias if specific controls carry more weight than other controls. Moreover, if a nuclear program contains fewer, yet more impactful negative controls than positive controls, the bias will be viewed toward non-use. However, when depicted on the Matrix, the negative controls appear to be fewer than positive controls; the audience may disagree with a non-use bias and the Matrix could lose credibility. Ultimately the value of the framework may be that it allows experts to have a meaningful discussion about C^2 and the potential for bias. SMEs may disagree about where the bias falls on the matrix (there is no "right" answer), but they can use the framework to express their disagreements using the same lexicon. To address this issue, the Team evaluated several mitigation strategies:

[17] A counter-point is that this was a characteristic of the technical measures or controls in place at the time.
[18] This recommendation is included in order to preserve the original recommendations from the DSRT, but follow-on reviews by several experts all agree that hardened communications are an aspect of technical control measures and should therefore be treated as such.

1. Gauge the qualitative weight of common controls and visually incorporate quality into the size/color on the Matrix or incorporate qualitative weight into the bias scale on the Matrix.
    i. Benefit: Matrix would be more accurate and conclusive.
    ii. Drawback: Matrix would be more complicated, visually confusing, and subject to opinion.
2. Gauge the qualitative weight of common controls and eliminate low value controls that are not significant.
    i. Benefit: Matrix would be simpler and easy to read.
    ii. Drawback: Matrix would be less accurate and more subjective.
3. Do not incorporate quality into the Matrix and allow the Matrix to be quantitative only.
    i. Benefit: Matrix would be simpler and easier to read.
    ii. Drawback: Matrix may be misleading.

The Team chose to employ the second mitigation strategy because it eliminates non-impactful controls,[19] which allows for simplicity when critical analysis and thought regarding the Framework is applied by SMEs. Given the simplicity of the core concept, technical SMEs may become frustrated with the lack of detail. However, to support a wide range of SME backgrounds (technical experts, politicians, policy makers, etc.) simplicity is important to support bilateral communication.

Application

To properly assess the Framework and identify points of confusion in the Matrix, the Team applied the Matrix using two (2) case studies. The chosen case studies were designed to test the Framework's concepts in an historical context. Additionally, the Team used the completed Matrices from these tests to inspect, identify, and correct sources of visual confusion to prevent

[19] A risk with this approach is that controls will have different significance in different operating environments (accident, theft, forward deployment, etc).

future SME misunderstandings while using the Matrix. To test the Framework, the Team first applied the updated Framework and Matrix to several common nuclear C^2 structures discussed by "A National Command and Control Network for India in view of Pakistan and China" to assess if the Matrix would consistently evaluate a wide spectrum of possible controls and biases.[20] Second, the Team applied the Matrix to historical events to determine if the biases and stability dynamics forecasted by the Matrix mirrored real world scenarios. Using each case study, the Team determined that the outcomes forecasted by the Matrix mirrored conventional analyses and identified potential sources of confusion. The following sections discuss and detail each case study, to include:

1. Nuclear C^2 structures
   - Common Nuclear C^2 structures
   - Nuclear Control Trends
2. Historical Controls, Bias, and Stability Depiction
   - Cuban Missile Crisis: Soviet's in Cuba
   - Indian Parliament Attack -2001: India's Nuclear Program

Nuclear C^2 Structure Case Study

The initial case study assessed the Matrix by mapping common nuclear C^2 structures to determine if the Matrix could accommodate a wide spectrum of controls and biases. These common C^2 structures (Table 2) vary by economic, technological and governmental factors:[21]

Table 2. Common C^2 structures[22]

[20] Bhushan", A National Command and Control Network for India in view of Pakistan and China", 2012, *http://frontierindia.net/a-national-command-and-control-network-for-india-in-view-of-pakistan-and-china*

[21] Bhushan", A National Command and Control Network for India in view of Pakistan and China", 2012, *http://frontierindia.net/a-national-command-and-control-network-for-india-in-view-of-pakistan-and-china*

[22] Ibid. Of note, follow-on reviewers of this DSRT assessment argued that these are not all NC2 structures since NC2 structures can be Civil and/or Military and centralized or decentralized with attributes that make it simple, complex, wealthy or poor. These categories may encourage generic stereotypes rather than in-depth analysis of real countries. The use of "wealthy" or "poor" may not be adequate descriptions of NC2 structures as they describe a

Wealthy	A nuclear program that has economic resources to research, expand, and bolster itself with both experienced people and technical innovations.
Poor	A nuclear program that does not have sufficient economic resources to properly research, expand, and bolster itself and relies on procedures instead of technology and experience.
Complex	A nuclear program that has the material resources and personnel to support a wide range of controls and redundancies.
Simple	A nuclear program that has minimal material resources or personnel to adequately support a robust and redundant C^2 structure.
Centralized	A nuclear program that maintains authority and control of its nuclear armament as a singular capability through a defined chain of command.
Decentralized	A nuclear program that distributes authority of its nuclear armament to a network of commanders or individuals who operate as independent decision makers with minimal oversight.
Civilian	A nuclear program that is governed by an elected, non-military government that maintains authority and control over the nuclear arsenal through a defined chain of authority.
Military	A nuclear program that is governed by a weak civilian government and/or the military maintains control and authority over the nuclear arsenal.

country's economy, not its C2 structure. The resources a nation devotes to its nuclear capability are not always proportional to other resource allocations, but alone may be indicative of a nations bias towards use or non-use.

For each nuclear C^2 structure, the Team identified and categorized controls listed by Bhushan in "A National Command and Control Network for India in view of Pakistan and China" on a Matrix according to the proposed definitions of each control to determine bias. The Team compared the biases of each nuclear C^2 structure on a single Matrix (Figure 7) to analyze the trends of financial resources (wealthy/poor), innovation (complex/simple), authority (centralized/de-centralized) and form of governing body (civilian/military). The trends portrayed by this common nuclear C^2 Matrix are discussed by other references, but not in the same manner. This Matrix provides a visual point of discussion to support its findings and determinations in a way that was not found by any other reference. The Team concluded that this Matrix can be used as an applicable discussion topic to gain SME feedback on the Framework.

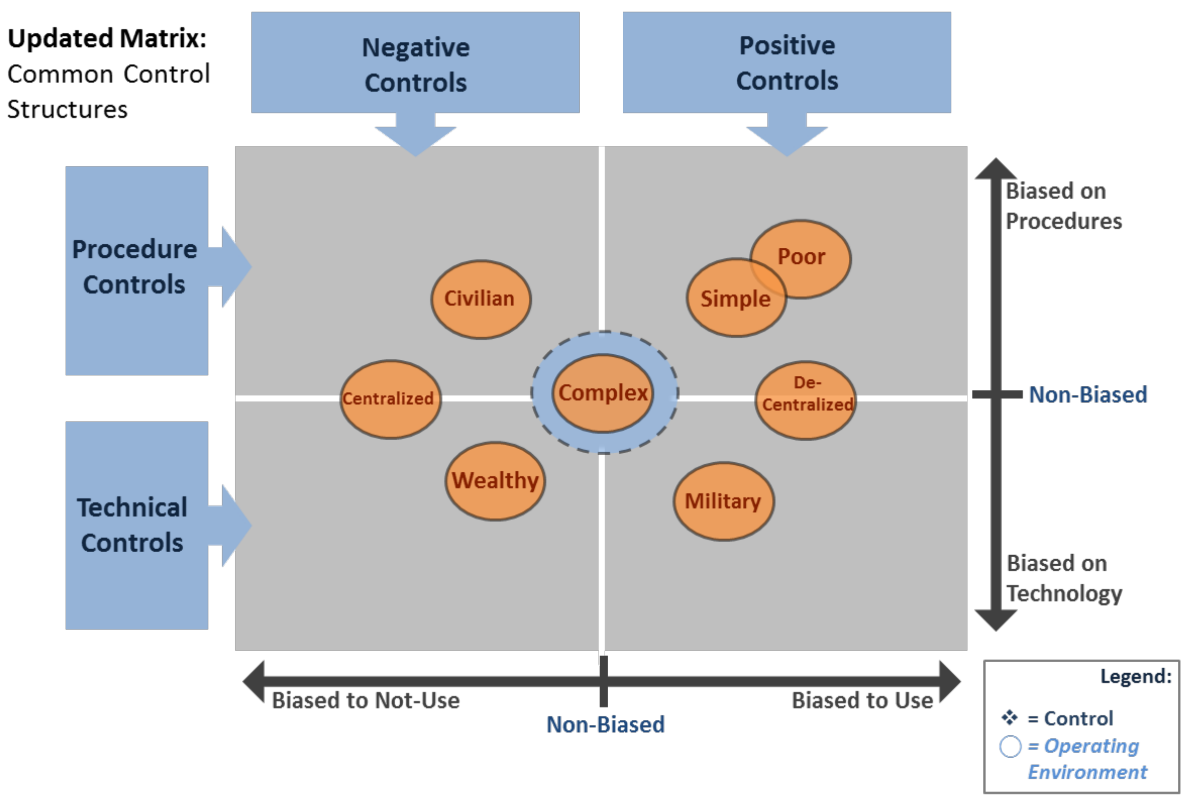

Figure 7. Common C^2 Structures[23]

For each nuclear C^2 structure, the Team categorized the controls listed by Bhushan on an individual Matrix according to their proposed definitions. Below, Figures 8-15 illustrate each individual Matrix of common nuclear C^2 structures with the controls which impact and/or dictate bias.

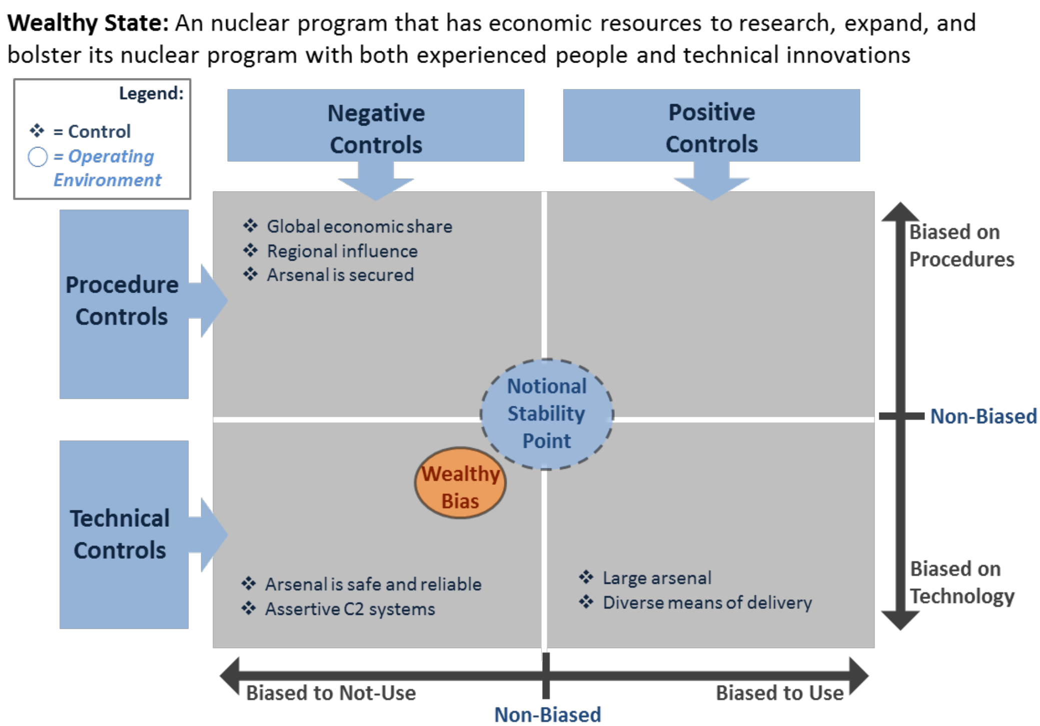

Figure 8. Wealthy C^2 Structure[24]

[23] An independent critique of this revised Framework questioned whether it is possible to fit these categories into the Matrix as the categories are too generic to say that they are biased in one way or another (some categories may be more clearly biased to technical or procedural, but harder to determine use/non-use based on these categories). It is also unclear where the controls listed in each quadrant come from and how it's possible to say that a wealthy/centralized/military program has a certain control. It may therefore make more sense to just look at each country individually (there are only nine) than to try to generalize these eight categories.

[24] It is understood that the term "wealthy" may place too much emphasis on the geo-political debate over "the haves & have-nots" within nuclear security discussions. Moreover, some reviewers observed that many of the "controls" listed on the matrix (e.g. economic share, regional influence, large arsenal) have nothing to do with C2 since a control is something that is put in place, not a feature of the country.

Poor State: A nuclear program that does not have sufficient economic resources to properly research, expand, and bolster its nuclear program and relies on procedures in place of technology and experience

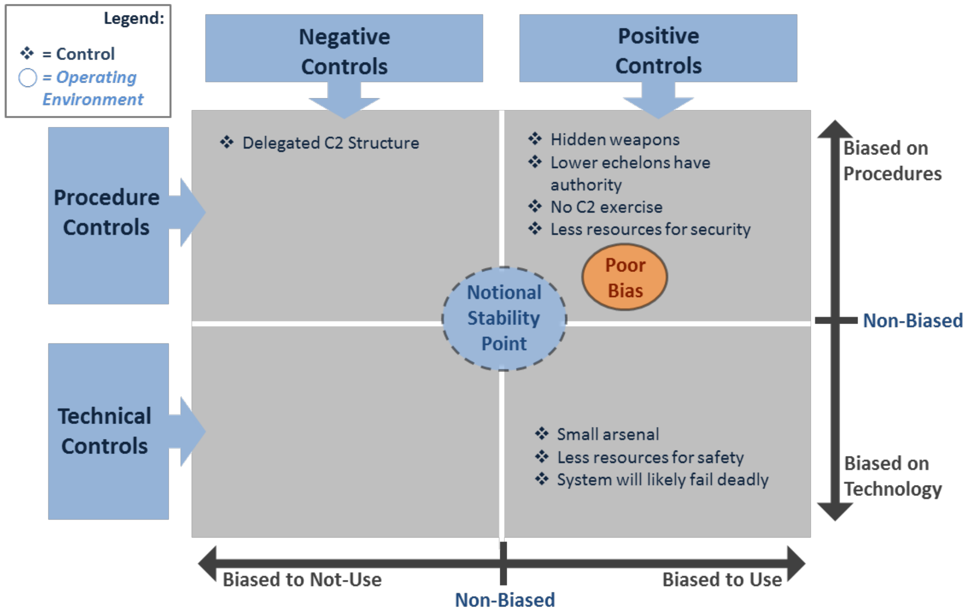

Figure 9. Poor C^2 Structure

Complex State: A nuclear program that has the material resources and personnel to support a wide range of controls and redundancies

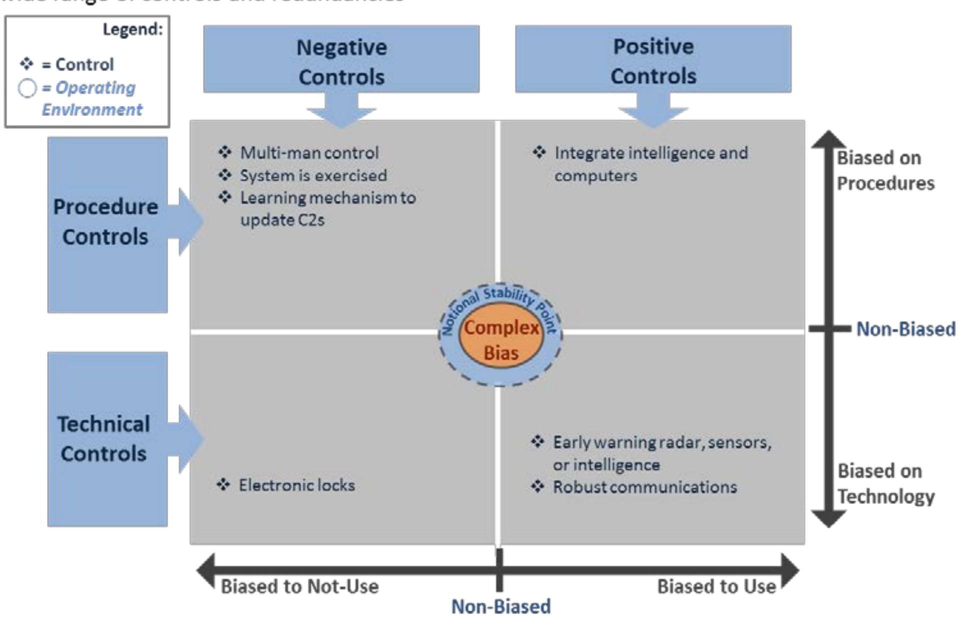

Figure 10. Complex C^2 Structure

Simple State: A nuclear program that has minimal material resources or personnel to adequately support a robust and redundant control structure

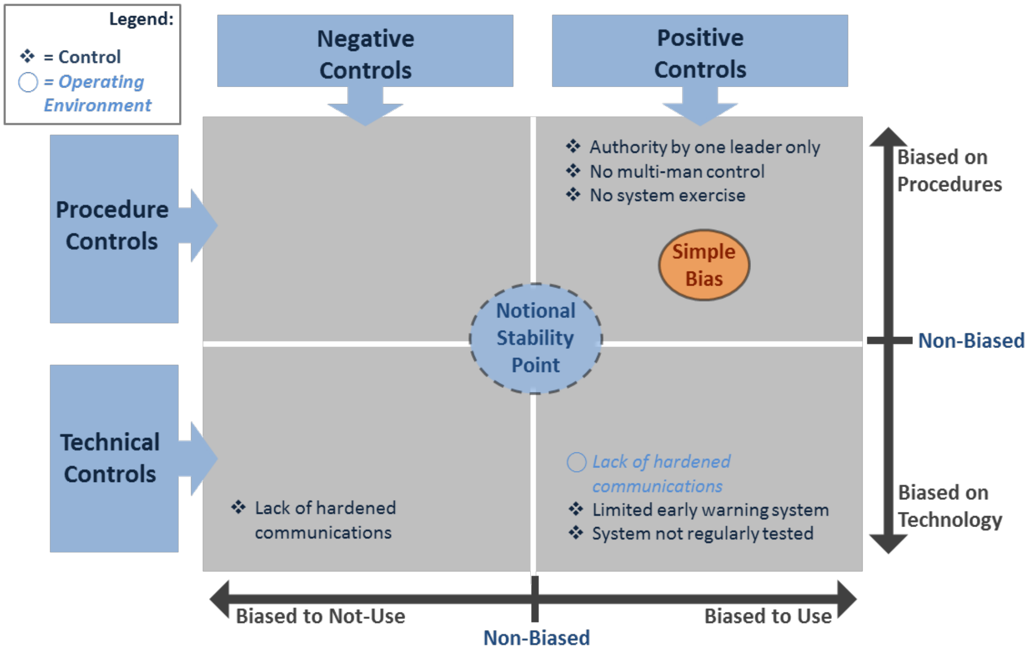

Figure 11. Simple C^2 Structure

Centralized State: A nuclear program that maintains authority and control of its nuclear armament as a singular capability through a defined chain of command and accountability

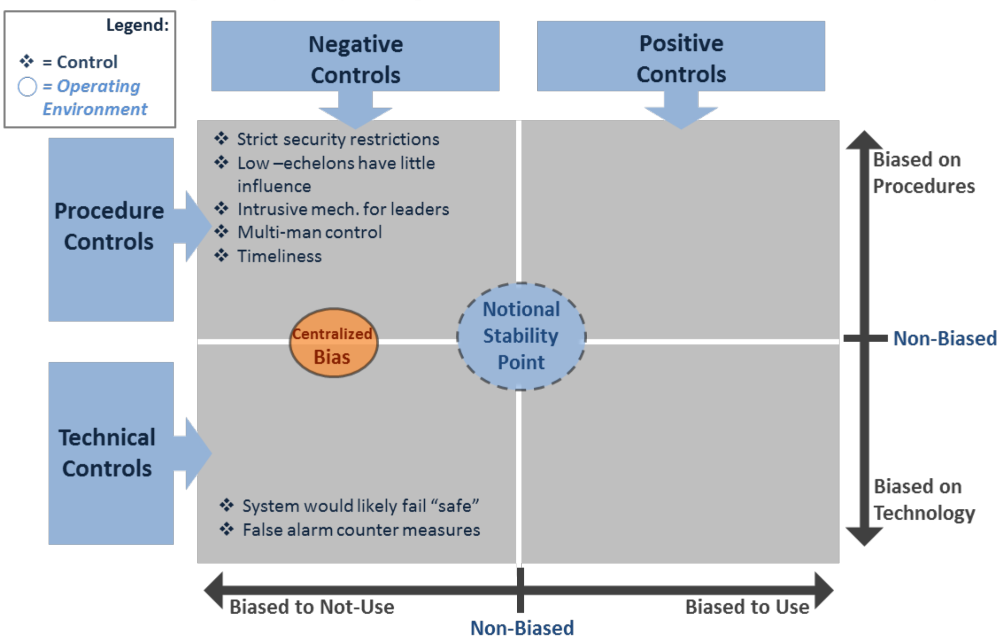

Figure 12. Centralized C^2 Structure

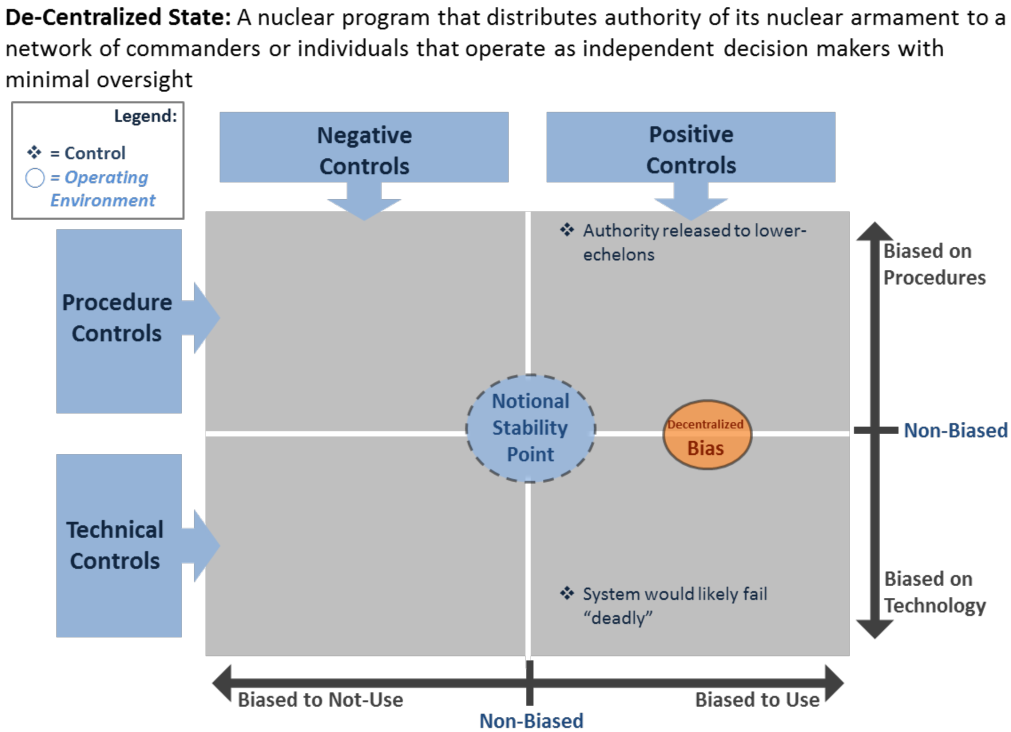

Figure 13. De-Centralized C^2 Structure

Civilian State: A nuclear program that is governed by an elected, non-military government that maintains authority and control over the nuclear arsenal through a defined chain of authority

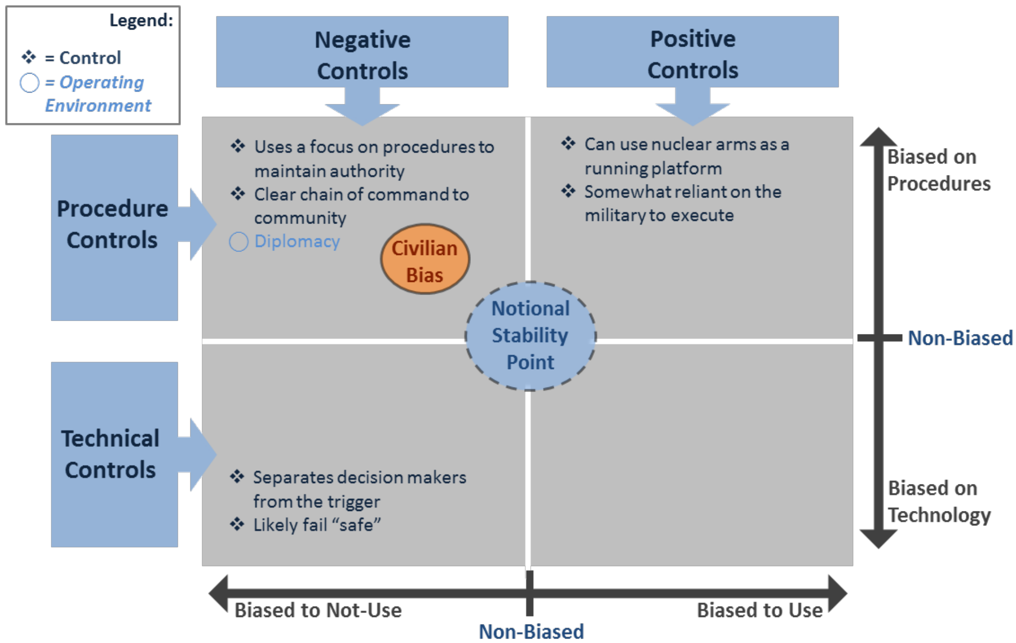

Figure 14. Civilian C^2 Structure

Military State: A nuclear program that is governed by a weak civilian government and/or the military maintains control and authority over the nuclear arsenal

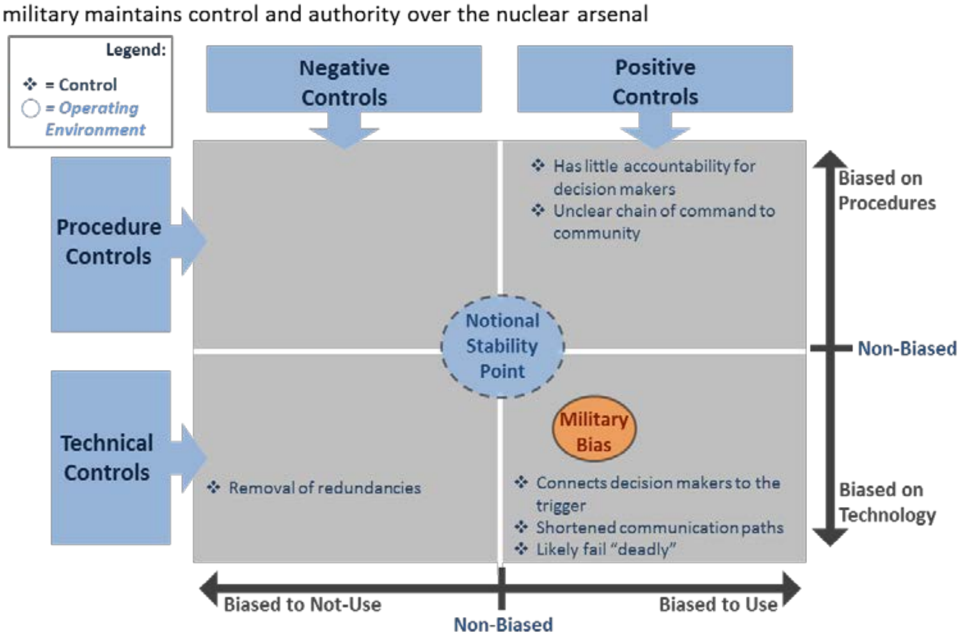

Figure 15. Military C^2 Structure

Historical Controls, Bias and Stability

The second case study focused on applying the Matrix to historical nuclear events to assess the utility and applicability of the Framework. In the original 2007 analysis, the Cuban Missile Crisis was used as an example of how to apply the outlined approach. The Team also selected this event as a case study as it has been well-researched and debated within the C^2 community of interest, providing ample resources to draw information from. The Team also selected a more recent nuclear confrontation, the India/Pakistan Stand-Off of 2001, in order to apply the Framework to a more modern and less conclusive historical event. The Team reviewed the Cuban Missile Crisis example provided by the original Framework and employed a similar rationale to the case studies as proofs of concept that the updated Framework and Matrix could be used to represent modern nuclear confrontations.

The Cuban Missile Crisis unraveled as a rapid rise in nuclear tensions between the Soviet Union and the United States. Both powers had the ability to deploy nuclear weapons but throughout the engagement, negative controls and "cooler heads" prevailed as no nuclear exchange occurred. The Soviet nuclear arsenal, though outmatched, was strategically placed to strike the United States' southeastern coast, yet the controls and bias of the Soviet's nuclear program kept its arsenal in check.[25] By placing the significant controls and environmental factors within the corresponding quadrants on the Matrix, the Team determined that the Soviet's bias toward non-use was easy to visualize and discuss.

However, the Team questioned if a non-use bias mirrored the historical events of the Cuban Missile Crisis. Whereas **the United States was not aware of the controls in place or the environment by which the Soviets were operating,** the United States was able to successfully blockade Cuba and force the Soviets to withdraw their nuclear armament. It stands to reason, that the Soviet's non-use bias and non-bias toward either procedural or technical controls,

[25] Norris, "The Cuban Missile Crisis: A Nuclear Order of Battle October/November 1962", 2012, http://www.wilsoncenter.org/sites/default/files/2012_10_24_Norris_Cuban_Missile_Crisis_Nuclear_Order_of_Battle.pdf

allowed the Soviets to maintain their chain of authority, while also maintaining their ability to rapidly respond, if necessary. Figure 16 depicts the C^2 and bias of the Soviets in Cuba scenario.

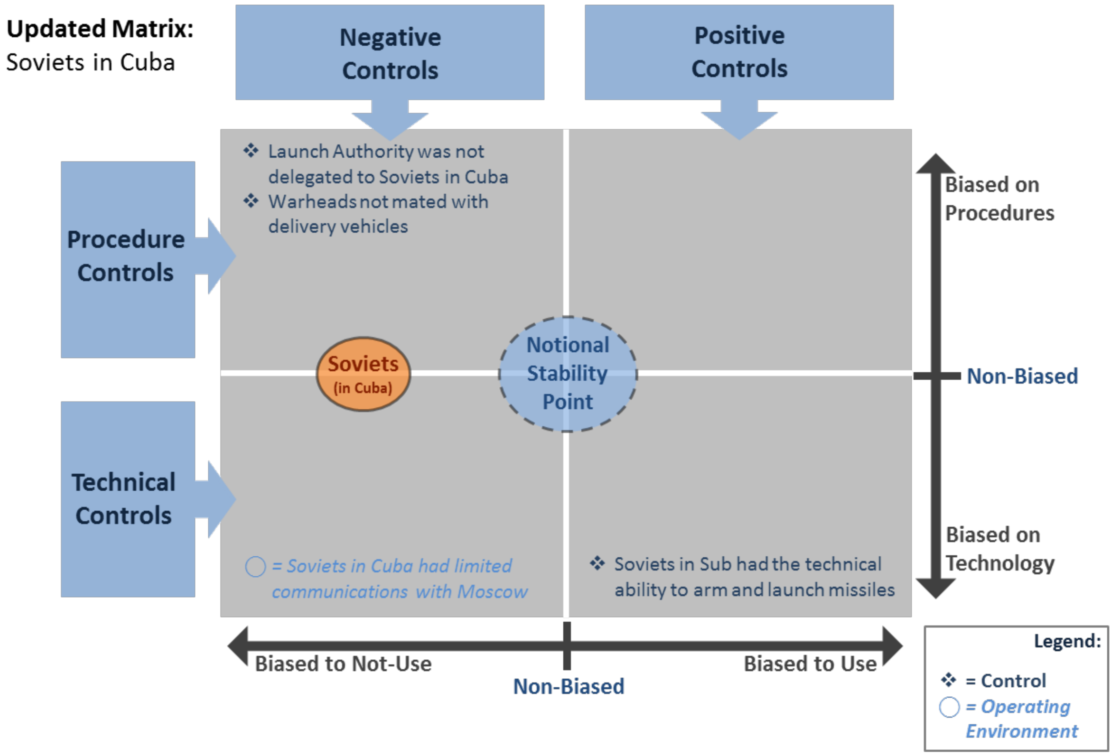

Figure 16. Soviets in Cuba C^2 Structure[26]

To further test the application and concepts of the Framework, the Team mirrored this process for a more recent nuclear crisis, the India/Pakistan Stand-Off of 2001. To avoid debated material, the Team focused its research on confirmed and widely accepted controls and circumstances to populate the Matrix, and to plot the bias of the Indian nuclear program throughout the Stand-Off. The Stand-Off occurred as a response to an attack on the Indian Parliament by a terrorist organization suspected of being harbored and funded by the Pakistani

[26] Secondary reviewers observed that the original framework had "notional balance of control measures" instead of "notional stability point" in the middle of the matrix. The former seems more accurate, but even that may be unnecessary to include because the original Framework did not argue that being in the center of the matrix is better/more stable. For this case study, there was a bifurcation of Soviet authority in Cuba – one controlled missiles while the other controlled the warhead storage access. In addition, Soviet submarines at the time had nuclear torpedoes rather than missiles.

intelligence services. India quickly assembled its conventional army and made threats to cross into Pakistan in an effort to bring justice to the terrorist organizations. Vastly outmatched by India's conventional forces and wearing thin because of the United States presence in Afghanistan, the Government of Pakistan said it would protect its sovereignty and promised a swift retaliation of any and all weapons if they were attacked by India.[27] Pre-conflict, India's arsenal was superior to Pakistan's in both quantity and quality. Though not publicized, India's civilian control was performing due diligence to maintain both procedural and technical controls to balance the nuclear program as it expanded.[28] However, as the Stand-Off worsened and tensions rose, the Indian nuclear arsenal was put on alert and though the weapons were not reported to be mated with delivery vehicles or ready to launch, the warheads were to a certain degree assembled to enable a response by eliminating several technical controls, thus changing the posture of its nuclear arsenal. Based on these events, the Matrix, as depicted in Figure 17, illustrates that India shifted its nuclear program to rely on procedural controls, thus potentially shifting its bias against the use of nuclear weapons to a more biased position. The Matrix further shows that Indian bias shifted to potentially rely more on procedural policies during the conflict. Many experts have espoused a belief that it was Pakistan's assured response that deterred India from taking the final steps of conventional warfare. However, India's negative controls allowed its nuclear arsenal to remain temperate throughout the Stand-Off, demonstrating that a shifting bias is not an intention or preference to use nuclear weapons but rather an indication of changing internal dynamics which could eventually impact the use of nuclear capabilities. This example also represents how the Matrix can be used to determine a shift in a nuclear program's bias in response to an international influence.

[27] Coll, "The Stand-Off: How Jihadi Groups Helped Provoke the Twenty-First Century's First Nuclear Crisis", *The New Yorker*, 2006; Clary, "Command and Control Trends and Choices for the Next Decade in South Asia", *Nuclear Learning: The Next Decade in South Asia; The Naval Post Graduate School* , 2012; Stolar, "To The Brink: Indian Decision-Making and the 2001-2001 Standoff", The Henry L. Stimson Center, 2008 http://www.stimson.org/images/uploads/research-pdfs/To_the_Brink.pdf

[28] Coll, "The Stand-Off: How Jihadi Groups Helped Provoke the Twenty-First Century's First Nuclear Crisis", *The New Yorker*, 2006

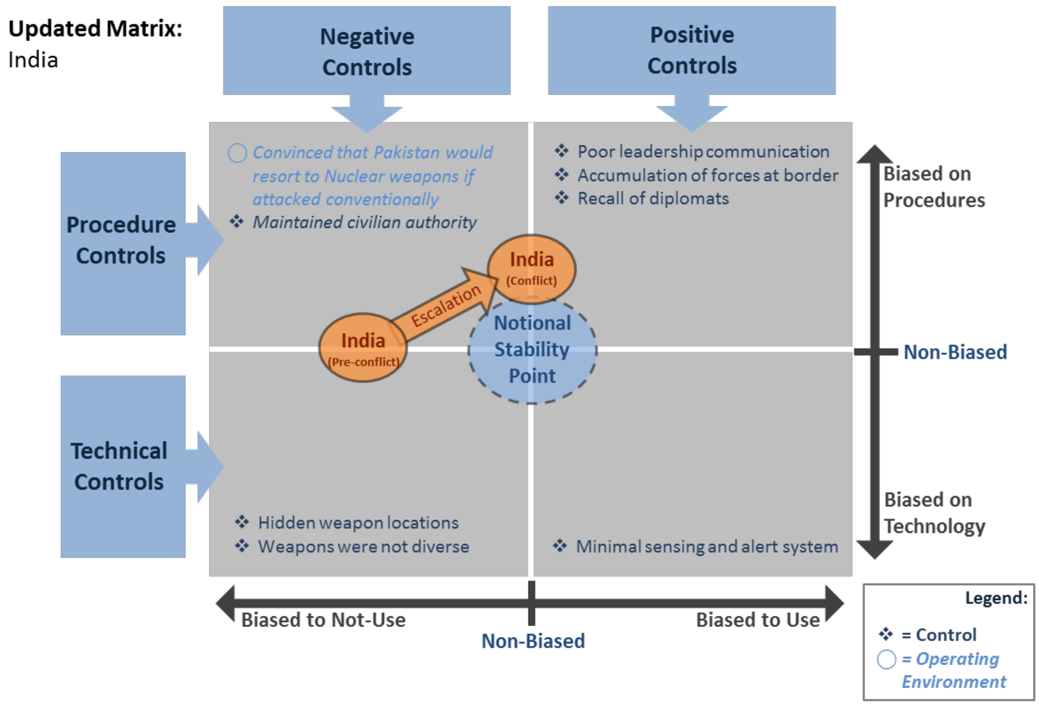

Figure 17. India/Pakistan Standoff: Indian C^2 Structure[29]

The second case study demonstrates that the potential for a nuclear war is a strong motivator to adjust a program's bias. It stands to reason, however, that similar adjustments can be made using international pressure or other motivating factors. As such, the Team recommends that the Matrix and Framework be applied to circumstances that represent historical events where political or regional pressure was used to shift or alter a nuclear program's bias. The Matrix could thus serve as a beneficial tool to a politician or policy maker to better assist them in recognizing and understanding the contributing factors and complexity related to a nuclear C^2 structure.

From these case studies, the Team concluded that the Matrix is a useful structure by which to visualize and discuss issues relating to the stability dynamics and bias shifts of nuclear countries

[29] Secondary reviewers of this case study matrix have observed that the combination of Operating Environment factors with C2 controls results in some confusion over the C2 factors which influence the shift in bias. For example, "weapons were not diverse" is a feature of the nuclear arsenal but not the C2 structure. "Recall of diplomats" is a political action that affects the political environment but is not related to nuclear C2.

from an analytical standpoint. Moreover, the Team assesses that factors from the operational environment, though very important, will be a source of conflict regarding how bias may be impacted. This challenge is somewhat predicated upon the qualitative/quantitative problem discussed previously, as some SMEs may consider certain factors or controls as more important than others. However, the Team recommends that a visualization which incorporates both qualitative and quantitative controls may be best to promote rigorous, yet constructive discourse.

Conclusion

The VT-ARC DSRT was unable to identify a comparable, competing Framework for understanding nuclear stability based on C^2 controls and procedures. To ensure the conceptualization of C^2 would be useful to the community of interest, the Team verified and amended the existing Framework to accurately reflect real world outcomes of C^2 policies. The limitation, though, is that individuals may have differing opinions regarding where a control should be placed on the Matrix. Even more so, the Team assessed that factors from the operational environment, though very important, may be a source of conflict regarding how the impact of a bias is understood. This challenge may be further complicated, based on the qualitative/quantitative difficulties identified previously, as some experts may consider certain factors or controls to be more important than others. A recommended solution to this challenge is to reduce the number of controls placed on the Matrix in order to reduce the quantitative nature of the Matrix while increasing the qualitative aspect of each control. However, the Team proposes that a mix of both qualitative and quantitative control visualization(s) may be most appropriate to promote healthy and constructive discourse.

Ultimately, the Team determined that the original C2 Framework proposed in 2007 presented a new approach to nuclear bias and stability that could not be found in other readily available sources. Though the Framework highlights new ideas and concepts regarding the controls and stability of a nuclear program, the findings of this Assessment strongly suggest that the concepts of the Framework are sound from an analytic point of view. However, real world use and application will be the true test for the Matrix's applicability. To mitigate these possibilities, the

Team has provided a proposed update to the Framework and Matrix which is designed to reduce confusion, while presenting the material in as consistent manner as can be vis-a-vis nuclear stability dynamics. To further assess and mitigate possible gaps in real world application, the Team used the updated Matrix—applying it to several case studies of historical events—to simulate and assess real world applicability.

Annex A: ANSER Assessment & Alternate Framework

As a secondary tasking, the ANSER team was asked to explore an alternative framework which might provide policy makers with a methodology to analyze and compare Nuclear Command and Control systems and assist in determining a nuclear weapon capable country's nuclear bias and overall stability metrics between two or more nuclear-capable countries. This tasking evolved as a result of the preliminary analysis which found that the 2007 Framework was overly simplistic and general in trying to express all C^2 factors impacting all nuclear capable states, and given the relative small number of nuclear capable states, that a deeper assessment was prudent for each state. The team therefore generated an outline of a framework that has the potential to provide an in-depth analysis of a country's nuclear command and control apparatus. This analysis in turn may assist policy makers with data and metrics to evaluate a country's bias towards use or no-use of nuclear weapon employment.

Study Plan

To accomplish this task, a two-phased approach was used. Phase I defines the DOTMLPF-P aspects of a nuclear weapons capable nation. Phase II applies theses aspects to the nine nuclear weapon capable nations to come up with an assessment of that nation's Nuclear C^2 and how it's positive and negative controls might determine a bias towards use or non-use of nuclear weapons. A comprehensive use of this framework potentially requires access to classified information and also requires subject matter expertise in a particular country's Nuclear Weapons command and control system in order to apply the DOTMLPF-P aspects.

Methodology

In order to provide a common assessment framework to ensure consistency and compatibility, the team recommends utilizing the Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities and Policy (DOTMLPF-P) methodology used by the DoD in it requirements generation process. For the purpose of this effort the DOTMLPF-P definitions should be modified and analysis of the DOTMLPF-P aspects be conducted.

This task uses Doctrine as an example of how a DOTMLPF-P analysis might be applied by examining positive and negative controls in a Nuclear C^2 system and supporting a determination of bias toward use or no-use of nuclear weapons.

(Excerpt from "Nuclear Command and Control in the Twenty First Century: Trends, Disparities and the Impact on Stability", *Debating 21st Century Nuclear Issues, 2007). A core challenge in the design and development of a C2 system is the need to strike a balance between having a process that ensures nuclear weapons are always employed when proper authorization is provided, and ensuring they are never employed (or detonated) in the absence of proper authorization. From a system design perspective, this "always-never" challenge is addressed through the development of positive controls (measures that ensure nuclear employment when properly authorized) and negative controls (measures that prevent accidental or unauthorized nuclear employment). In mature C2 systems, these positive and negative controls are applied in a layered and redundant manner in order to achieve six primary functions:*

1. Maintain the technical conditions and combat readiness of the strategic systems;
2. Prevent the accidental or unauthorized use of nuclear weapons;
3. Facilitate routine operations among staff and subordinate forces;
4. Provide inter-service and interagency coordination on all aspects of the nuclear mission, to include ballistic missile defense, early warning, reconnaissance, etc;
5. Develop and update nuclear war plans; and
6. Enable the combat use of nuclear weapons.

Two general approaches are applied when developing the negative and positive controls necessary for achieving these six functions: the use of procedural and technical measures.

Procedural Approaches to Negative and Positive Controls
Procedurally, operational plans, doctrine, and training can dictate varying degrees of safety, security, and reliability as the strategic forces transition from a peacetime posture through a crisis, and toward employment. Procedural measures in support of negative controls can include: the use of a two-person rule that makes it impossible for a single person to initiate a launch; the separation of special nuclear material (SNM) from the high-explosive assembly of a warhead; the separation of a warhead from its delivery vehicle; or restricting access to launch codes. In addition, a strategic doctrine that espouses no-first use (NFU) or delayed retaliation posture can be considered a negative control. These postures seek to provide a cushion of time for strategic decision-makers who may be subject to stress and "the fog of war" during a crisis and potentially face the unintended use of nuclear weapons due to the inadvertent escalation of a crisis. In this context, nuclear use is authorized by the appropriate command authority, but "unauthorized" in the context of inaccurate and incomplete knowledge or not meeting the original, pre-crisis intent of the strategic authority.

Technical Approaches to Negative and Positive Controls

A broad array of technical measures for providing negative and positive controls have been developed and fielded over the past sixty years, though the availability and use of these measures vary among the spectrum of nuclear nations. Technical measures include "one-point safety" designs for weapons that ensure the accidental detonation of a weapon's high-explosive assembly does not provide an adequate impulse for detonation of the nuclear core. Other negative controls include mechanical and electronic locks (to include Permissive Acton Links - PALs), fail safe designs, weak links, electric exclusion zones, and other technical measures that prevent unauthorized or accidental use. Technical measures that provide positive nuclear controls include hardened communications systems, frequency diversity, mobile command posts, interference resistant communications, and environmental sensing devices for warhead arming.

DOTMLPF-P Framework. The framework is not all-inclusive and may require further analysis to expand nuclear C^2 procedural and technical control measures. The Doctrine example below (Figure 1) is illustrative in nature and would be applied across the DOTMLPF-P spectrum. Upon completion of each DOTMLPF-P section, an overall score would determine a bias towards use or no-use of nuclear weapons (Figure 2). Aspects of procedural and technical controls should be balanced and/or weighted to ensure equal consideration of positive and negative controls.

Doctrine Section

Purpose: To map out some of the key doctrine aspects that could be considered in an organization's nuclear C^2 system.

Description: The development of doctrine is a process that continues throughout the growth of an organization. As new polices and circumstances develop, so will the need for appropriate doctrine. The goal of this section is to develop foundations for analysis of nuclear C^2 procedural measures by examining the negative and positive controls employed.

Definition: Doctrine is the fundamental principle that guides the operations and functions of the organization toward common goals and objectives. Doctrine includes documents that formalize the organization's strategy, policy, and procedures to codify authority, roles and responsibilities. Doctrine provides the strategic context and linkage between the top levels of the organization and the tactics, techniques, and procedures required at the operational levels.

In general, doctrinal aspects of a nuclear C^2 system are primarily procedural in nature and classified as either negative or positive controls. Listed below are terms unique to this doctrine section:

Negative Controls
- Delayed retaliation posture
- No-first use or Launch on Warning
- Two-person rule
- Restricted access to launch codes
- Separation of warhead components
- Separation of warheads & vehicles
- Other

Positive Controls
- Airborne alert status
- Launch on Warning (LOW) posture
- Strip alert for strategic bombers
- Pre-delegation of launch authority
- Final assembly of warhead
- Mating warhead with delivery vehicle

- Other

Summary: Doctrine outlines the C^2 system's behavior and establishes a means of achieving its goals and objectives. Evaluating doctrine is critical in determining whether a nuclear C^2 system may be biased toward use or non-use. Specifically, the nuclear doctrine prescribes the strategic context, authorities, roles and responsibilities, and limitations that govern how the C^2 system accomplishes its mission.

Doctrine Section (example)
Figure 1

Section	Weight	Procedural Aspect	Control	Weight
Doctrine	**2**		**(-) Y/N**	
		Delayed retaliation posture	**Y**	**3**
		No-first use or Launch on Warning	**Y**	**2**
		Two-person rule	**N**	**1**
		Restricted access to launch codes	**Y**	**1**
		Separation of warhead components	**N**	**2**
		Separation of warheads & vehicles	**Y**	**3**
		Other		**TBD**
Non-Use	←		**Total**	**9**
			(+) Y/N	
		Airborne alert status	**N**	**1**
		Launch on Warning (LOW) posture	**Y**	**2**
		Strip alert for strategic bombers	**Y**	**3**
		Pre-delegation of launch authority	**N**	**1**
		Final assembly of warhead	**Y**	**2**

		Mating warhead with delivery vehicle	**N**	**3**
		Other		**TBD**
			Total	**7**

Other: additional aspects as required/needed such as survivability

Overall assessment (example)

Figure 2

Country X			
DOTMLPF/BIAS	**USE**	**NEUTRAL**	**NON-USE**
Doctrine			2
Organization			
Training			
Materiel			
Leadership			
Personnel			
Facilities			
Policy			
OVERALL			

Annex B: Acronym Table

ACRONYM	DEFINITION
C2	Command and Control
CEIP	Carnegie Endowment for International Peace
CEISM	Center for International Security and Arms Control Studies
CSIS	Center for Strategic and International Studies
DSRT	Decision Support Red Team
FRS	Foundation for Strategic Research
IDA	Institute for Defense Analyses
INSS	Institute for National Security Studies
MIT	Massachusetts Institute of Technology
NPS	Naval Postgraduate School
OUSD(P)	Office of the Undersecretary of Defense (Policy)
PONI	Project on Nuclear Issues
RUSI	Royal United Services Institute
SD	Stability Dynamics
SME	Subject Matter Expert

VT-ARC	Virginia Tech Applied Research Corporation

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Annex D – Original 2007 Framework

CHAPTER TWELVE

NUCLEAR COMMAND AND CONTROL IN THE TWENTY-FIRST CENTURY

TRENDS, DISPARITIES AND THE IMPACT ON STABILITY

Jerome M. Conley

With the turn of the twenty-first century a renewed interest has arrived in the role of nuclear weapons as symbols of national power as well as tools for strategic posturing. The 1998 nuclear tests in South Asia, the 2002 U.S. Nuclear Posture Review (NPR), the British debate over Trident replacement, and the overt pursuit of nuclear capabilities by Iran and North Korea represent key examples of an overall shift in the number of states with nuclear capabilities, nuclear aspirations, and legacy systems that require modernization. However, the 2001 attacks on the United States with airplanes and anthrax underscore a changing security environment in which asymmetric risks created by non-state actors may alter and/or diminish the degree of security afforded by nuclear deterrence.

As discussed in the previous chapters, these multifarious factors converge to provide a rich forum for assessing the future utility of nuclear weapons and the transformation of nuclear deterrence. These assessments and projections, however, focus almost exclusively on the quantity and quality of warheads and delivery systems and seldom broach the equally critical topic of the command and control (C^2) systems that define nuclear operations. As the design and robustness of C^2 systems impact the safety, security and reliability of nuclear weapons during peacetime, crises, and wartime, an adequate and balanced assessment of nuclear deterrence and stability in the twenty-first century must simultaneously explore the quantity and quality of nuclear weapon systems as well as the systems and processes that control them. In an era when the true strategic intentions of existing and aspiring nuclear nations grow more opaque, an analysis of the command and control trends within these states can serve to clarify the role of nuclear weapons for these actors.

KEY ASPECTS OF NUCLEAR COMMAND AND CONTROL

This chapter explores the technical and procedural aspects of nuclear safety, security, and reliability, the ongoing changes in global and regional security dynamics, and the implications of these factors on nuclear deterrence and stability in the twenty-first century. Overall, nuclear command and control[1] involves the designation of select personnel who have the authority to determine the disposition and employment of nuclear weapons; it also involves the creation of systems and processes to ensure the intentions and decisions of these authorities are properly executed. The U.S. Department of Defense defines nuclear command and control as:

> The exercise of authority and direction by the President, as Commander in Chief, through established command lines, over nuclear weapon operations of military forces; as Chief Executive over all Government activities that support those operations; and, as Head of State over required multinational actions that support those operations. The [nuclear command and control] structure supports the exercise of authority and direction by the President.[2]

The means through which this presidential authority is executed is the nuclear command and control system and includes the "combination of facilities, equipment, communications, procedures, and personnel essential for planning, directing, and controlling nuclear weapons, weapons systems, and associated operations."[3] Though the names and authorities may vary, all C^2 programs involve the same attributes of a human decisionmaker(s) and the employment of technical and procedural control measures to ensure the safe, secure, and reliable execution of these decisions. Where differences occur, however, are in the types of control measures emphasized by these actors and the ability of their command and control systems to ensure consistent and balanced safety, security and reliability during times of peace, crisis, and hostility (nuclear or otherwise).

The "Always-Never" Challenge and the Role of Positive and Negative Controls

A core challenge in the design and development of a C^2system is the need to strike a balance between having a process that ensures nuclear weapons are always employed when proper authorization is provided, and ensuring they are never employed (or detonated) in the absence of proper authorization. From a system design perspective, this "always-never" challenge is addressed through the development of positive controls (measures that ensure nuclear employment when properly authorized) and negative controls (measures that prevent accidental or unauthorized nuclear employment).[4] In mature C^2 systems, these positive and negative controls are applied in a layered and redundant manner in order to achieve six primary functions:

1. Maintain the technical conditions and combat readiness of the strategic systems;
2. Prevent the accidental or unauthorized use of nuclear weapons;
3. Facilitate routine operations among staff and subordinate forces;
4. Provide inter-service and interagency coordination on all aspects of the nuclear mission, to include ballistic missile defense, early warning, reconnaissance, etc.;
5. Develop and update nuclear war plans; and
6. Enable the combat use of nuclear weapons.[5]

As detailed below in Figure 12.1, two general approaches are applied when developing the negative and positive controls necessary for achieving these six functions: the use of procedural and technical measures.

Procedural Approaches to Negative and Positive Controls

Procedurally, operational plans, doctrine, and training can dictate varying degrees of safety, security, and reliability as the strategic forces transition from a peacetime posture through a crisis, and toward employment. Procedural measures in support of negative controls can include: the use of a two-person rule that makes it impossible for a single person to initiate a launch; the separation of special nuclear material (SNM) from the high-explosive assembly of a warhead; the separation of a warhead from its delivery vehicle; or restricting access to launch codes. In addition, a strategic doctrine that espouses no-first use (NFU) or delayed retaliation posture can be considered a negative control. These postures seek to provide a cushion of time for strategic decision-makers who may be subject to stress and "the fog of war" during a crisis and potentially face the unintended use of nuclear weapons due to the inadvertent escalation of a crisis.[6] In this context, nuclear use is authorized by the appropriate command authority, but "unauthorized" in the context of inaccurate and incomplete knowledge or not meeting the original, pre-crisis intent of the strategic authority.

Figure 12.1. Procedural and Technical Approaches to Negative and Positive Controls

	Negative Controls (-)	Positive Controls (+)
Procedural Controls	• Delayed retaliation posture • No-first use or Launch on Warning • Two-person rule • Restricted access to launch codes • Separation of warhead components • Separation of warheads & vehicles • Other	• Airborne alert status • Launch on Warning (LOW) posture • Strip alert for strategic bombers • Pre-delegation of launch authority • Final assembly of warhead • Mating warhead with delivery vehicle • Other
Technical Controls	• One-point safety warhead design • Mechanical / electrical locks • Fail safe weapon designs • Electrical exclusion regions • Weak-link designs • Environmental sensing devices • Other	• Fully automated launch system • Frequency diversity • Hardened communication systems • Sea-based delivery vehicles • Mobile command systems / posts • Jam / interference resistance • Other

Examples of procedural measures that promote positive control over nuclear forces include the delegation of launch authority to subordinate or field commanders, the final assembly of warhead components, the mating of warheads with their delivery vehicles, the initiation of airborne alert status for bombers and the deployment of mobile missile forces. These measures provide for the rapid execution of authorized launch orders and an assurance of nuclear use. From a doctrinal perspective, a launch-on-warning (LOW) posture (sometimes referred to as a "hair-trigger" posture) can also provide rapid and assured nuclear use.[7]

Technical Approaches to Negative and Positive Controls

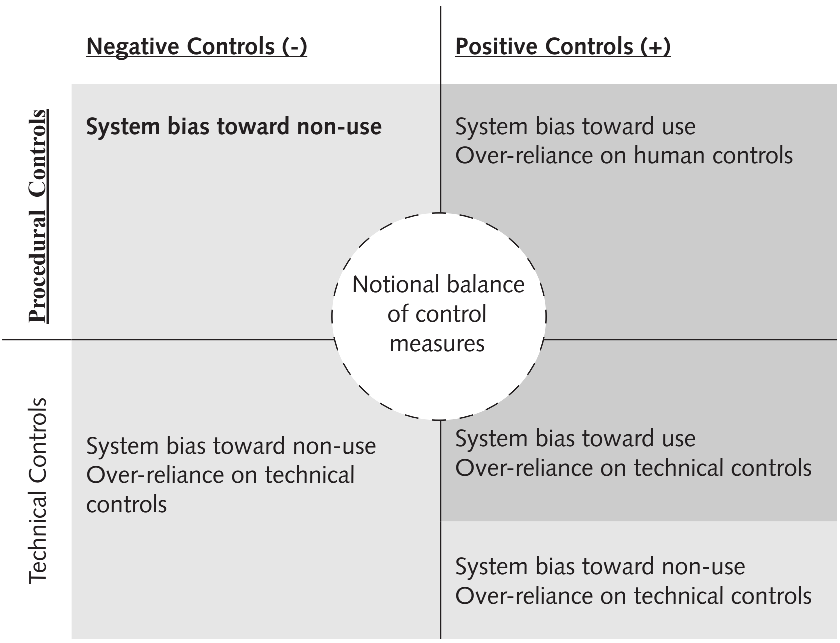
A broad array of technical measures for providing negative and positive controls have been developed and fielded over the past sixty years, though the availability and use of these measures vary among the spectrum of nuclear nations. Technical measures include "one-point safety" designs for weapons that ensure the accidental detonation of a weapon's high-explosive assembly does not provide an adequate impulse for detonation of the nuclear core. Other negative controls include mechanical and electronic locks (to include Permissive Acton Links - PALs), fail safe designs, weak links, electric exclusion zones, and other technical measures that prevent unauthorized or accidental use. Technical measures that provide positive nuclear controls include hardened communications systems, frequency diversity, mobile command posts, interference resistant communications, and environmental sensing devices for warhead arming.[8] An additional technical positive control measure is a fully automatic launch system, such as the Dead Hand ("Mertvaya Ruka") system explored but never deployed by the Soviet Union.[9] This type of automatic system, however, may be considered destabilizing as it removes the human decisionmaker from the response cycle and does not allow for a strategic pause if de-escalation is desired.

General Impressions on Strategic Stability and Negative and Positive Controls

Figure 2 provides a summary graphic of the general implications and trends associated with the procedural and technical measures of negative and positive control. As this overall analysis centers on the role of command and control within strategic stability, it is important to note that certain C^2 trends may bias a system toward use, but this bias does not predetermine actual use. From a strategic stability perspective, the maintenance of negative controls during peacetime, crisis, and conflict ensures that nuclear assets are only employed when properly authorized by the designated authority(s). In many cases, however, the procedural aspects of negative controls rely on the proper and disciplined execution of these measures by people within the command and control system. For this reason, Personnel Reliability Programs (PRPs)[10] are critical in established as well as emerging nuclear programs.

Figure 2 also underscores the critical procedural transition that can occur during a crisis when the negative control measures of having warheads disassembled and unmated with delivery vehicles change to positive control measures of fully assembled warheads being mated to delivery vehicles and deployed to the field. This "either-or" aspect of negative/positive controls poses significant risk for countries lacking mature technical negative controls as the decision to cross into positive procedural controls eliminates the primary negative controls provided by weapon disassembly.[11]

Figure 12. 2. Balancing the "Always-Never" Challenge



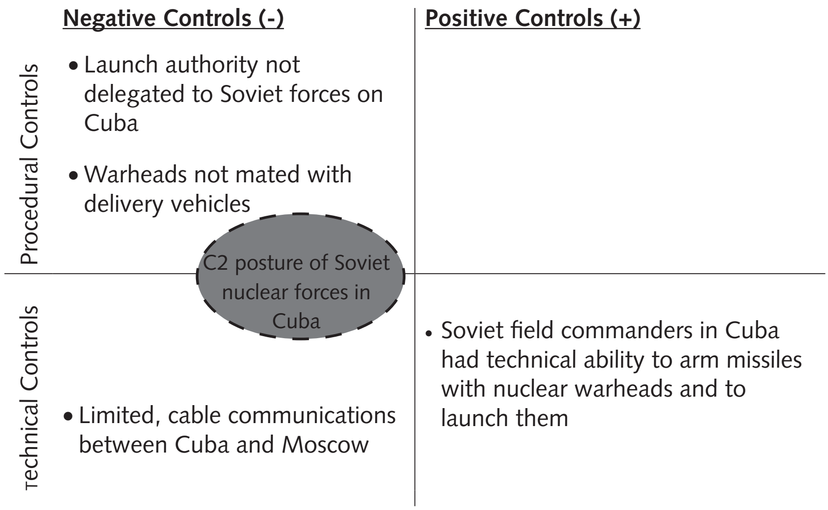
The role of technical approaches to negative and positive controls is perhaps the most significant and destabilizing aspect of C^2 disparity in the twenty-first century as new and emerging nuclear custodians rely heavily on procedural measures due to their limited expertise and financial resources for developing robust technological measures. Moreover, unlike positive procedural controls that foster a bias toward use, most positive technical controls (with the exception of fully automated launch systems) foster a bias toward non-use during crises. This is because the robustness and assurances provided by these technologies can allow adequate guarantees against the complete loss of nuclear forces and/or C^2 in the case of an adversary's first strike. In this respect, a balanced mix of positive technical controls and negative controls (both procedural and technical) and the limitation/avoidance of positive procedural controls can provide a sufficiently robust C^2 system to ensure a safe, secure, and reliable nuclear arsenal. Stated differently, the promotion of a C^2 posture that continuously maintains positive and negative controls within the left side and bottom right portion of Figure 2 will meet the requirements of the "always-never" challenge for a nuclear custodian while simultaneously assuring a credible deterrent to potential adversaries.

Cuba 1962: Historical Example of the Role of C^2 within the "Always-Never" Challenge

The Cuban missile crisis of October 1962 is the most cited case of the potential risks created when two nuclear nations enter into a crisis. Analysis of the Soviet records of this event show that heavy reliance on negative controls (primarily procedural) provided a sufficient C^2 bias toward non-use that the actual approach toward the nuclear brink was perhaps less precipitous than often cited. Central to this assertion is the fact that General Issa Pliyev, commander of Soviet forces in Cuba, did not have full authority to employ nuclear forces. In addition, procedural safeguards were enacted to ensure that the nuclear weapons on the island were stored separately from their delivery vehicles and required authorization directly from Moscow (instead of General Pliyev) to remove them from storage.[12] Figure 3 captures the resultant non-use bias created by these procedural negative controls.

As stated above, however, heavy reliance on procedural measures during a crisis places significant emphasis on the personnel within the C^2 structure and their ability (and willingness) to execute the orders of the national command authority. During the Cuban crisis, General Pliyev made repeated requests to Moscow to remove the warheads for the medium-range Frog missiles from storage. Though these requests were all denied, as commander of all Soviet forces on the island, he could theoretically have forced the officer in charge of the nuclear storage site to release the weapons to him, at which point General Pliyev had the technical capability to launch the nuclear-armed missiles without final authorization from Moscow. Due to the strict Soviet command structure, General Pliyev did not violate his orders from Moscow and the negative procedural controls remained intact. This potential loss of negative controls unnerved the Soviet leadership and as Mark Kramer recently observed, "After the Cuban missile crisis, however, the option of relying solely on the physical separation of warheads and delivery vehicles was deemed inadequate."[13]

Figure 12. 3: Cuba, 1962: Historical Example of C^2 System Bias Toward Non-Use



TWENTY-FIRST CENTURY NUCLEAR ACTORS AND THEIR C^2 POSTURES

Given the previous discussion on the key concepts and aspects of negative and positive controls, it is appropriate to explore these issues within the context of the international actors that currently possess or are pursuing nuclear capabilities. Though certain limitations exist on the availability and quality of open source data for some actors, sufficient information exists to identify trends and potential biases within their C^2 postures.

The P5 Nations

China, France, Russia, the United Kingdom, and the United States are all custodians of legacy nuclear capabilities and their associated command and control systems. In the sixteen years since the end of the Cold War, each nation has explored the future structure and posture of their strategic arsenals in the context of the changing global security environment.[14]

The specific design and construct of the Chinese nuclear command and control system is believed to be based on an assertive, centralized command structure with the Chairman of the Central Military Commission, currently President Jiang Zemin, as the national authority for nuclear use. For negative controls, China is believed to employ a "two man rule," as well as the separate storage of warheads and delivery vehicles. Positive technical controls include hardened command and control facilities, redundant, flexible and EMP-hardened communication networks, and the pursuit of new digital microwave communication systems for all weather and encrypted capabilities. China is not believed to employ permissive action link (PAL) technologies but maintains a sufficient land-based and sea-based ballistic missile capability to meet the survivability requirements of its minimal nuclear deterrent posture.[15]

France has recently placed considerable emphasis on the need to have a tailored deterrent that goes beyond its large, cold war posture of "deterrence by the weak of the strong."[16] This desire to develop flexibility through smaller, more accurate warheads on its submarine-launched ballistic missiles (SLBMs) is a departure from France's cold war policy of executing a complete sixteen-missile retaliatory response from its ballistic missile submarines[17] and will require enhanced communication procedures and C^2 planning. France also employs procedural negative controls such as the two-person rule, technical negative controls that include a locking system similar to PALs, and redundant, hardened command and control facilities. France's nuclear launch authority is expected to remain firmly centralized and under presidential control.[18]

Russia has a long history of utilizing a broad range of negative and positive controls for ensuring the safety, security and reliability of its nuclear deterrent. However, recent Russian emphasis on the development and deployment of new Project 955 Borey class submarines, Bulava SLBMs and Topol-M mobile ICBMs, and the 1999 abandonment of its no first use doctrine were seen by some observers as a shift toward a preemptive strike posture.[19] In response to these accusations, a leading Russian strategic analyst remarked that the development of survivable strategic systems, at a much greater cost than silo-based systems, represents a significant investment by Russia in an assured retaliatory strike capability. These investments in new delivery vehicles are also accompanied by the enhancement of certain aspects of the Russian command and control system.[20] Similar to the United States, however, Russia has significant negative control procedures, including the use of the two-person rule, employment of feedback loops that allow senior commands to monitor subordinate commands, electronic systems that allow higher echelons to remotely disable missile launchers, and the use of blocking devices to physically prevent unauthorized use of weapons.[21] From a C^2 perspective, therefore, these efforts to enhance the survivability of delivery vehicles and communications networks, coupled with a strong Russian/Soviet history of negative controls, promotes an overall Russian C^2 bias toward non-use under crisis conditions.[22]

The nuclear arsenal of the United Kingdom is centered on a sea-based nuclear deterrent with current discussions exploring the modernization of this single-legged capability. The warhead currently employed on the British Trident missile is similar to the U.S. W76 warhead and is presumed to have similar technical positive and negative control measures, since the Arming, Fusing and Firing System (AF&F) is reported to be designed by Sandia National Laboratory in the United States.[23] The United Kingdom has a centralized strategic release structure, with the prime minister maintaining launch authority. In addition, the United Kingdom relies heavily on procedural measures such as two-person rules, as well as authentication codes to prevent unauthorized nuclear use aboard its submarines.[24]

The United States employs many of the technical and procedural aspects of negative and positive controls discussed at the beginning of this chapter, including the two-person rule and use of PALs.[25] For negative controls within the U.S. SSBN fleet, a "Use Control" system was installed during the summer of 1997 that requires the receipt of an external code in order to unlock a critical component of the SSBN system (the Captain's Indicator Panel Key) which is stored in a safe onboard the submarine. Without this component, the system is unable to launch.[26] In 2001, the Department of Defense initiated an "End-to-End Review of the U.S. Nuclear Command and Control System." Though many of the findings from the review were classified, some of them included the need to enhance system survivability and hardness due to: degradation since the end of the cold war; a decline in the number of people who have expertise in nuclear command and control; challenges associated with incorporating a vertical, hierarchical C^2 structure with the new broad, dispersed mission space of U.S. Strategic Command; and the integration of nuclear and conventional capabilities within the new U.S. strategic triad.[27] A central challenge posed by this C^2 modernization is the maintenance of nuclear positive and negative controls if certain components and delivery vehicles of the nuclear system are simultaneously conducting conventional operations. This challenge is discussed below.

Though not a declared nuclear weapon state, Israel is believed to maintain up to 300 nuclear warheads of various types that can be delivered by aircraft, ballistic missiles, and potential artillery. Israel is also pursuing an assured second-strike capability through the acquisition of three Dolphin-class submarines from Germany. The authority to employ nuclear weapons rests with the Israeli prime minister and physical control of the weapons falls under the defense minister. For negative controls, Israel is believed to store its weapons disassembled, with the capability to rapidly assemble them and mate the warheads with their delivery vehicles.[28] Due to the opaque nature of its nuclear deterrent, further details about the technical control measures for Israeli nuclear weapons are not openly published.

Following the 1998 nuclear tests in India and Pakistan, both countries forfeited the luxury they previously had of not having to discuss their strategic command and control procedures. India released its draft nuclear doctrine in the summer of 1999 and began to discuss more openly some of the positive and negative controls that it was enacting. These included the creation of a Nuclear Command Authority (NCA), maintaining civilian control of nuclear weapons, the declaration of an NFU doctrine, keeping warheads unmated from delivery vehicles, keeping weapon components disassembled with separate custody organizations, and pursuing a retaliatory strike capability through hardened command bunkers and a sea-based leg of the deterrent.[29] Some concern remains, however, over the chain of succession in the case of the demise of the prime minister, the sole authority over nuclear use, as well as operational challenges for the military units who are tasked with nuclear employment responsibilities during war but unfamiliar with the weapons for training purposes. In certain circumstances, India is expected to pre-delegate nuclear authority to military leaders to ensure a retaliatory strike capability.[30]

Pakistan has also recently increased its public discourse on its nuclear command and control structure and processes. These include an announcement about separation of the authorities to use nuclear weapons from the authorities responsible for executing use,[31] establishment of an organization dedicated to weapon security, and not mating warheads with delivery vehicles. Unlike India, however, Pakistan retains the right to first use in its nuclear doctrine. In addition, Pakistan relies heavily on negative procedural controls that are slowly degraded during a crisis in favor of positive procedural controls (such as assembling warheads or mating warheads with delivery vehicles), thus creating a potential C^2 bias toward nuclear use.[32] The implications of this degradation are discussed below.

The final two nuclear actors to be explored in this chapter are North Korea and Iran. Due to the nascent and secretive nature of both programs, limited information is readily available through open sources about any negative and positive controls measures that may exist, though it is expected that both nations maintain a tight, centralized control over their limited nuclear stockpiles. On 9 October 2006, North Korea openly stated its nuclear intentions by conducting a nuclear test. The technical challenges apparently experienced during the test underscore the early stages of the North Korean program and the likelihood that any negative control measures currently in place will be primarily procedural, such as storing weapon components disassembled. North Korea is expected to rely initially on aircraft delivery for any nuclear devices it develops for operational purposes, with positive controls restricted to procedural measures related to the forward deployment of assembled weapons at airfields and possibly the mating of assembled weapons with the aircraft. In addition, the authoritarian nature of the North Korean regime raises concern over the chain of custody for nuclear devices if Kim Jong Il dies.[33] One U.S. expert who visited North Korea shortly after the October 2006 test remarked, "The officials we met appeared to have little appreciation for the new challenges they faced for nuclear weapons safety and security that results from the possession of nuclear weapons."[34]

Similar to North Korea's secrecy regarding its nuclear program, Iran continues to claim that its nuclear aspirations are strictly peaceful and serve no military purpose. Due to the lack of transparency, analysis of

Iranian nuclear C^2 is limited to the current understanding of civilian-military authorities within Iran and its previous command and control procedures for its chemical weapons program. Central to the development and potential deployment of Iranian nuclear capabilities is the role of the Islamic Revolutionary Guard Corp (IRCG). Iran maintains a dual military structure, with the regular armed forces responsible for the defense of Iran's territory and political integrity, while the IRGC is responsible for preserving the Islamic revolution. The IRGC is believed to be developing nuclear weapons through four military organizations in Iran and operates at a much higher strategic level than the regular armed forces. Due to the immaturity of Iran's nuclear program, safety and security procedures for the initial nuclear devices will primarily involve procedural measures such as the separation of warhead components for storage; but these procedural negative controls will be forfeited if warheads are assembled and mated to delivery vehicles during a crisis (i.e. a transition to procedural positive controls). In addition, it is possible that an internal security organization may be created to specifically ensure the security of Iran's nuclear weapons.[35]

C^2 STABILITY DYNAMICS IN THE TWENTY-FIRST CENTURY AND IMPLICATIONS FOR POLICY

The preceding discussion explores the stability dynamics associated with a variety of negative and positive nuclear control measures. This assessment highlights the potential stability provided by a non-use bias during a crisis when procedural negative controls (such as two-person rules, restricted access to launch codes, or a delayed response posture) are maintained simultaneously with technical negative controls incorporated in the weapon design and positive technical controls that ensure system robustness and survivability during combat operations. The brief overview of existing nuclear C^2 postures provided above highlights four key areas where existing command and control systems risk transitioning toward a use bias during a crisis:

1. Procedural chain of custody measures (negative controls) in Iran, North Korea, and Pakistan that potentially exist without complimentary negative technical controls;
7. South Asian security dynamics and the degradation of Pakistani negative control procedures during crisis escalation;

8. U.S.-Russian crisis management during conventional SLBM and BMD engagements against third party threats; and
9. Deliberate asymmetric threats against existing C^2 systems.

Though Iran and North Korea maintain a greater shroud of secrecy around their nuclear weapons programs than Pakistan, all three nations appear to rely on negative procedural controls and the associated personnel reliability procedures as the primary means of ensuring the safety and security of the nuclear capabilities. With its totalitarian organizational structure, North Korea may have adequate security for its nuclear devices as long as they remain in a non-deployed and disassembled status. The safety of North Korea's devices, however, is most likely lacking since technical measures such as one-point safety, weak links and electrical exclusion zones are probably inadequately incorporated in their weapon designs. For this reason, policy efforts should focus on not provoking any nuclear posturing from North Korea that may include the final assembly and potential deployment of their nuclear devices.

Iran poses a significant challenge in that its negative procedural controls appear inadequate if the forces transition into a deployed status. Even if they remain under the control of the authorized nuclear command structure, it would be the Islamic Revolutionary Guard Corps, which is the more bellicose branch of the Iranian armed forces. The end result is a challenge similar to North Korea in that external pressures may have limited ability to prevent the acquisition and development of nuclear weapons, but ill-considered external pressures may result in a deployed nuclear posture and a potential C^2 instability bias toward use.

Pakistan, a more advanced nuclear state than Iran and North Korea, can leverage the influence of external actors to assist in dampening regional crisis escalation involving India, which is the most likely reason for a Pakistani transition from negative to positive procedural controls. South Asian security dynamics highlight an Indian C^2 posture that is biased toward non-use and a Pakistani C^2 posture biased toward use.[36] The geography of the region provides India with sufficient strategic depth to assure some level of retaliatory strike capability, an advantage that simultaneously creates an almost immediate requirement for Pakistan to transition toward a use bias in order to present a credible deterrent. Pakistani confidence in the survivability of its nuclear deterrent can decrease the perceived need for positive procedural controls and reduce crisis instability and escalation. Potential bilateral measures that can contribute to a non-use bias during a crisis include the avoidance of counter-force targeting-- including C^2 networks and command posts—by conventional as well as nuclear forces, and the declaration of a no first use posture.[37] Overall, the criticality of C^2 stability in South Asia is captured well by one expert who noted, "A peacetime environment in the region will pay the dividend of keeping arsenals non-deployed and the safety and security coefficient will remain high. This situation would change, however, if regional strategic dynamics lead to formal nuclear deployments…"[38] Finally, Pakistan may be willing to receive information and assistance on negative technical controls as long as this level of cooperation does not threaten the security of its nuclear stockpile.[39] This type of assistance can provide safety during regional crises as well as scenarios involving theft of a device where negative procedural controls are insufficient.

U.S.-Russia

The ongoing transformation in U.S. and Russian strategic postures poses a unique challenge and has global implications. Though both countries have stated policies that they are no longer adversaries and do not target each other with strategic systems, the adaptation of legacy weapon systems and legacy command and control processes to address new and emerging threats can still place these two nations at strategic odds during a crisis. The pursuit of global strike and global missile defense capabilities by the United States significantly increases the need for transparency between the two countries, as misperceptions may result during the employment of conventionally armed ballistic missiles (especially submarine-launched) or interceptor flight paths that broach Russian airspace. The U.S. Congress identified some of these risks in the *National Defense Authorization Act for Fiscal Year 2007* in which Congress calls upon the Secretary of Defense to provide:

- a report on the capabilities of other countries to discriminate between the launch of a conventional or nuclear sea-launched ballistic missile;
- an assessment of the notification and other protocols that would have to be in place before using any conventional sea-launched ballistic missile and a plan for entering into such protocols; and
- a joint statement by the Secretary of Defense and the Secretary of State on how to ensure that the use of a conventional sea-launched

> ballistic missile will not result in an intentional, inadvertent, mistaken, or accidental reciprocal or responsive launch of a nuclear strike by any other country.[40]

Some of these concerns and requirements can be addressed through the execution of the June 2000 "Memorandum of Agreement Between the Government of the United States and Government of the Russian Federation on the Establishment of a Joint Center for the Exchange of Data from Early Warning Systems and Notifications of Missile Launches."[41] This agreement, commonly referred to as the Joint Data Exchange Center (JDEC), is held up by legal wrangling between the two countries over personal tax and liability issues for U.S. personnel working in the proposed Moscow-based center.[42]

Figure 12.4. C^2 Stability Dynamics and Policy Implications
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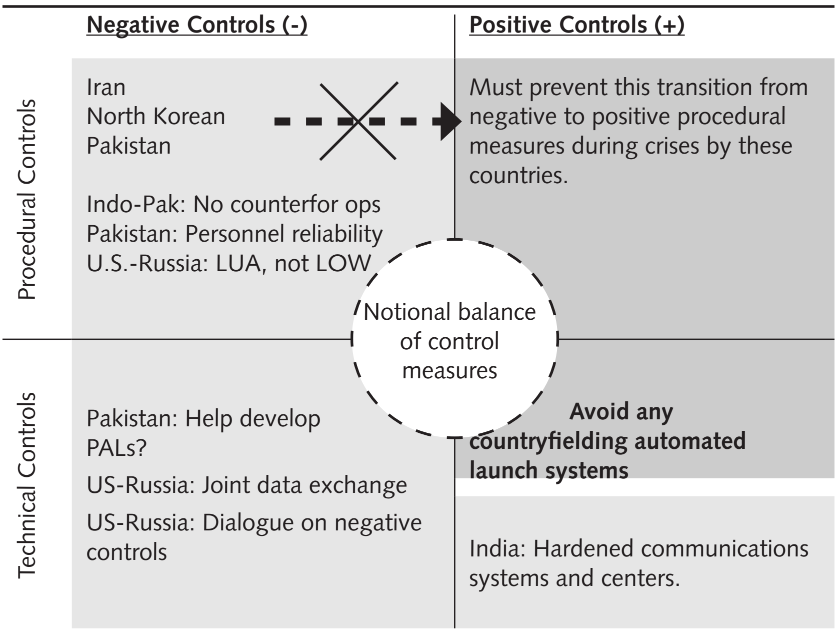

An additional bilateral concern involving the United States and Russia is their maintenance of launch on warning (LOW) postures despite their stated non-adversarial relationship. This perceived "hair trigger" environment was tested during the 25 January 1995 launch of a Norwegian sounding rocket from an island off the northwest coast of Norway, a general area for U.S. Trident submarine patrol routes.[43] A senior Russian general who served in the Strategic Rocket Forces (SRF) command center during the event asserts that the negative procedural controls in place adequately diffused the situation and Russian forces were never prepared for launch. The launch commands associated with the Russian strategic systems involve four stages:

- *preliminary command*—after the identification of a potential threat from EW systems;
- *permission command*—upon confirmation of a missile attack against Russia, preparation by the president, minister of defense and chief of the General Staff of authorization for nuclear use, and delegation of use to the three military commanders in chief;
- *direct command*—submission of launch commands with special unblocking code values and the number of the operational plan, to launch crews at the operational level; and
- *launch command*—the execution of the launch order by the missile crews.[44]

According to the Russian General, only the first level of launch command was initiated during the Norwegian incident as command center personnel recognized the launch as an anomaly and considered it very unlikely that the United States would engage Russia with a single submarine-launched ballistic missile (SLBM). American officials have also stated that their perception of the incident was that the Russian system "worked" and no launch authorization was issued over a misinterpreted threat.[45] Despite these assurances, however, experts from the Russian and American strategic communities agree on the need to enhance bilateral transparency in the areas of early warning and data exchange.

A final area for exploration in C^2 stability dynamics is the potential risks created by deliberate, asymmetric attacks against the command and control system of a nuclear nation in order to generate false warnings or unauthorized procedures. These attack profiles may involve the degradation of negative control procedures or the manipulation of positive control procedures and center on taking remote control of command systems rather than physical control of the actual nuclear weapons. In the investigations following the September 11 attacks in the United States, intelligence officials discovered that one of the plots discussed in an Al Qaeda training camp was the hijacking of a Russian ICBM launcher and forcing the crew to launch their missile against the United States.[46] Though much more technically challenging (if not impossible), this asymmetric attack profile represents a scenario that merits further consideration and consultation: the intentional manipulation of nuclear command and control procedures in order to execute nuclear release.[47] Of particular concern is the assurance that negative control procedures are adequately robust from a security perspective (and safety perspective) to prevent all possible avenues for initiating nuclear release. Moreover, the joint exploration of negative controls can be conducted without posing a risk to the positive control measures or degrading the efficacy of the negative controls.[48] Finally, joint discussions on negative controls can also cover potential insider threats emerging from underpaid nuclear scientists and military personnel serving in nuclear duties, a cause of concern in the West.[49] This chapter highlights the role of nuclear command and control systems in promoting strategic stability during a crisis. The previous discussion underscores the importance of promoting a non-use bias through sustained procedural and technical negative controls and assured system robustness and survivability through positive technical control measures. The end result of this balanced mix of control measures is that command and control systems are sufficiently safe, secure, and reliable during the transition from peace to crisis, and into wartime, that nuclear use never occurs as a result of unauthorized or accidental events, and that nuclear authorization is less likely to occur as a result of the fog of war.

Notes

1. This chapter uses the term "command and control" to represent all aspects of the system developed by a state to conduct its nuclear operations and provide safety, security and reliability to its arsenal. Included in this discussion are the communication processes that are part of the command and control system but not the supporting intelligence capabilities. As such, this discussion of nuclear command and control also explores the topic of nuclear command, control, and communications (C3) but not command, control, communications, and intelligence (C3I).

2. "U.S. Nuclear Command and Control System Support Staff," Department of Defense Directive 3150.06 (dated August 25, 2006). Available online: www.fas.org/irp/doddir/dod/d3150_06.pdf.

3. Ibid, page 2.

4. See for example John D. Steinbruner, "Choices and Trade-offs" in Ashton B. Carter, John D. Steinbruner, and Charles A. Zraket, *Managing Nuclear Operations* (Washington, D.C, Brookings Institution, 1987): 539-541; and Bruce G.

Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Washington, D.C, Brookings Institution, 1985): 68-69. It should be noted that positive controls are different from "positive measures" which the U.S. Department of Defense defines as "design features, safety rules, procedures, accident prevention or mitigation measures, or other controls including physical security and coded systems, used collectively or individually, to enhance safety and to reduce the likelihood, severity, or consequences of an accident, unauthorized act, or deliberate threat." Source: DOD 3150.2-M, *DOD Nuclear Weapon System Safety Program Manual* (December 1996).

5. The six functions are based on a list provided in Valery E. Yarynich, *C3: Nuclear Command, Control Cooperation* (Washington, DC: Center for Defense Information, 2003): 17.

6. Inadvertent escalation refers to scenarios where conventional operations may result in the unintended targeting of an adversary's strategic assets and the potential triggering of a nuclear response by the adversary who perceives the conventional strike as a decapitation or counter-force attack. This type of scenario is commonly mentioned in the need for escalation control in South Asia. On "inadvertent escalation," see Barry R. Posen, "Inadvertent Nuclear War? Escalation and NATO's Northern Flank," *International Security* Vol. 7, No. 2 (Fall 1982): 28-54. For a theoretical discussion on inadvertent escalation in South Asia, see Rajesh Rajagopalan, "The Threat of Unintended Use of Nuclear Weapons in South Asia," *India Review* Vol. 4, No. 2 (April 2005): 214-232. Concerning the limited time available for executing strategic decisions, Dr. Zbigniew Brzezinski has stated his training indicated he had "roughly three minutes in which to verify the nature of the attack and its scale, which would involve several progressive steps. The President, once I reached him, would have four minutes to decide how to respond depending on the scale of the attack. Then the execution would be set in motion." The Atlantic Council of the United States, Christopher J. Makins Lecture given by Dr. Zbigniew Brzezinski on 31 May 2006 at the British Ambassador's Residence in Washington, DC (transcript page 3). Former Soviet President Mikhail Gorbachev stated in a 14 July 2006 interview on radio station Echo in Moscow that when conducting exercises to simulate a strategic attack from China, "they suddenly report to me that missiles are flying from a certain direction, I give a command, I receive proposals [for action], I give my agreement…and it all takes 10-15 minutes…" Available in Russian at: http://www.echo.msk.ru/programs/razvorot/44851/index.phtml (Translation provided by Dr. Mikhail Tsypkin). The September 11, 2001 attacks in the United States highlight, however, that unplanned, real-time communications cannot always be achieved for national leaders. President Bush was unable to conduct critical communications with key strategic advisors in the White House while he was onboard Air Force One. Kimberly Weisul, "How Air Force

One Let Bush Down," *Business Week* (4 November 2002). Available online: http://www.businessweek.com/magazine/content/02_44/c3806015.htm

7. Further discussion on the operational risks associated with no first use (NFU), launch under attack (LUA), and launch on warning (LOW) postures are discussed in the final section of this chapter.

8. For a detailed discussion on the technical aspects of positive and negative nuclear controls, see Chuck Hansen, *The Swords of Armageddon: U.S. Nuclear Weapons Development Since 1945*, Volume VIII (1995); Donald R. Cotter, "Peacetime Operations: Safety and Security," in Ashton B. Carter, John D. Steinbruner, and Charles A. Zraket, *Managing Nuclear Operations* (Washington, D.C, Brookings Institution, 1987): 42-55; and Chris Burroughs, "Tiny 'Micro Guardian' Promises to Safeguard Nuclear Weapons in Big Way, *Sandia Lab News* Vol. 51, No. 1 (15 January 1999).

9. Some confusion exists over whether the Soviet Union ever fielded Dead Hand and the misidentification of this system with the Soviet Perimetr system. A recently declassified top secret memorandum drafted in 1985 for the Soviet Politburo by Oleg Belyakov (titled "On Shortcomings in the Organization for Work to Increase the Effectiveness of Strategic Armaments") states that "no attention at all has been given to an extremely important military-political proposal to create a fully automated system for retaliatory strike operations that could be activated by the highest command levels during a threatening period." The implications of this memorandum and the known Soviet emphasis on centralized, assertive control seem to indicate that Dead Hand never went beyond the proposal stage. Correspondence with Mark Kramer, 1 March 2007. For a discussion on the Perimetr system that employs rocket-borne transponders to communicate launch orders to Russian ICBM crews when landlines are severed, see Valery E. Yarynich, 156-159. Perimetr concepts appear to mirror those of the U.S. Emergency Rocket Communication System (ERCS).

10. Personnel Reliability Program refers to the screening of military and civilian personnel before they are assigned to nuclear duty positions. Nuclear duty positions are generally divided into two categories: a critical nuclear duty position (where the person has served in a command and control position, has technical knowledge of the system, or has access to nuclear weapons under the two-person rule), or a controlled nuclear duty position (where the person has access to nuclear weapons but does not require technical knowledge). Critical nuclear duty positions include personnel who perform maintenance and/or modifications on nuclear weapons or serve in critical command and control positions such as PAL teams, delivery and warhead support units, or emergency action message authentication and employment responsibilities. Controlled nuclear duty positions include personnel who handle nuclear weapons, such as vehicle, equipment and aircraft operators, and members of nuclear weap-

on storage site security forces. See Donald R. Cotter, "Peacetime Operations: Safety and Security," 60-61; and "DODD 5210.42 Nuclear Weapon Personnel Reliability Program (PRP)" (15 December 1995). Available at: www.fas.org/nuke/guide/usa/doctrine/dod/dodd-5210_42.htm

11. This point is explored in the final section during the discussion on South Asian stability dynamics.

12. Soviet operational procedures in the early 1960s specifically required that theater commanders receive approval prior to using tactical nuclear weapons in a war. General Anatolii Gribkov, whose comments at a U.S.-Russian meeting in Havana in 1992 initiated some of the rumors about Soviet delegation of launch authority to General Pliyev, later retracted his comments to state Pliyev "was *categorically forbidden* to use nuclear weapons of any type" during the Cuban crisis. Quoted in Mark Kramer, "Tactical Nuclear Weapons, Soviet Command Authority, and the Cuban Missile Crisis." Colonel Nikolai Beloborodov, who commanded the storage site for the Soviet nuclear weapons in Cuba, stated in an interview, "No nuclear munitions of any type, whether for the medium-range or the tactical weapons, were ever moved out of storage during the crisis. Nor could they have been moved without my knowledge." Quoted in Mark Kramer, "'Lessons' of the Cuban Missile Crisis," page 353, footnote 17.

13. Mark Kramer, "'Lessons' of the Cuban Missile Crisis for Warsaw Pact Operations," Cold War International History Project Bulletin: 352.

14. As the space constraints of this chapter do not allow for a detailed discussion on the warheads and delivery vehicles employed by each of the nuclear actors, this section focuses on general trends as they impact command and control requirements.

15. "Command and Control—China Nuclear Forces." Federation of American Scientists. Available at: http://www.fas.org. While trying to improve its strategic communications capabilities, China has openly admitted that the Second Artillery Corps continues to be challenged when conducting field exercises. See Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie, *Chinese Nuclear Forces and U.S. Nuclear War Planning*. Federation of American Scientists & The Natural Resources Defense Council (Washington, DC, November 2006): 47-52.

16. David S. Yost, "France's Evolving Nuclear Strategy," *Survival* Vol. 47, No. 3 (Autumn 2005): 122.

17. David Yost, "France's New Nuclear Doctrine," *International Affairs* Vol. 82, No. 4 (2006): 704. Dr. Yost also highlights French discussions on possibly reducing the yield of existing weapons to only a detonation of the "primary" warhead stage ("amorce") thus reducing collateral damage. See also Bruno Tertrais, "Nuclear Policy: France Stands Alone," *Bulletin of the Atomic Scientists*

(July/August 2004): 48-55.

18. David Yost, "France's New Nuclear Doctrine," Bruno Tertrais, "Nuclear Policy: France Stands Alone," as well as a discussion on French nuclear command and control in Gurmeet Kanwal, "Command and Control of Nuclear Weapons in India," S*trategic Analysis* Vol. 13, No. 10).

19. Mark Schneider, "The Nuclear Forces and Doctrine of the Russian Federation." A Publication of the United States Nuclear Strategy Forum (Washington, DC, National Institute Press, 2006).

20. Vladimir Dvorkin, "On Strategic Relations between Russia and the U.S.: An Analysis of Mark Schneider's paper titled 'The Nuclear Forces and Doctrine of the Russian Federation,'" (September 2006). General Dvorkin also observed that the Russian abandonment of its no first use doctrine mirrored the postures of France, Great Britain and the United States (Dvorkin, 13-18).

21. Valery Yarynich, 206-209.

22. The final section of this chapter includes a more detailed discussion of Russian procedural negative controls in the context of the January 1995 launch of a Norwegian sounding rocket and Russian response to this event.

23. Paul Robinson of Sandia National Laboratory is reported to have stated in 1994 that "Sandia also designs the arming-fusing-firing mechanisms for the British nuclear weapons programme." Included in these design features would be two strong links and one weak link component. See John Ainslie, "The Future of the British Bomb," WMD Awareness Programme (Glasgow, UK, Clydeside Press, 19 October 2006).

24. Robert S. Norris and Hans M. Kristensen, "British Nuclear Forces, 2005," *Bulletin of the Atomic Scientists* Vol. 61, No. 6 (November/December 2005): 77-79.

25. An extensive discussion of U.S. command and control procedures and technologies can be found in Bruce G. Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Washington, DC: Brookings Institution, 1985); Ashton B. Carter, John D. Steinbruner, and Charles A. Zraket, *Managing Nuclear Operations*; and Valery E. Yarynich, *C3: Nuclear Command, Control Cooperation.*

26. Mel Lyman, "Crimson Tide: They Got It All Wrong," *The Submarine Review* (April 1999).

27. Robert D. Critchlow, "Nuclear Command and Control: Current Programs and Issues," CRS Report to Congress (3 May 2006).

28. Seth Elan et al, "Open-Source Research on Nuclear Doctrine and Strategy, Command and Control, and Delivery Systems in Iran and Israel," Library of Congress (December 2005). "Israel Nuclear Overview." Center for Nonpro-

liferation Studies (September 2004). Available at: www.nti.org; and Warner D. Farr, "The Third Temple's Holy of Holies: Israel's Nuclear Weapons," The Counterproliferation Papers, Future Warfare Series No. 2 (Maxwell Air Force Base, Alabama, September 1999).

29. Ashley J. Tellis, "Toward a 'Force-in-Being': The Logic, Structure, and Utility of India's Emerging Nuclear Posture"; Feroz Hassan Khan, "Nuclear Command-and-Control in South Asia during Peace, Crisis and War," *Contemporary South Asia* Vol. 14, No. 2 (June 2005): 163-174; Peter R. Lavoy and Christopher Clary, "Strategic Stability in South Asia: Conference Summary," (29 June–1 July 2004), available at: http://www.ccc.nps.navy.mil/events/recent/jul04southasia.pdf; and Harsh V. Pant, "India's Nuclear doctrine and Command Structure: Implications for India and the World," *Comparative Strategy* Vol. 24 (2005): 277-293.

30. Peter R. Lavoy and Christopher Clary, "Strategic Stability in South Asia: Conference Summary."

31. Though some observers believe key people in Pakistan have both use and execution authorities.

32. Feroz Hassan Khan, "Nuclear Command-and-Control in South Asia during Peace, Crisis and War" and Peter R. Lavoy and Christopher Clary, "Strategic Stability in South Asia: Conference Summary."

33. Robert S. Norris and Hans M. Kristensen, "North Korea's Nuclear Program, 2005," *Bulletin of Atomic Scientists* (May/June 2005): 64-67.

34. Siegfried S. Hecker, "Report on North Korean Nuclear Program," Center for International Security and Cooperation, Stanford University (15 November 2006). Available at: www.fas.org.

35. Gregory F. Giles, "The Islamic Republic of Iran and Nuclear, Biological, and Chemical Weapons," in Peter R. Lavoy, Scott D. Sagan, and James J. Wirtz, eds., *Planning the Unthinkable. How New Powers Will Use Nuclear, Biological, and Chemical Weapons* (Ithaca: Cornell University Press, 2000): 79–103; Seth Elan et al, "Open-Source Research on Nuclear Doctrine and Strategy, Command and Control, and Delivery Systems in Iran and Israel;" and Jack Boureston and Charles D. Ferguson, "Schooling Iran's Atom Squad," *Bulletin of the Atomic Scientists* (May/June 2004): 31-35.

36. Peter R. Lavoy and Christopher Clary, "Strategic Stability in South Asia: Conference Summary."

37. Though India already has a no first use policy and is believed to have a counter-value targeting strategy, the inability to verify/enforce these policies makes it difficult for Pakistani officials to be comfortable accepting these Indian declarations at face value. For conventional operations, India can avoid offensive actions against known weapon and vehicle storage sites and known

command and control networks and posts.

38. Feroz Hassan Khan, "Nuclear Command-and-Control in South Asia during Peace, Crisis and War," *Contemporary South Asia* Vol. 14, No. 2 (June 2005): 170-171.

39. The sharing of PAL technology and other negative controls is viewed by many observers as a violation of the nuclear non-proliferation treaty (NPT) since it would be a de facto acceptance of Pakistan as a nuclear weapons state. Similar discussions surround the sharing of civilian nuclear energy technologies with India by the United States. From a policy perspective, therefore, the crux of the issue is that negative controls prevent unauthorized use but can be perceived as enhancing Pakistani nuclear capabilities and increase the risks they might be able to take during a crisis. From a nuclear safety and security perspective, however, negative controls can also prevent the use of a nuclear device due to theft or diversion by an insider.

40. Section 219, paragraph b (5), (6) and (14).

41. "Agreement on the Establishment of a Joint Warning Center for the Exchange of Information on Missile Launches and Early Warning." White House Fact Sheet, Office of the Press Secretary (4 June 2000).

42. Wade Boese, "Joint Data Exchange Center on Hold," *Arms Control Today* (June 2006). Available at http://www.armscontrol.org/act/2006_06/CartwrightInterview.asp#Sidebar

43. Pavel Podvig, "If It's Broke, Don't Fix It," *Bulletin of the American Scientists* (July/August 2005): 21-22. Despite some reporting, this launch of a Black Brant XII was not an unannounced event but part of a series of three rocket launches scheduled for the period of 15 January–10 February 1995 from the Andoya Rocket Range. See "Royal Ministry of Foreign Affairs (Oslo) letter to The Heads of Mission," Number 21776/VII/94 (dated 21 December 1994).

44. Valery E. Yarynich: 152-153.

45. Interview with Russian and American officials directly involved in the incident (July 2002).

46. Faye Bowers and Peter Grier, "9/11 Panel Details Plots of Al Qaeda," *Christian Science Monitor* (17 June 2004).

47. Valery E. Yarynich, "The Ultimate Terrorism," *Washington Post* (30 April 2004): A29.

48. For an extensive discussion on this topic, see Valery E. Yarynich, *C3: Nuclear Command, Control Cooperation.*

49. There was a highly publicized incident in September 1998 in which a sailor killed a guard and seven crew members aboard an Akula-class SSN at the Northern Fleet's Gadzhiyevo Base and then attempted to detonate the subma-

rine's torpedoes (resulting in his own death). Western experts often cite this as an example of potential vulnerabilities created by poor living conditions and low pay for Russian service members. See James Clay Moltz and Tamara C. Robinson, "Dismantling Russia's Nuclear Subs: New Challenges to Non-proliferation," *Arms Control Today* (June 1999). For a discussion on Russian efforts concerning nuclear security, see Yevgeny Maslin, "Security of Nuclear Arsenals in the Russian Federation," *Yaderny Kontrol Digest* Vol. 9, No. 3-4 (Summer/Fall 2004): 6-13; and Vladimir Verkhovtsev, "Nuclear Weapons Security—Russia's Top Priority in the Long Term," *Yaderny Kontrol Digest* Vol. 10, No. 1-2 (Winter/Spring 2005): 38-45.