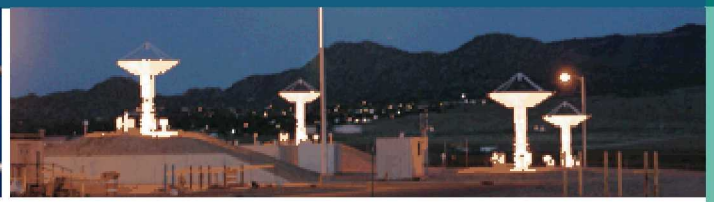
SAND2019-15133PE

Deterrence, Modeling, and Gaming



PRESENTED BY

Jason C. Reinhardt & Kiran Lakkaraju

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Agenda

Overview and History of Deterrence

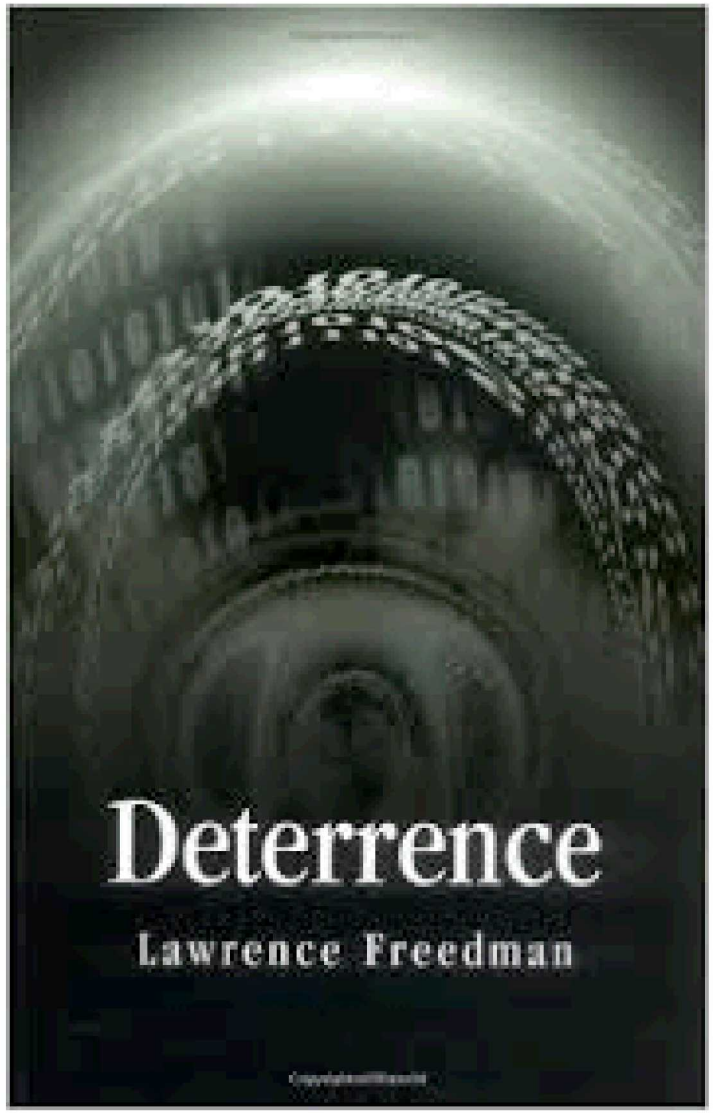
Advanced Modeling Approaches for Modern Deterrence Problems

Gaming Methods for Deterrence Conflict Research

If you can only read one book…

"Deterrence is a coercive strategy… the potential or actual application of force to influence the actions of a voluntary agent."

– Lawrence Freedman
Deterrence
Policy Press, 2004, 130pp



But, for gosh sakes, read more than one book!

Common Distinctions of Deterrence

See Freedman for more information

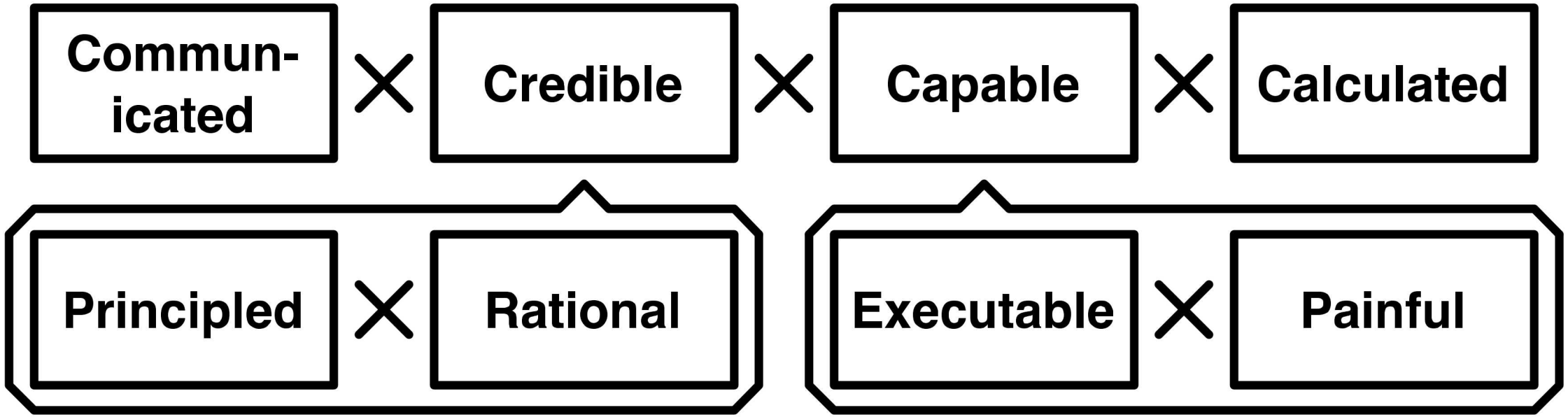
Deterrence	Compellence
Threatening a response to prevent someone taking a proscribed action	Threating an action to cause someone to change a course already taken (start or stop acting)

Central	Extended
Deterring (superpower nuclear) conflict	Deterring aggression toward a(n) (non-nuclear) ally

Immediate	General
Deterrence in times of crisis and high tensions, working to avoid escalation	Deterrence in times of relative peace, maintaining status quo

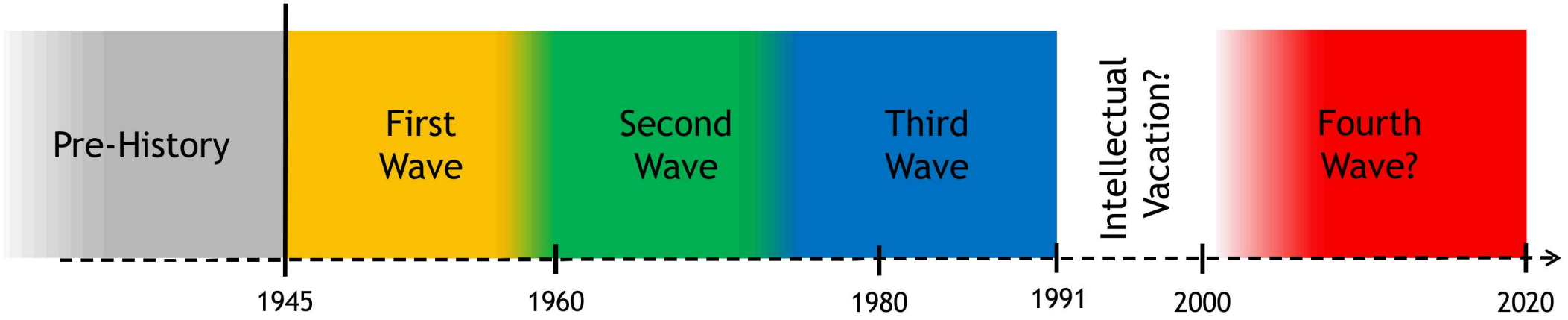
Punishment	Denial
Deterrence purely through threat of imposed costs	Deterrence through removing an opponent's strategic options, or increasing costs of action

A Framework for Deterrence Effectiveness



Communicated	The protagonist must issue a counter-threat, and the antagonist must receive, and understand that threat.
Credible	The counter-threat must align with the protagonist's principles, and must be rational to carry out.
Capable	The protagonist must be able to execute counter-threat, and it must inflict pain on the antagonist if executed.
Calculated	The antagonist must consider the counter-threat and its implications when choosing a course of action.

Deterrence Theory and History Comes in Waves.

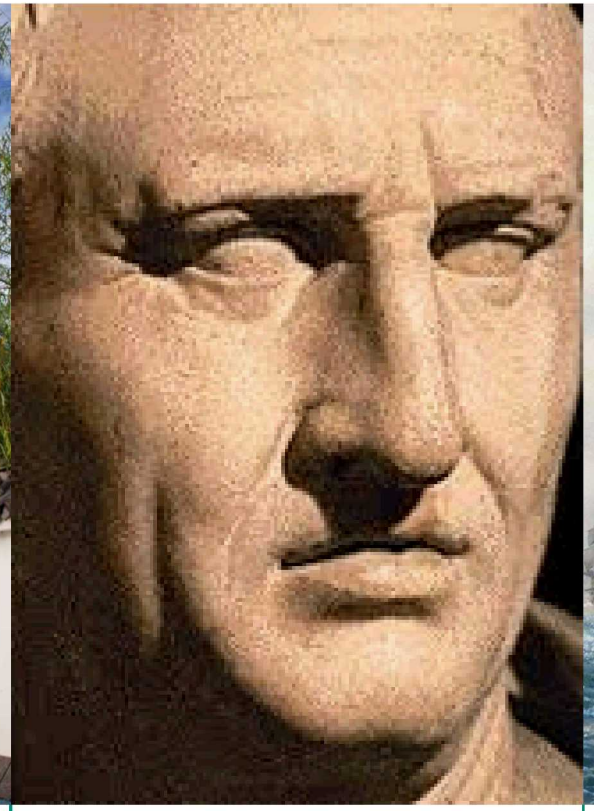


See:

- Quester, *Deterrence Before Hiroshima* (1966)
- Jervis, "Review: Deterrence Theory Revisited" (1979)
- Lupovici, "An Emerging Fourth Wave of Deterrence Theory" (2010)

Deterrence and coercion concepts are as old as conflict.

"The supreme art of war is subdue the enemy without fighting."
– Sun Tzu, 6th Century BCE



"Si vis pacem, para bellum"

– Publius Flavius Vegetius Renatus, 6th Century BCE

The naval threat to U.S. port cities in 19th century served as a backstop against British fears of a U.S. invasion on Canada.

Late Pre-history
Offensive strategic bombing changed the game.

Japanese bombing over China, 1937

Bombing of Barcelona, 1938

"I think it is well also for the man in the street to realise that there is no power on earth that can protect him from being bombed. Whatever people may tell him, the bomber will always get through; the only defence is in offence..."

- Stanley Baldwin, 1932

Deterrence pre-history set the intellectual stage for strategists.

Military strategists long understood the basic issues of strategic interaction in conflict

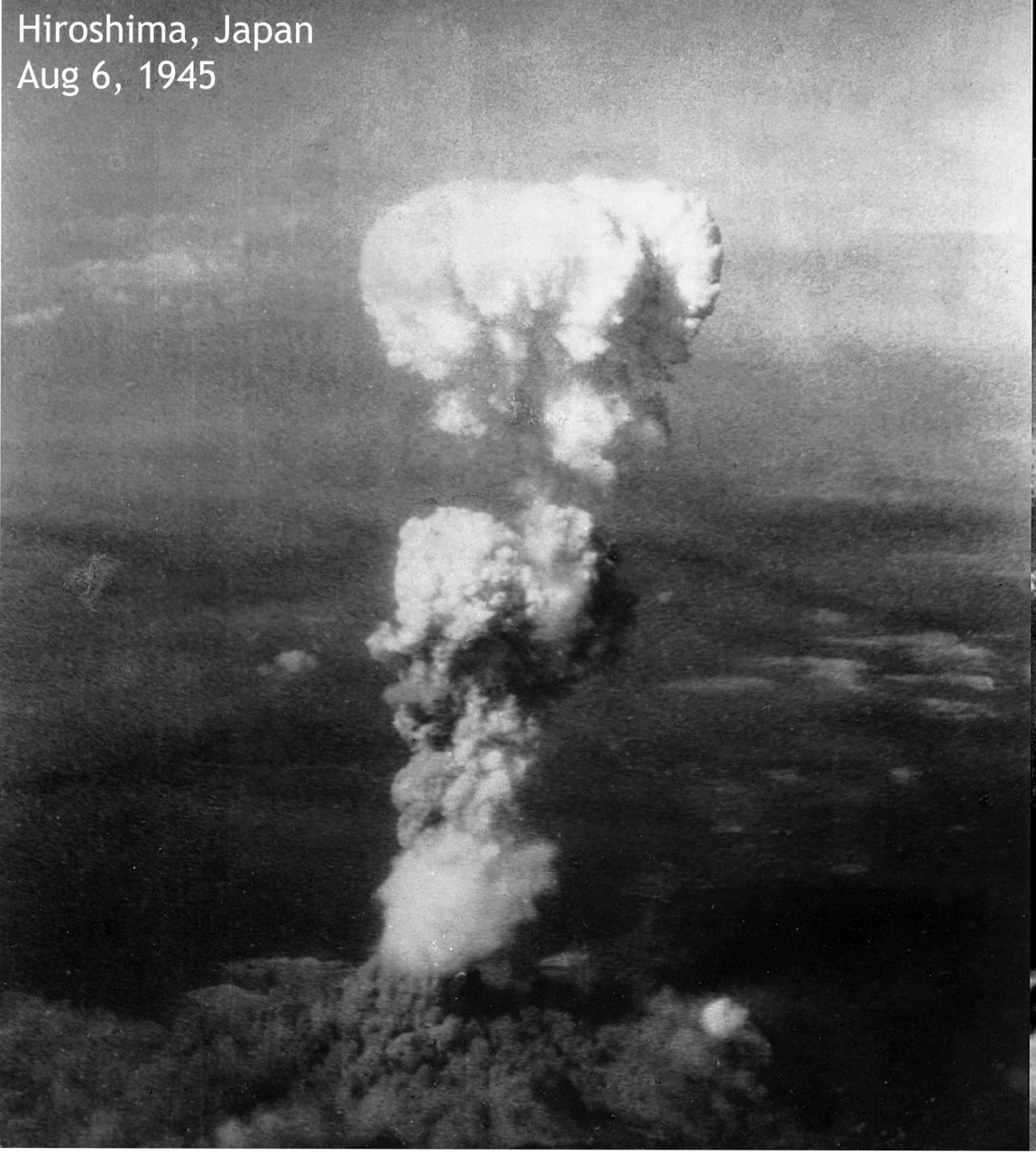
Offensive strategic bombing brought consequences away from the frontlines and to home territory and was thought sufficient to deter aggression

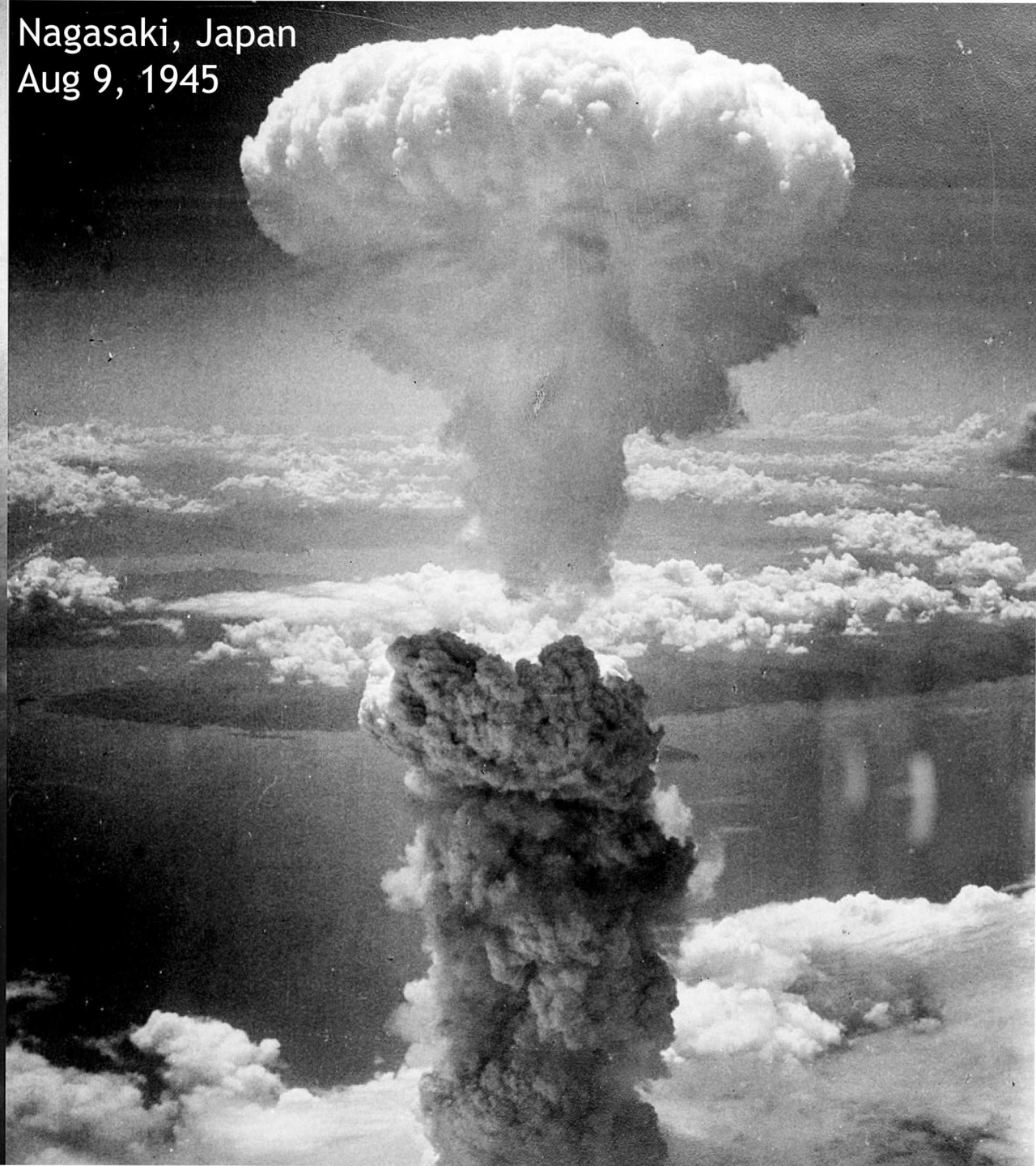
- e.g., Britain in dealing with Germany in the 1930s*

Strategic decisions about conflict were still primarily viewed as issues of comparative firepower and attrition

German V2 Rocket, WWII

*It's important to note that cross-domain (economic) factors also played a role here.


Hiroshima, Japan
Aug 6, 1945

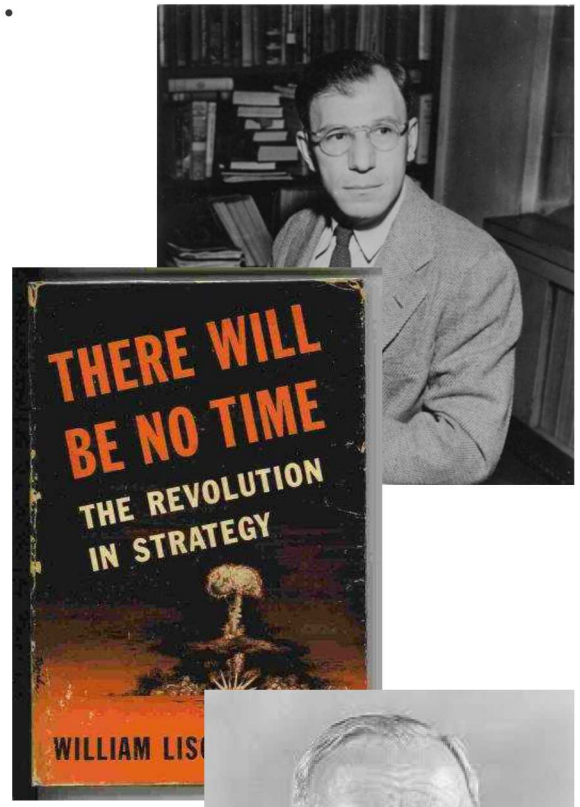

Nagasaki, Japan
Aug 9, 1945

First Wave Theory (1945 to Late 1950s)

We know things are different, we just don't know how do deal with it…

"…to speak of it as just another weapon was highly misleading. It was a revolutionary development which altered the basic character of war itself…Thus far the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them."

B. Brodie, 1946



"We must think unthinkable thoughts and do unthinkable deeds and our enemies are preparing to do worse to us."
Nuclear war is tactical, not strategic, can be won, arms races will happen, incentives for pre-emptive strikes are high.

W.L. Borden, 1946

"You have got to understand that this isn't a military weapon. It is used to wipe out women and children and unarmed peopled, and not for military uses. So we have got to treat this differently from rifles and cannons and ordinary things like that."

H.S. Truman, July 1948

The Outcomes of First Wave Theory

Early NW abolition movements (e.g., Acheson-Lilianthal) failed for the same reasons most subsequent attempts did: no one wants to be the first one to put the gun down

Most decisions about capability investments were being made through the lens of pre-WWII military strategy (what one might call *balance sheet approaches* – see the Gaither Report 1957, for example)

U.S. Doctrine: Massive Retaliation

Deter aggression "primarily [with] a great capacity to retaliate instantly by means and at places of our own choosing." - John Foster Dulles

"…blow the hell out of them in a hurry if they start anything."- Dwight D. Eisenhower

Second Wave Theory (Late 1950s to 1970s)

Let's build some tools to help us think about this problem…

Structural Theory

- Argues for "balance of power" and "preponderance of power" theories
- Major conclusions
  - Symmetric, quantitative arms races can help to prevent wars
  - Asymmetric, quantitative arms races incentivize first strikes and pre-emptive war
  - Effective defenses make war more likely
  - Selective proliferation of nuclear weapons can prevent war and promote peace
  - If everything is in balance, we need only fear "accidental" war

Decision Theory

- Assumes a preference order over outcomes (& generally that conflict is the worst for both sides)
- Extends the conclusions of structural theory with tactical bargaining recommendations
- Implicitly adopts many assumptions of structural theory
- Works to identify equilibria conditions and argues about policies that support or detract for those

Second Wave Theory (Late 1950s to 1970s)

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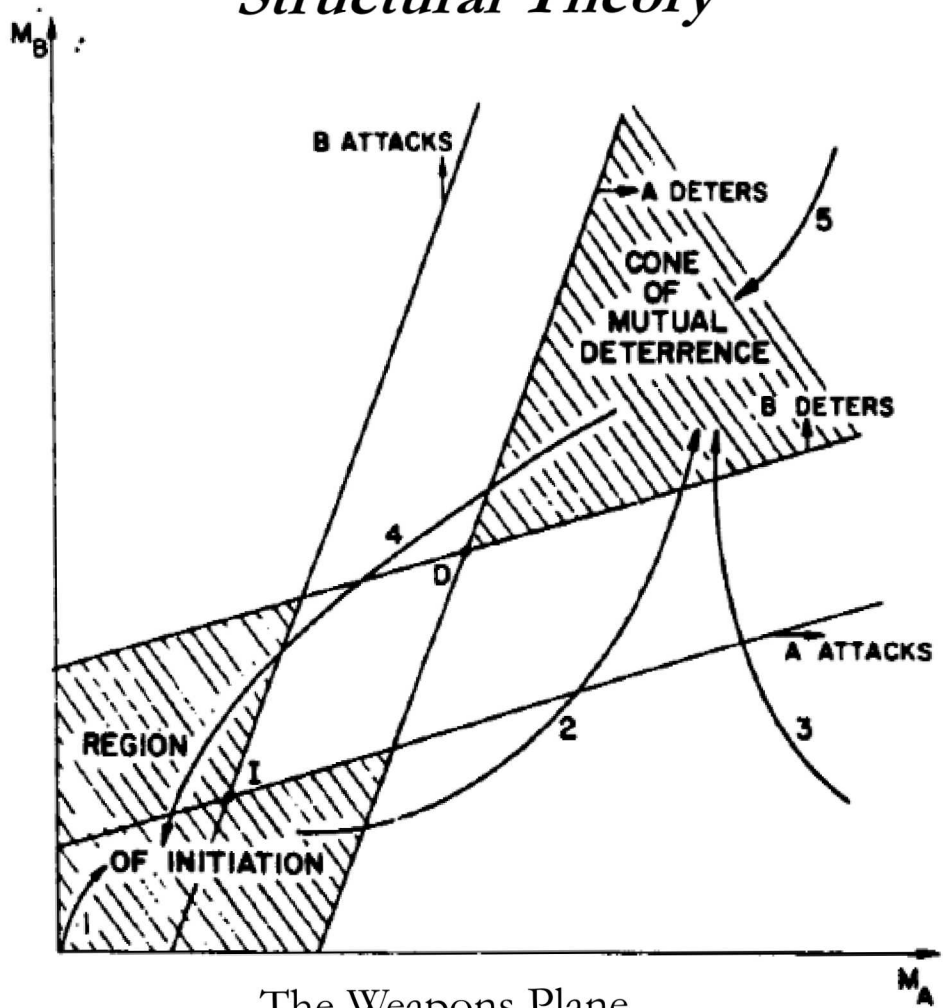


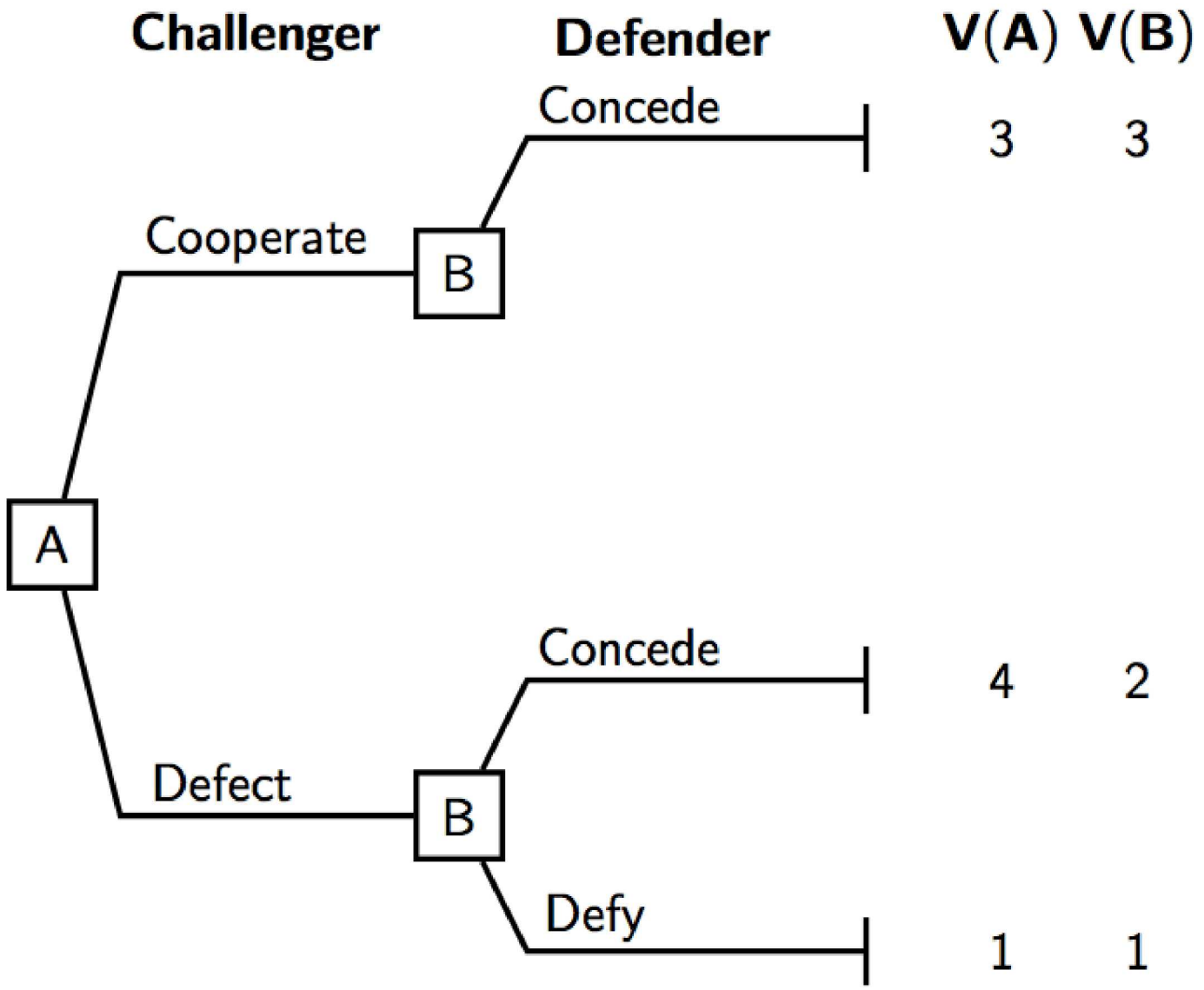
The Weapons Plane
Intriligator and Brito, 1984

Decision Theory

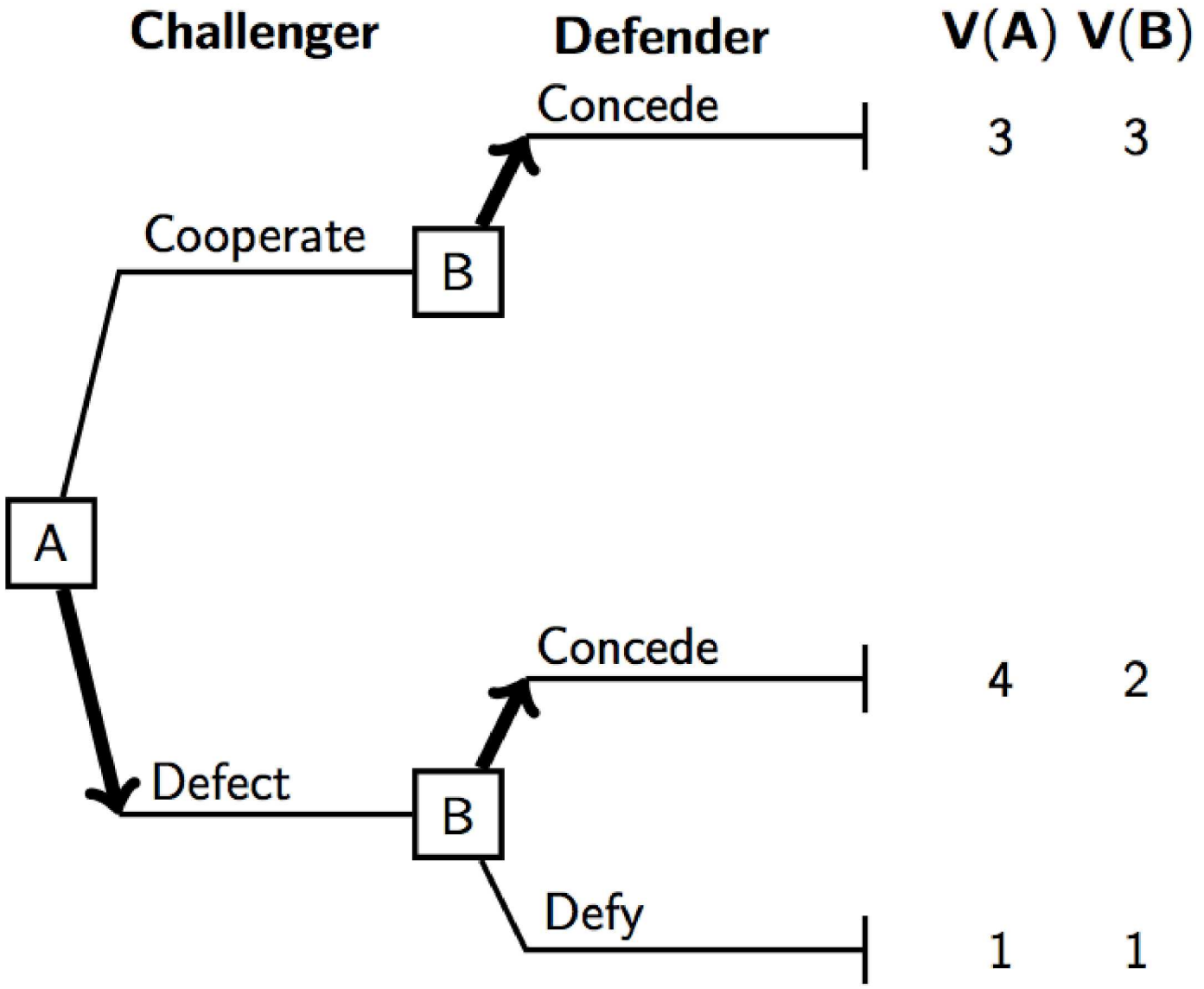
	Attack	Do Not Attack
Attack	(1,1)	***(4,2)***
Do Not Attack	***(2,4)***	(3,3)

Deterrence (Chicken) Game

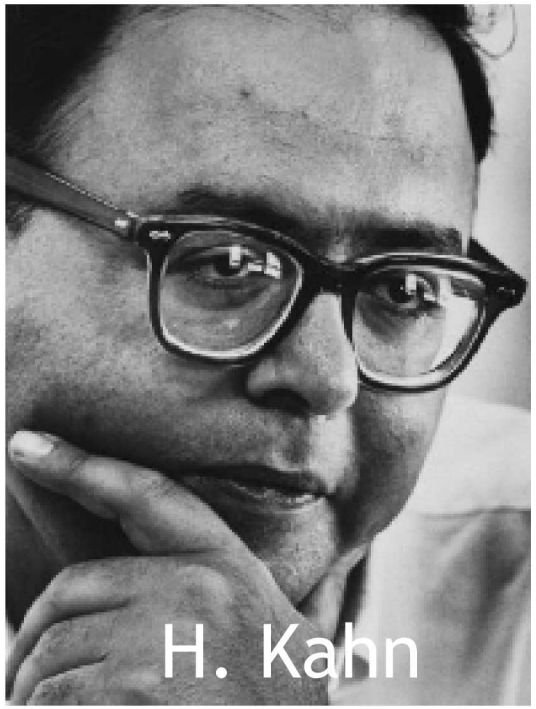
Paradox of Mutual Deterrence



Paradox of Mutual Deterrence: Solved?



1960s: Two Competing Solutions

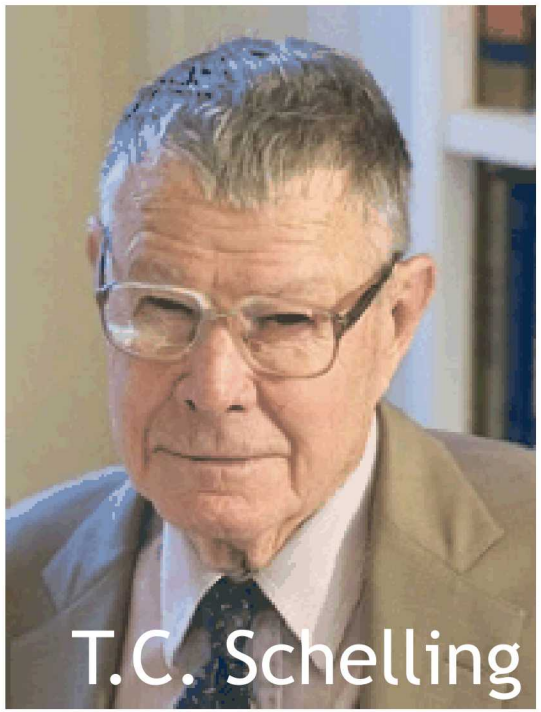


Irrevocable Commitments

Demonstrable Capabilities

Robust Defenses

Controlled Escalation



Constructive Uncertainty

Retaliatory Threats

Bargaining in Violence

Rational Risk Taking

The Outcomes of Second Wave Theory

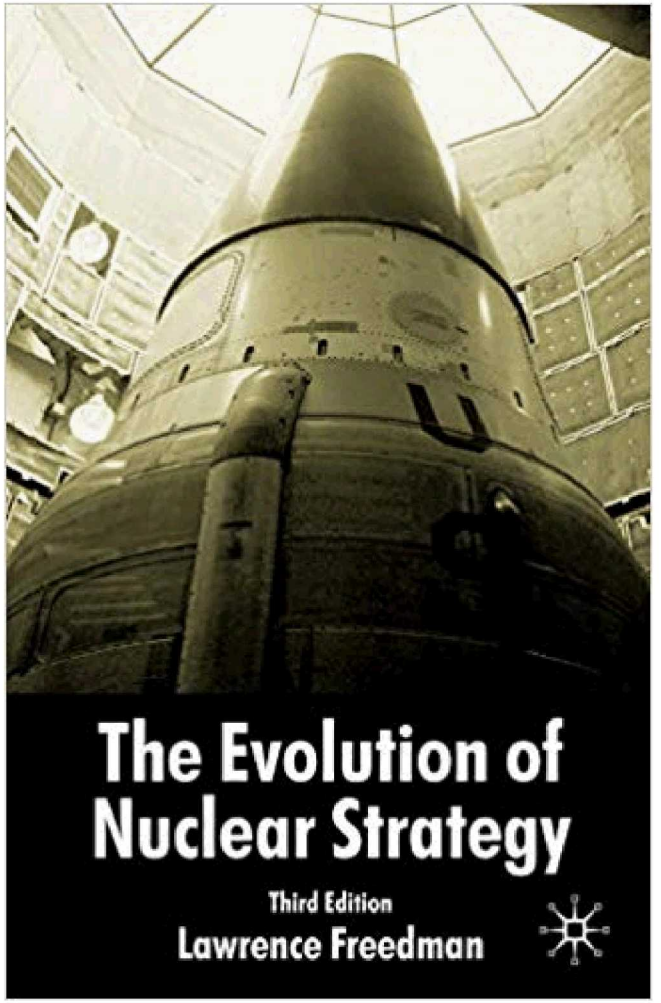
At the beginning of the 1960s, U.S. planners initial sought more diverse options short of total war

As the decade progressed, focus shifted toward survivable retaliatory forces and away from overwhelming first strike capabilities

Strategies for commitment and management of credibility became a policy centerpiece

Systemization of arsenal decision making

- Preference orderings were seen as aspirational
- Judgments were made about sufficient damage levels required to enforce preference orderings
- Arsenal capabilities and sizing problems partly became (for some) optimization problems



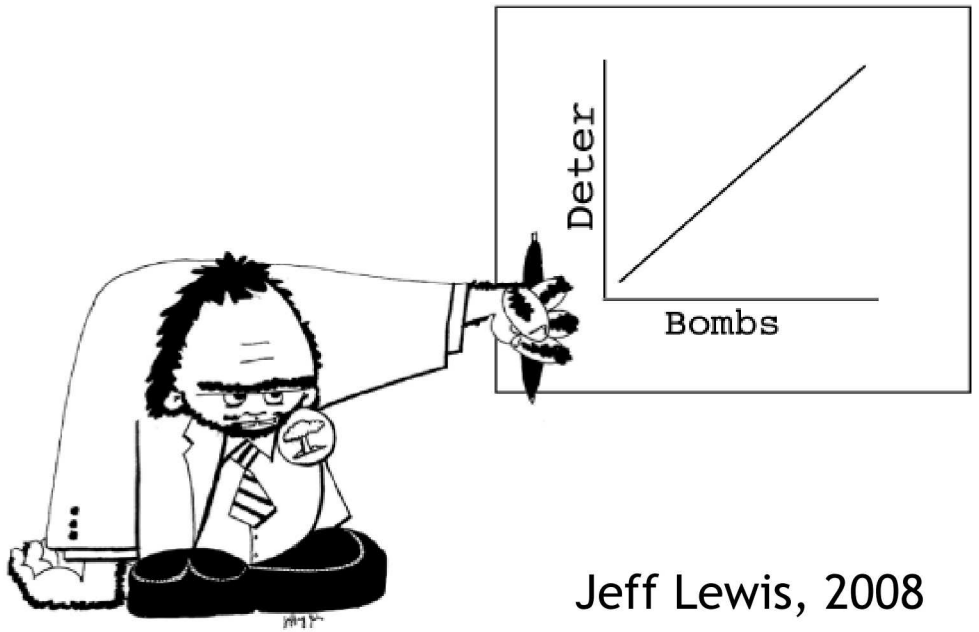
Third Wave Theory (1970s to 1990)

The search for empirical credibility (or the lack of it)…

Social psychology, behavioral studies, and historical case analysis became a dominant force in academic deterrence theory

Scholars identified three primary issues with deterrence theory based on a lack of empirical evidence

- Historically, people aren't actually rational
- Models allow only a narrow view of opponent's alternatives, beliefs, understanding of conflict, and values
- Actors are typically non-unitary, and domestic politics must be considered



Jeff Lewis, 2008

More Bombs Deter More. Next Slide Please.

A third-wave theorists view of second wave theorists?

Third Wave Theory argues Second Wave may have made things worse.

George and Smoke assessed historical use of deterrence strategies in US foreign policy, and evaluated the results

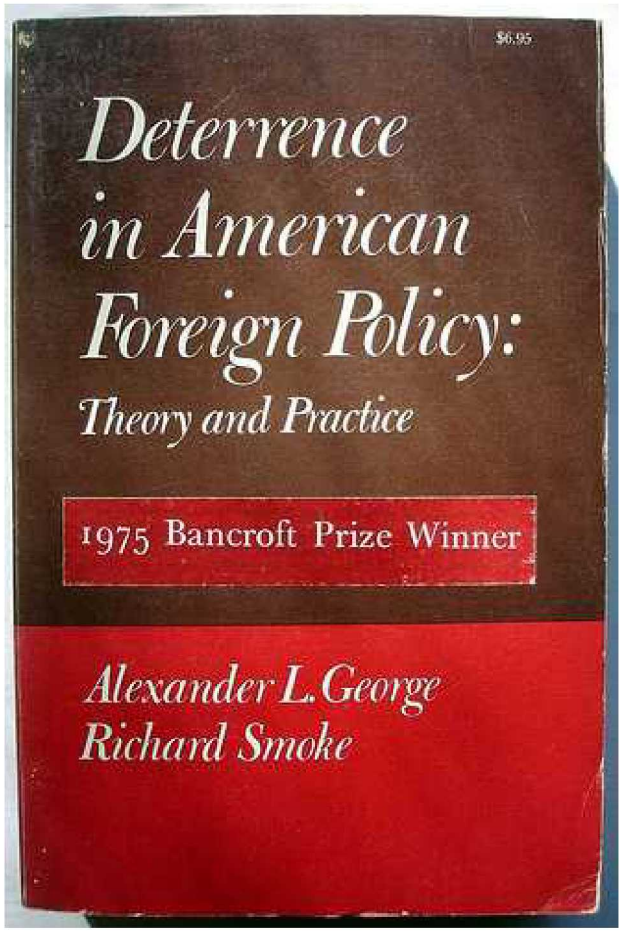
- Deterrence led to exaggerated role for military options, which likely prolonged the Cold War and begat further conflict

Lebow and Stein argued deterrence as practiced was destructive

- Fixation on demonstrating resolve (through rationalist bargaining tactics) unnecessarily escalated conflicts that may have otherwise been minor, and aggravated antagonism

Deterrence theory and practice continued to play a primary role in foreign policy

- Easy to explain and intuitive
- Translatable into action and strategy
- Seems to have worked so far



After the Third Wave (1990 – Present)

The Cold War is over! We never have to think about this again!...Wait.

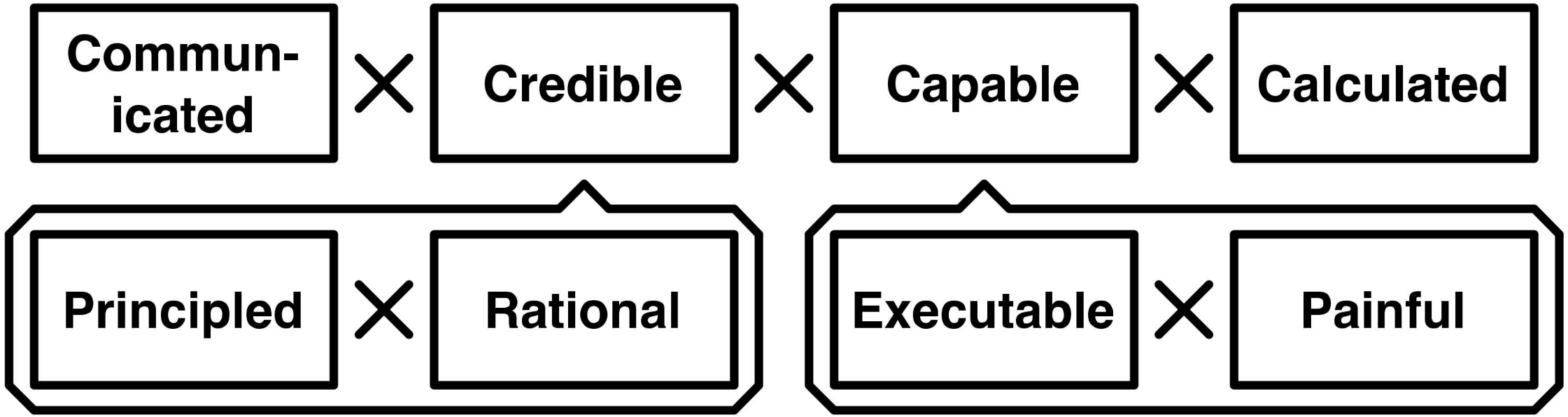
1990s: Not much attention

2000 - Present

- Multiple adversaries
- Non-classical adversaries (terrorists, rogue states, etc.)
- Non-nuclear means
- Asymmetric capabilities
- Escalation & de-escalation
- Cross-Domain Deterrence: Using retaliatory threats in one domain to deter action in another

*See ME Bunn, 2007; Lupovici, 2010; Knopf, 2010; Larkin, 2011

A Framework for Deterrence Effectiveness



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Modern deterrence and strategic stability challenges require new analytic approaches to bridge the complexity-scarcity gap.

Strategic Stability and Conflict Escalation

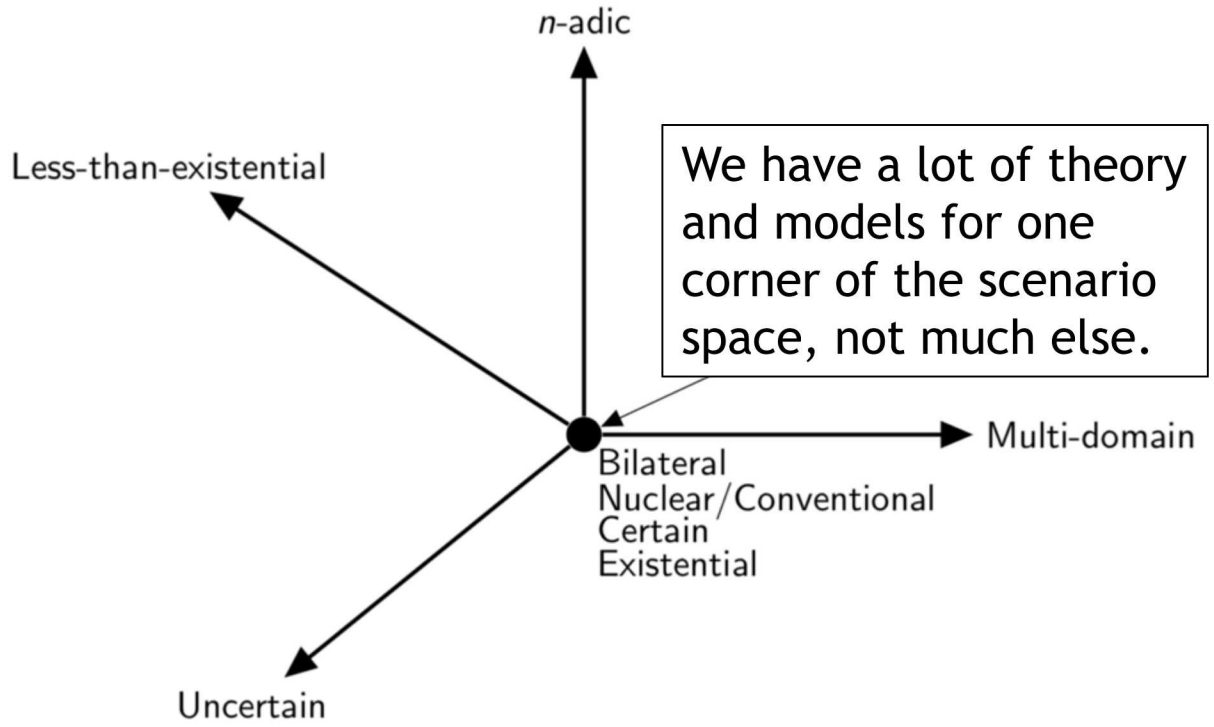
- First-strike stability
- Crisis escalation stability

Strategic Asymmetries

- Asymmetries of stake
- Asymmetries of forces
- Changes in capabilities

Nuclear Armed Regional Challengers

- Protection of regional partners and allies
- Grey-zone "salami-slices" and *faits accomplis*



Central Analytic Challenge: Given *increasing complexity* in disputes, number of actors, capabilities, and strategies, and an *increasing scarcity* of relevant historical data, how can scholars and strategists develop theories and models to inform policies and decision making?

Agenda

Overview and History of Deterrence

Advanced Modeling Approaches for Modern Deterrence Problems

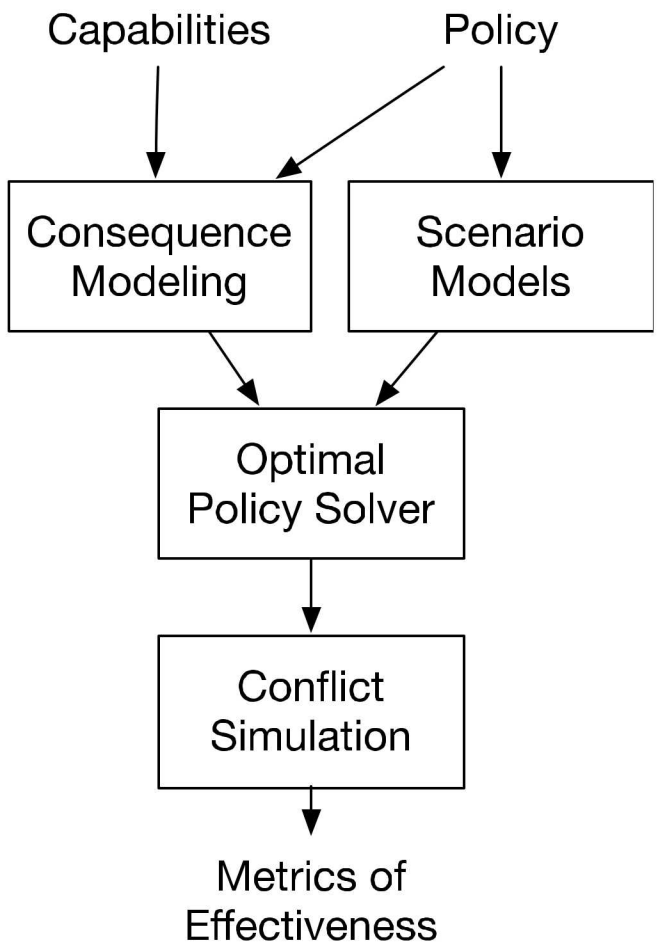
Gaming Methods for Deterrence Conflict Research

New modeling methods enable examination of complex escalation scenarios, quantifying risk trade-offs.

Research Question: How do changes to nuclear deterrent (policies, arsenal size, arsenal composition, weapon capabilities, etc.) affect strategic stability and deterrence outcomes?

Proposed Multi-Step Modeling Approach:

- **Conflict Consequence Modeling:** Actor value models, conventional net assessments, and nuclear weapons effects calculations
- **Scenario Modeling:** Discrete time Interactive Partially Observable Markov Decision Processes (IPOMDP)
- **Actor Decision Models:** Finite State Controller (FSC) representations of conflict management policies
- **Evaluation Method:** Forward stochastic simulation of conflict dynamics under optimal response policies
- **Metrics of Effectiveness:** Probabilities of outcomes of interest over the course of the simulation
  - Probability of Conflict Initiation
  - Probability of Nuclear Use
  - Probability of Defeat



See: Jason Reinhardt, "A Probabilistic Analysis of the Risk of Nuclear Deterrence Failure," PhD diss., Stanford University, 2018, performed under the supervision of M. Élisabeth Paté-Cornell

(Interactive) Partially Observable Markov Decision Processes

Treats descriptions of scenario as discrete mathematical states

State transitions (evolutions of scenario) are governed by probabilities and impacted by actor choices

Transition probabilities only depend on current state

Actors cannot observe states directly, but work to optimize outcomes accrued at each step

Single decision-maker or multiple decision-maker versions

Specified by states, observations, actions , outcomes, and probability distributions, for each actor that describe their evolutions from stage to stage given actor decisions

Conflict Model Example:

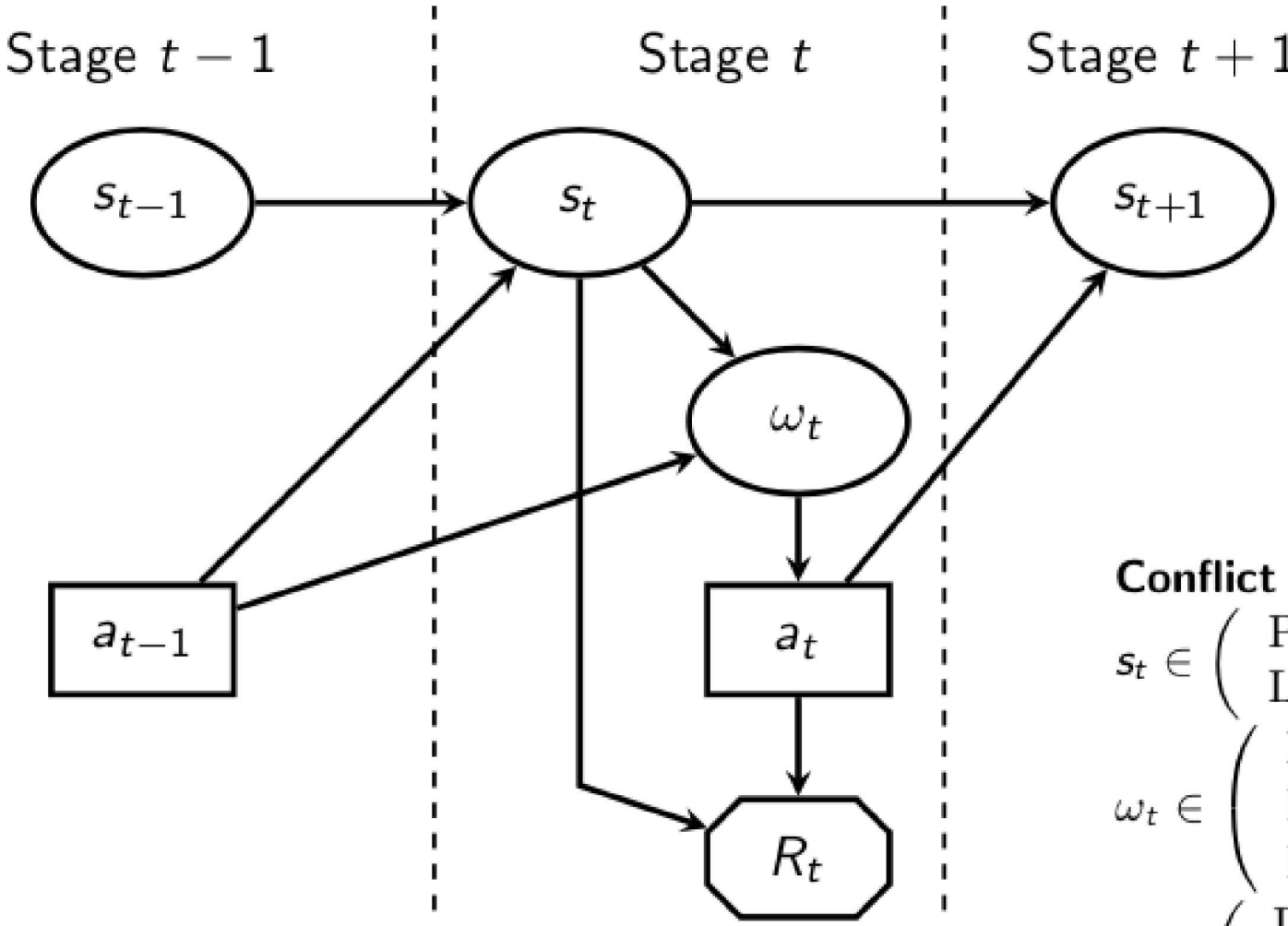
$$s_t \in \begin{pmatrix} \text{Peace, Crisis,} \\ \text{Low Conflict, } \ldots \end{pmatrix}$$

$$\omega_t \in \begin{pmatrix} \text{Intelligence,} \\ \text{Battle Outcomes,} \\ \text{Political Status, } \ldots \end{pmatrix}$$

$$a_t \in \begin{pmatrix} \text{Do Nothing,} \\ \text{Engage, Launch} \end{pmatrix}$$

$$R_t = \text{Gains and Losses}$$

Partially Observable Markov Decision Processes



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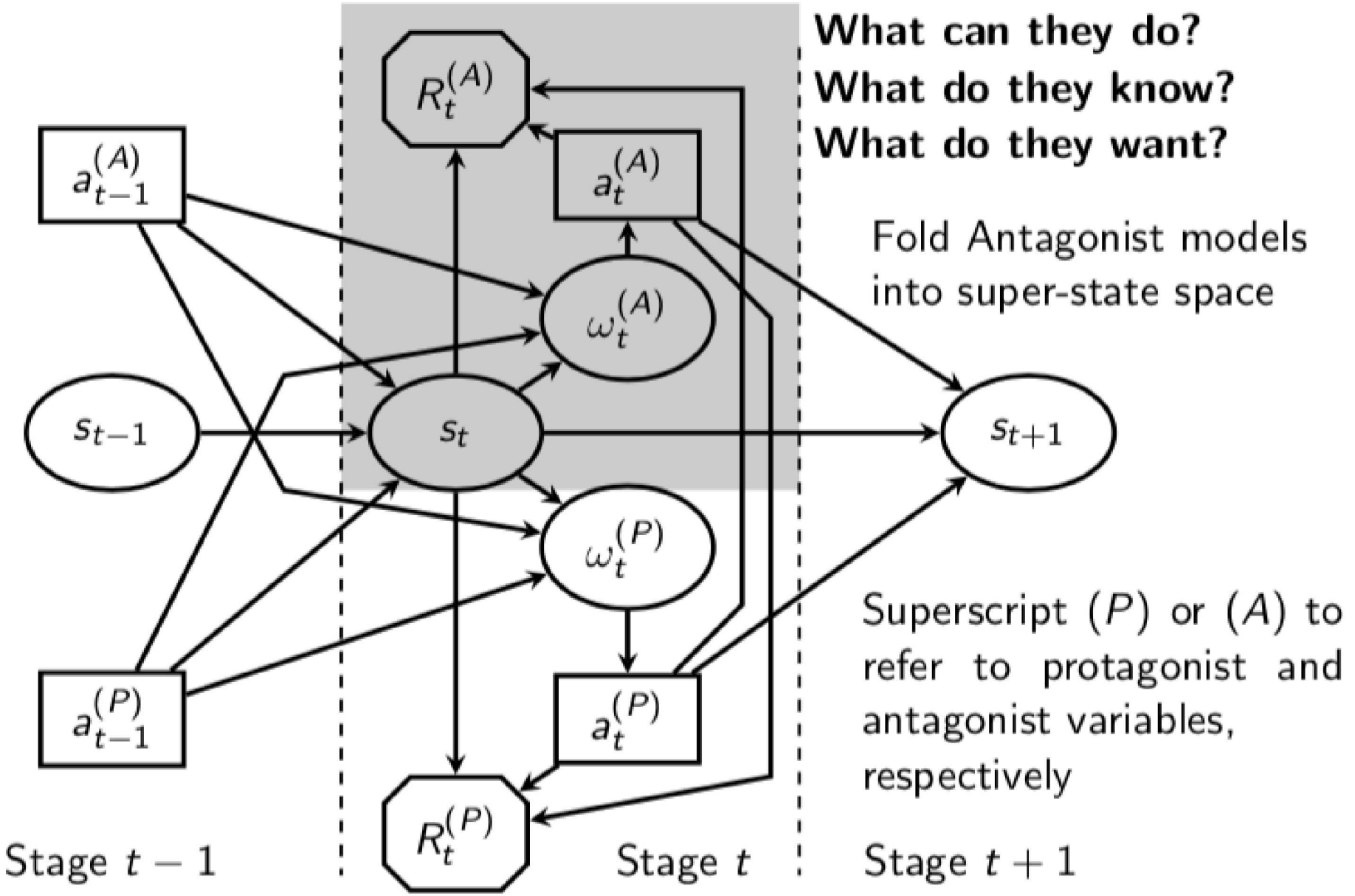
INTERACTIVE Partially Observable Markov Decision Processes



Finite State Controllers (FSCs) Represent National Policies

Nodes capture actions and updated probability distribution over conflict state, other actor actions, etc.

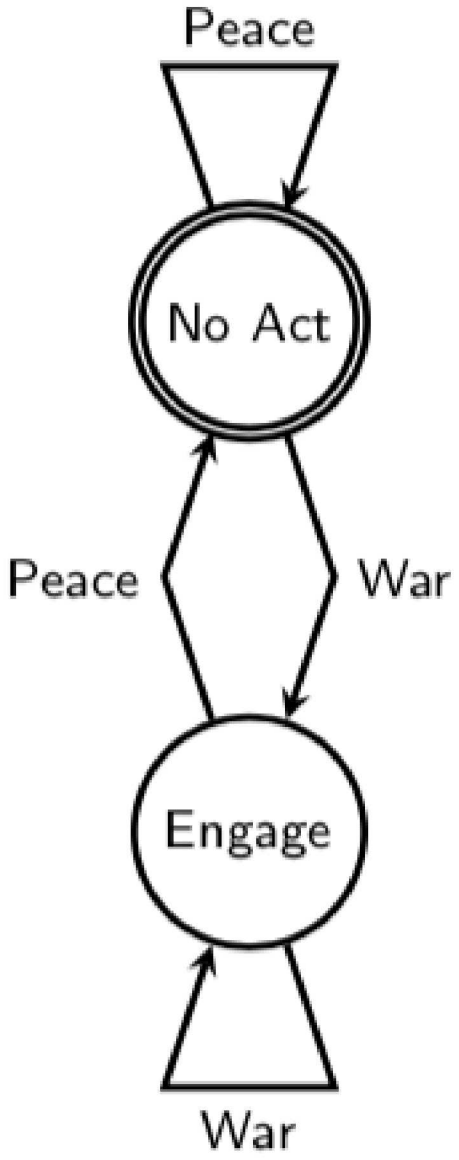
Observations dictate node transitions

- Approximates update to probability distribution

Starting node determined by highest value node given initial probability distribution on system state

Compact and discrete policy solution representation

- Nodes for an antagonist policy solution can be rolled into protagonist state space



The game model must be solved iteratively to find optimal policy for all actors in the scenario.

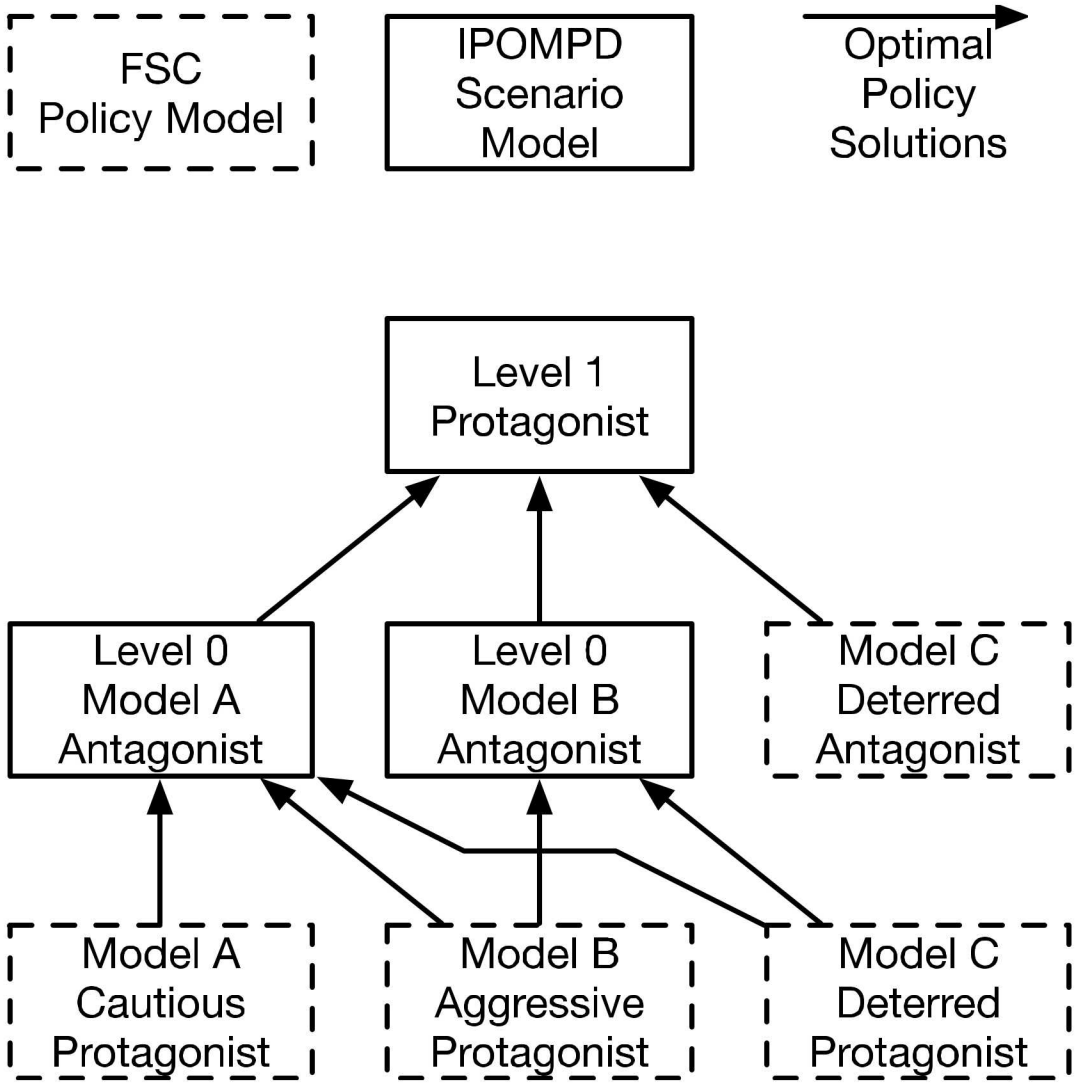
Example: Regional dispute, protagonist would like to protect the status quo, antagonist would like to revise it.

Three Antagonist models:

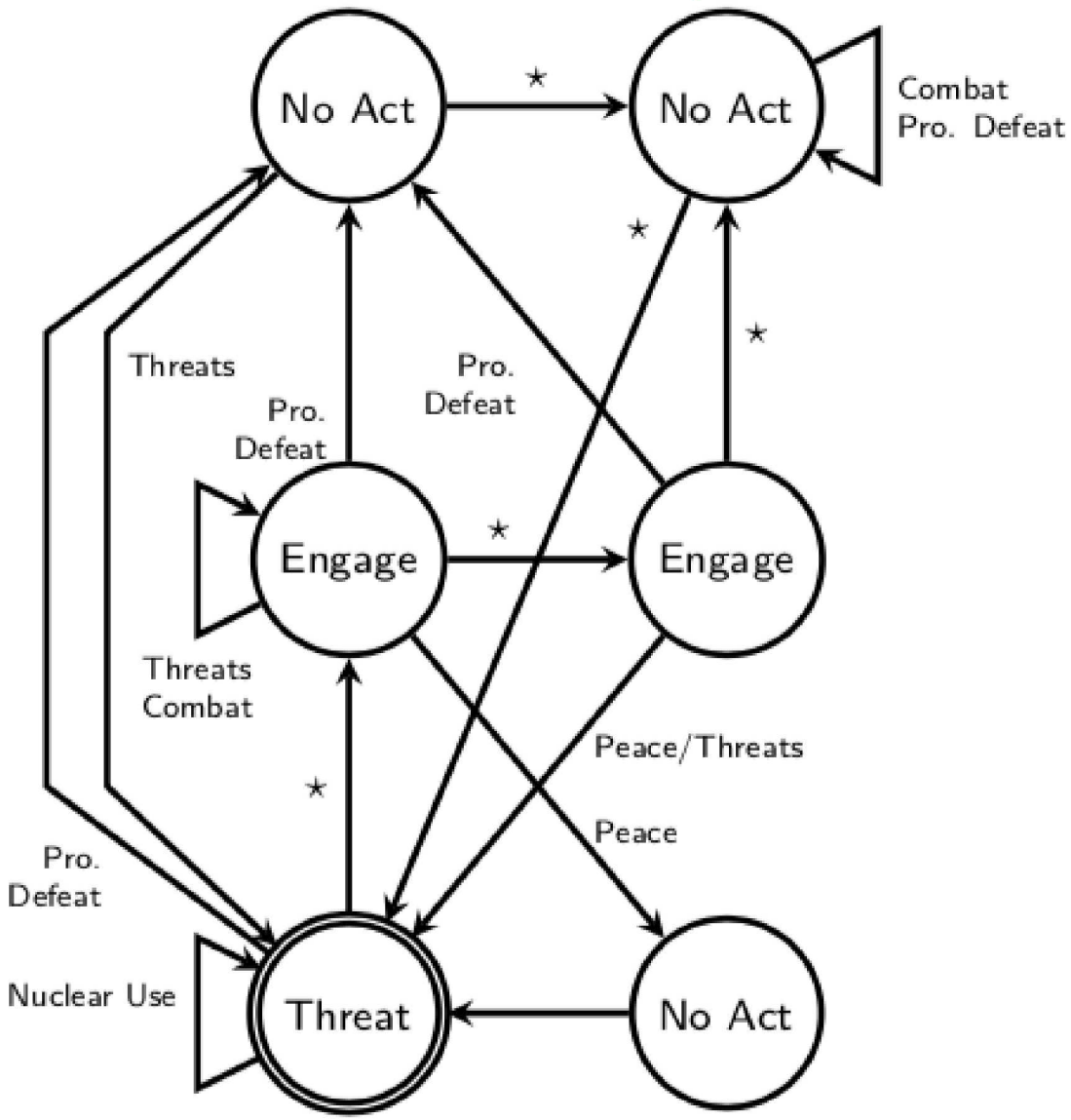
- Model A: High desire to revise status quo
- Model B: Low desire to revise status quo
- Model C: Strategic response only (asserted behavior)

Three Protagonist models:

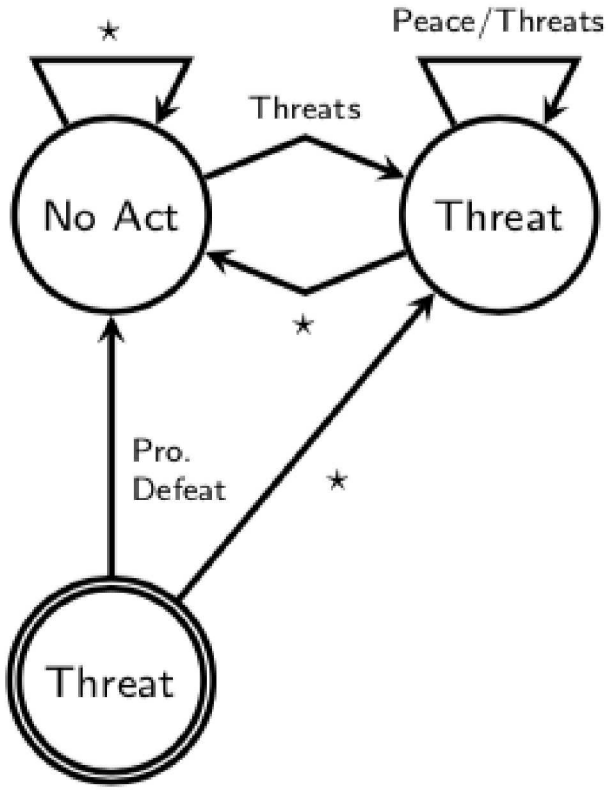
- Model A: Nuclear cautious response
- Model B: Nuclear aggressive response
- Model C: Strategic response only



Antagonist Solutions (Models Considered by Protagonist)



Solution A: Engage Persistently



Solution B: Grey Zone

Example Results: Alternate Protagonist Arsenals (Options) & Deterrence Effectiveness

Slight increase in the Antagonist conflict initiation probability

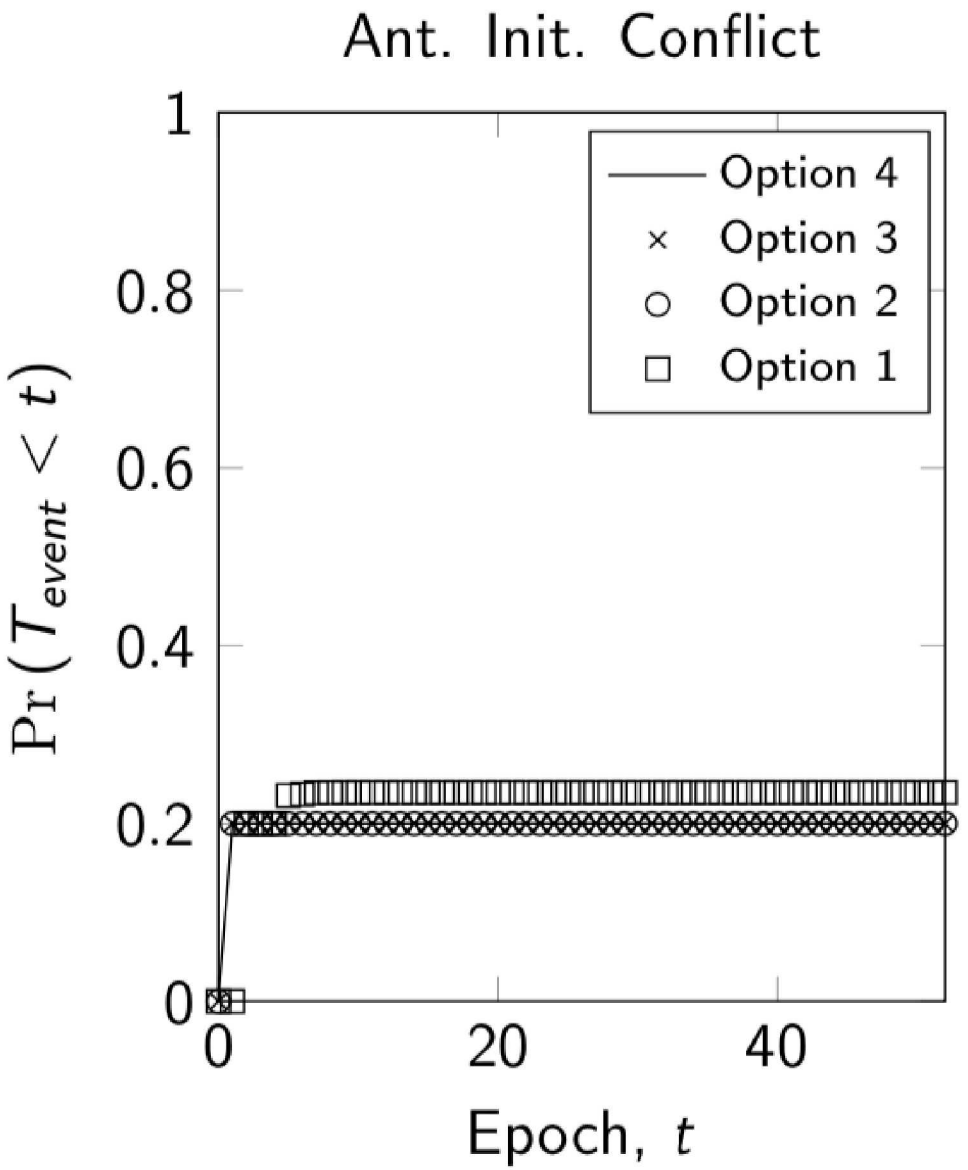
Protagonist motivated to initiate conflict with smaller arsenals

Antagonist initiated conflict more likely to be nuclear

Strategic nuclear deterrence holds

Reducing Protagonist arsenal size reduces the Protagonist defeat probability

- Puts Protagonist in a position to act more aggressively to protect interests due to more aggressive antagonist



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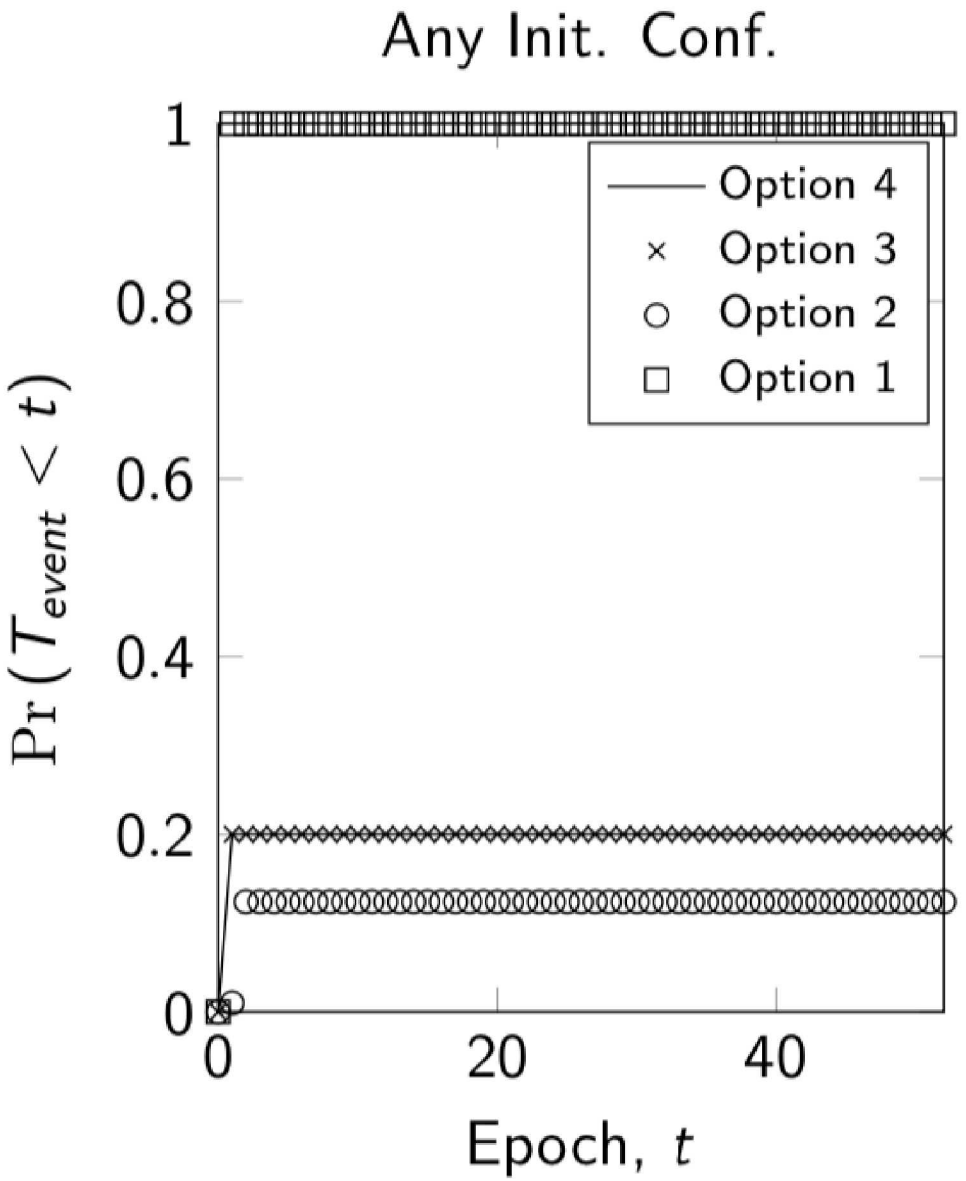

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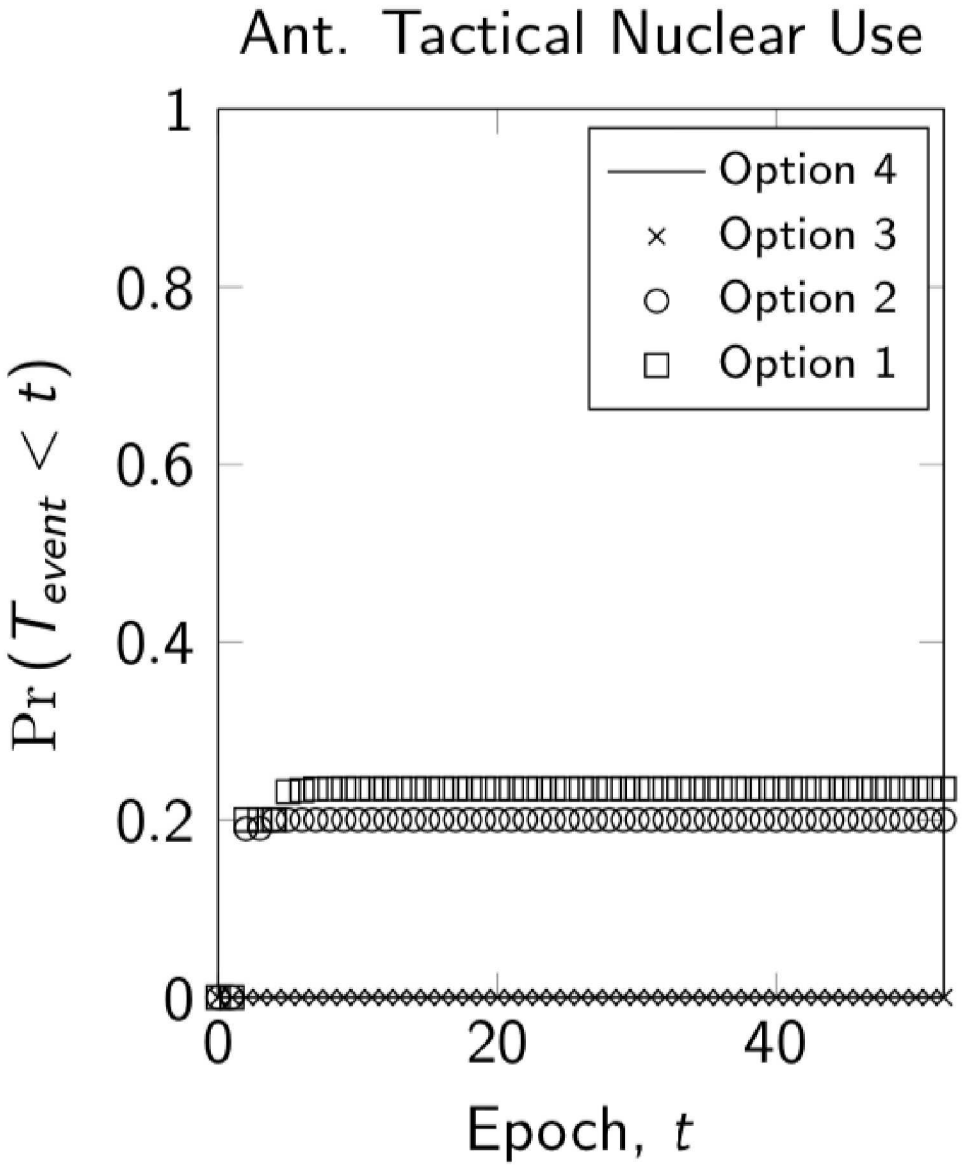

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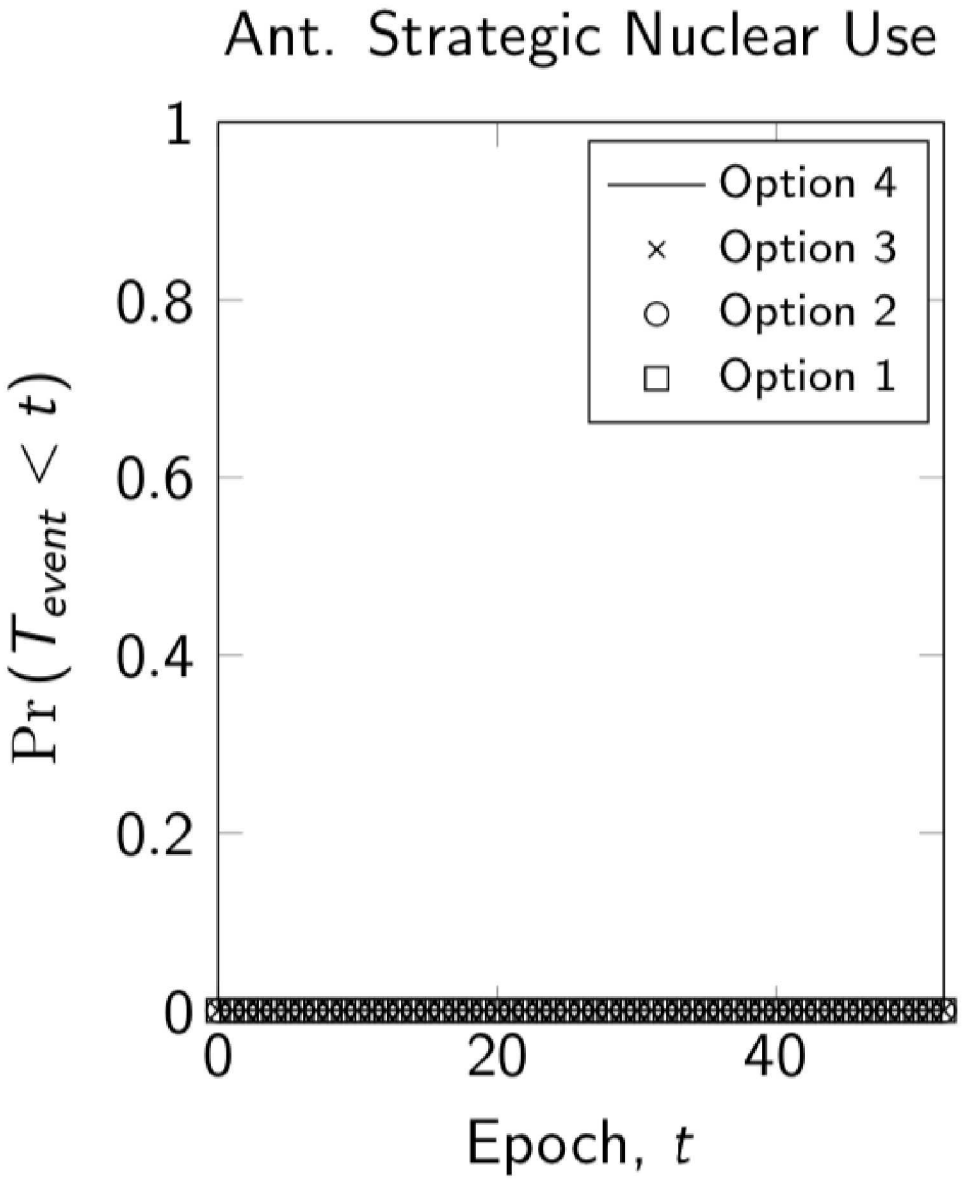

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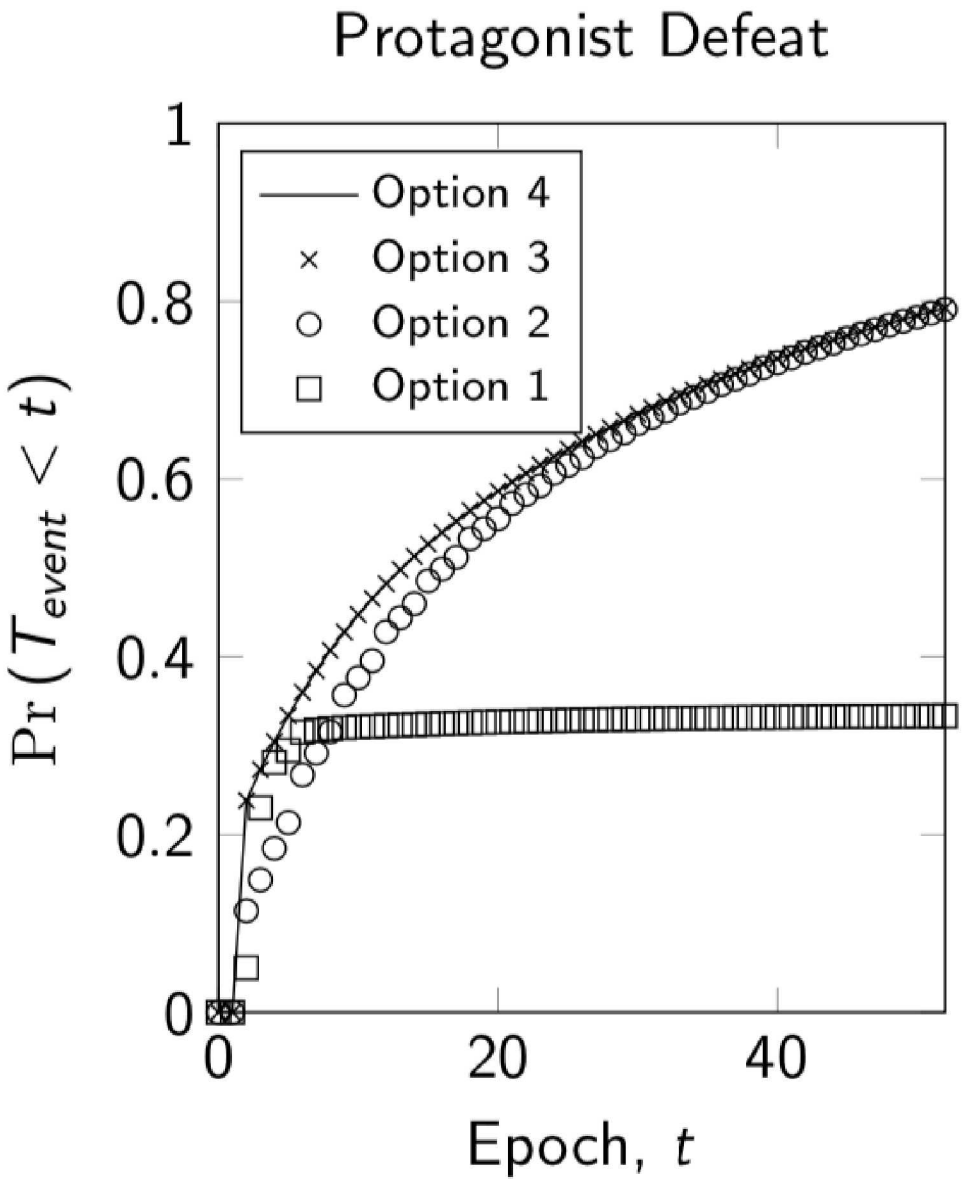

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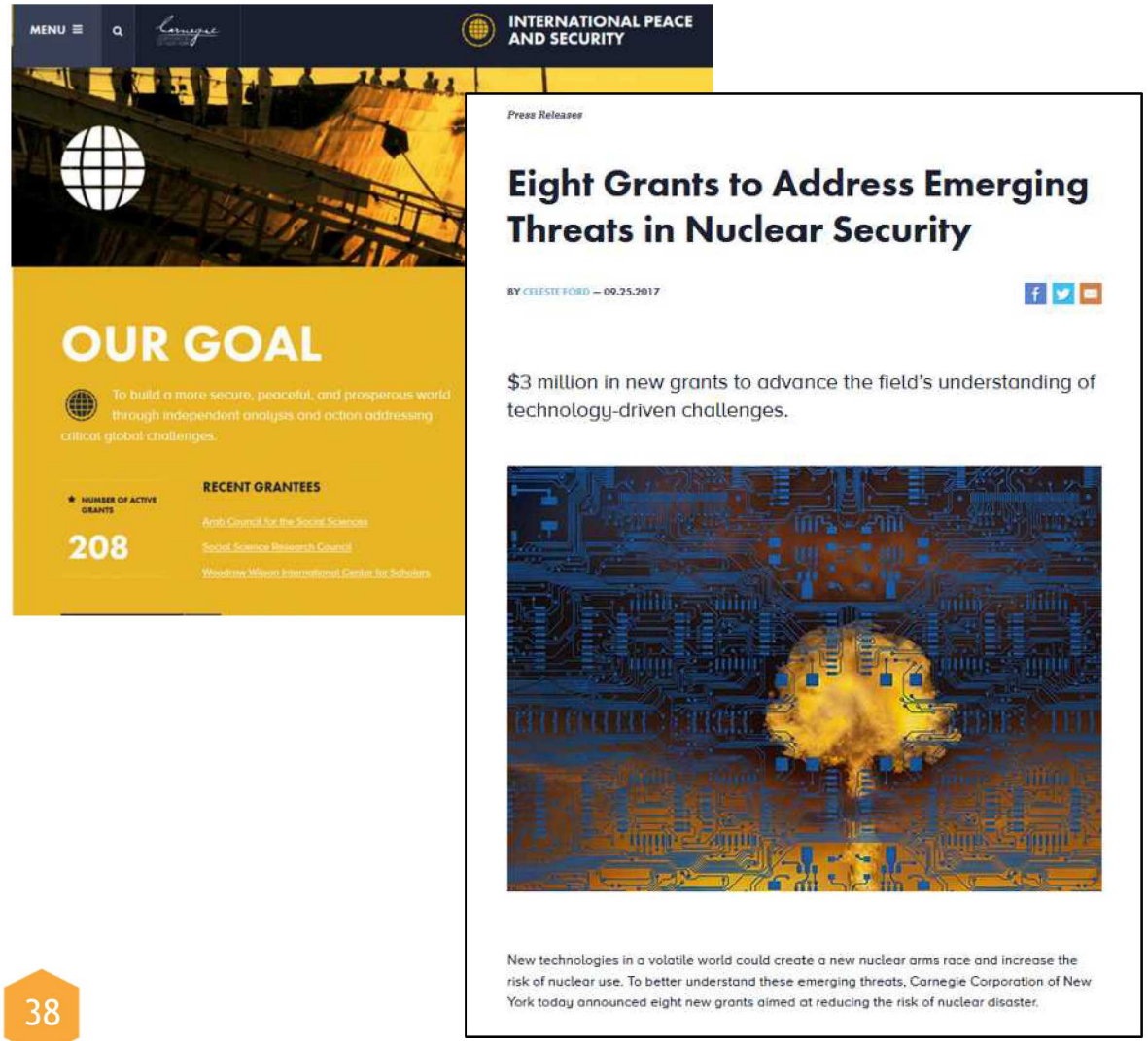
Gaming Methods for Deterrence Conflict Research

The Project on Nuclear Gaming is supported by the CCNY International Peace and Security Program.



Carnegie Corporation of New York

$500K funding over two years

"…assess the implications for global strategic stability of advances in technologies…"

PROJECT ON NUCLEAR GAMING

The Project on Nuclear Gaming is a consortium.

- UC Berkeley Goldman School of Public Policy
- Nuclear Science and Security Consortium, an NNSA-sponsored program to develop new generation of laboratory-integrated nuclear experts

- Systems Analysis and Engineering experience
- Support application of Sandia experimental and serious game technology & subject matter expertise
- Mentoring and hosting of student interns

- Center for Global Security Research
- Providing expertise in weapons effects and international security
- Mentoring and hosting of student interns
- Organizing and hosting project workshops

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The Project on Nuclear Gaming has many goals.

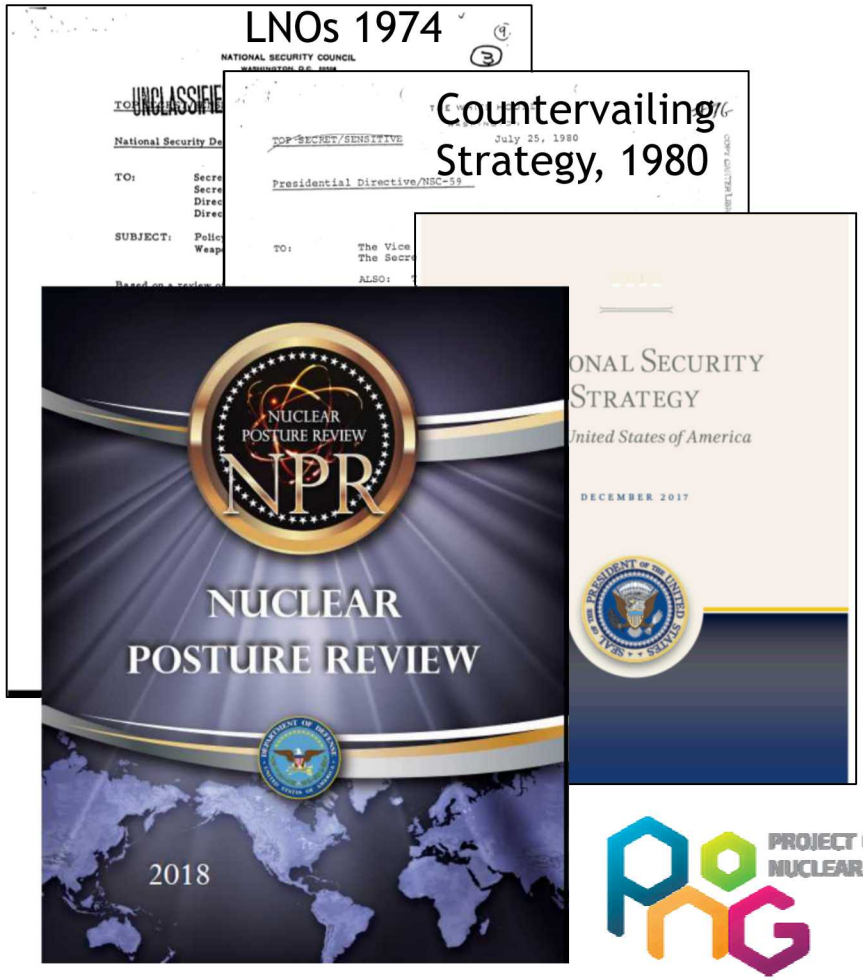
Research Questions:

- How can experimental games be constructed and executed to place players in abstract and hypothetical situations to model escalation challenges, including threats of nuclear use?
- What impact might different weapon capabilities have on deterrence and strategic stability?

Partnering and Mentoring Objectives:

- Strengthen and leverage existing partnerships between National Labs and Universities
- Engage the next generation of scientists, analysts, and researchers on nuclear matters

PoNG is NOT making an assessment of any specific national policy or conflict scenario, but is informed by a long history of strategy and concepts.



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Model problem to explore: Traditional vs Tailored Effect NW

Potential Costs of Tailored Effect NW:

- Breaking the nuclear taboo/Lowering threshold of nuclear use (Tannenwald 1999, Rovere and Robertson 2013, Doyle 2017)
- Lack of utility (Nelson 2010)
- Crisis instability
  - Blurring the distinction between conventional and nuclear weapons
  - Risk of inadvertent escalation if the adversary cannot discriminate between low- and high-yield attack (Sagan 1992, Posen 2013)
  - Inability to control escalation (Work 2015)
- Proliferation risk: Encouraging other countries to develop their own low-yield nuclear deterrent (Coyle and McKeon 2017, Gerstein 2018)

Potential Benefits of Tailored Effect NW :

- Tailored effect weapons less likely to lead to civilian deaths (Carpenter 2016)
- Increased probability of damage/kill for a given yield (Gen. Schwartz 2014)
- Providing a more credible nuclear deterrent for certain regional scenarios (Lieber and Press 2009)
- Raising the threshold for nuclear use (Williams and Lowther 2017)

Where does the data to answer these questions come from?

Existing data sources:

- Survey experiments (Press et al. 2013; Sagan and Valentino 2017)
- Archival wargames (Pauly 2018)
- Conflict databases (Palmer, 2015)
- Laboratory experiments (Quek 2016)
- Commercial games (Lakkaraju, 2019; Epifanovskaya 2018)

Experimental Wargames: Games designed to quantitatively study national security scenarios of interest.

- Place players in conflict situations
- Minimally (but consistently) constrained in their potential responses
- Situation, potential responses, and abstraction driven by research question(s) of interest

Experimental wargames complement existing data sources

Experimental games have attractive features.

Replicability

- Strengthen our conclusions and address human variability by replicating a set of initial conditions and capturing significant quantities of data.

Controllability

- Allow for variable manipulation in initial conditions set.

Clear instrumentation

- Capture clear data about when a player chooses to take certain actions.

Neutrality

- Remain uninvolved with the actual data gathering, reducing the bias of the experiment team.

Fidelity

- Create an appropriate abstraction of scenarios of interest that focus on research questions and experimental design considerations.

The Project on Nuclear Gaming's Experimental Approach

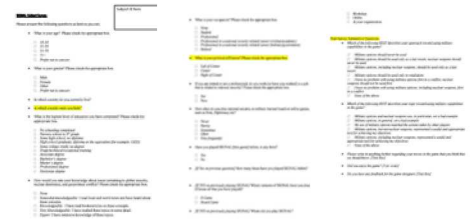
Experimental Games:

SIGNAL Board (Knowledgeable and Expert Players)

- Highly structured scenarios, rules based adjudication, fluid conversation and over-the-table player dynamics, improved quantitative data collection

SIGNAL Online (Any Player)

- Highly structured scenarios, rules based adjudication, more structured player dynamics, high quantitative data collection



Benchmarks:

SIGNAL TTX (Elite Players)

- Fluid exploration of scenario features, player concerns, and boundaries for outcomes, control team adjudication, qualitative and narrative data collection

Survey Experiments (Targeted Responders)

- Questionnaires focused on evaluating subject responses to specific situations, no dynamic interaction, serves as a control set

Slide 44

AR3 Amended to reflect Bethany and Sheryl's comments

Andrew Reddie, 4/28/2019

SIGNAL includes critical aspects of deterrence, escalation, and decision making.

Important elements and action

- Military
- Economic
- Political/diplomatic

Important dynamics and mechanics

- Bargaining
- Signaling
- Uncertainty

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The approach varies initial conditions in the game to explore alternate scenarios.

- Vary military capabilities of players
  - NW Capabilities
  - Conventional Forces
  - Cyber
  - Defensive
- Vary existing economic/political ties
- Execute a series of rounds, each with three phases
  - ***Signaling Phase* for Diplomacy/Threats**
  - *Action Phase* for Making Moves
  - *Upkeep Phase* for Accounting of Results
- Gather Data
  - What signals do players send to each other?
  - What actions and reactions do players take?

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SIGNAL is an experiment created using experimental design principles.

- Multiple conditions for our players

- Estimated time to play:
  - 2-4 hours for board game.
  - 1-1.5 hours for the online game.

- Key elements of game design:
  - **Abstract Environment:** Abstract countries. Reduces impact of cultural stereotypes/role-playing.
  - **Minimal Stochasticity:** Few actions are stochastic which increases controllability.
  - **Multiple Avenues for Winning:** Players can succeed in multiple ways, allowing for diversity of play.
  - **No white cell/adjudicator:** Rules are provided to players. Rapporteurs available to help.

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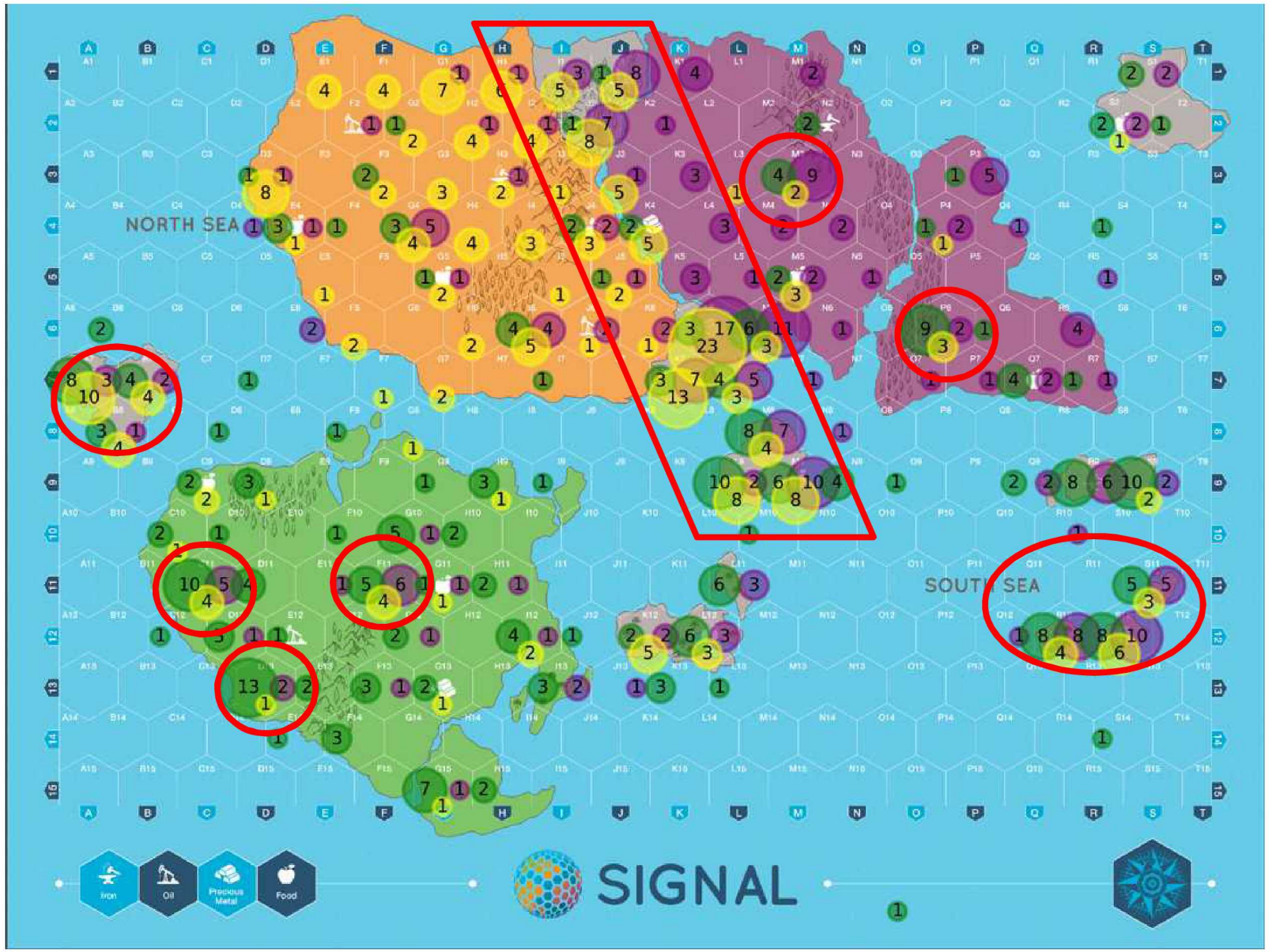
Visualization of game actions illustrate trends in player behaviors and strategies.



Overall strategic focus seems to be on:

- Contiguous borders
- Adjacent minor states
- Military and 'Value' targets

NOTE: While based on real data, these results are preliminary, non-conclusive, and for illustration only.

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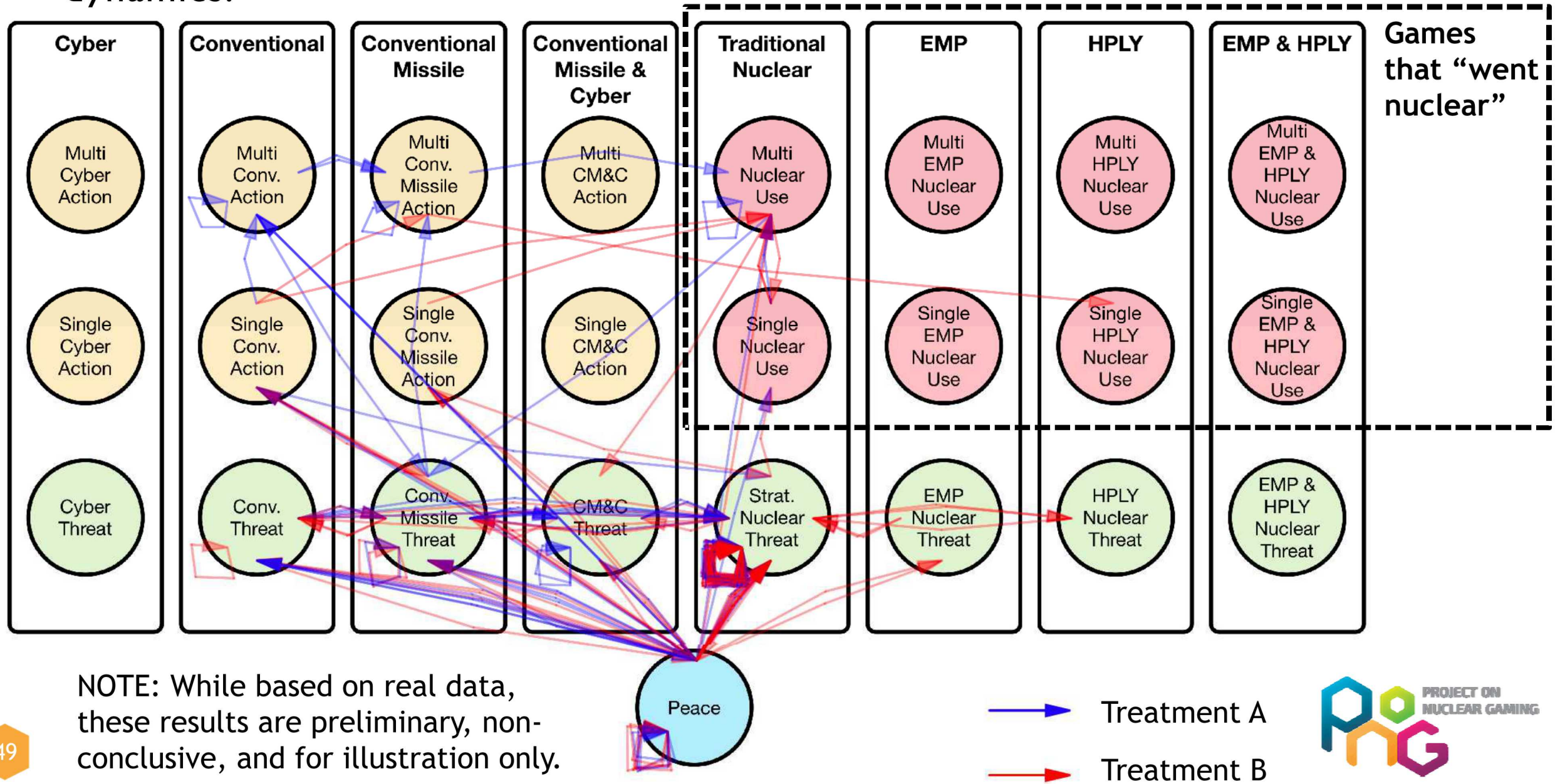
Establishing Conflict Classes from raw data enables analysis of escalation dynamics.



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The Project on Nuclear Gaming is building experimental games that collect data to study deterrence and conflict.

Partnering between Carnegie Corporation of New York, UC Berkeley, Sandia National Laboratories, and Lawrence Livermore National Laboratory

Building experimental game methodologies to enable new ways to study deterrence and conflict escalation

- Methodology and tool development is primary focus
- Abstract scenarios and capabilities
- Quantitative exploration of strategy space to help develop conflict theory

Creating new tools for conflict study that complement existing wargaming approaches

- Initial scenarios and game mechanics center on traditional vs. tailored nuclear weapon capabilities and their impacts on escalation and nuclear use within the context of the abstract scenario
- Experimental design, instrumented processes, and data analytics are flexible and adaptable to new scenarios, new capabilities, and new questions

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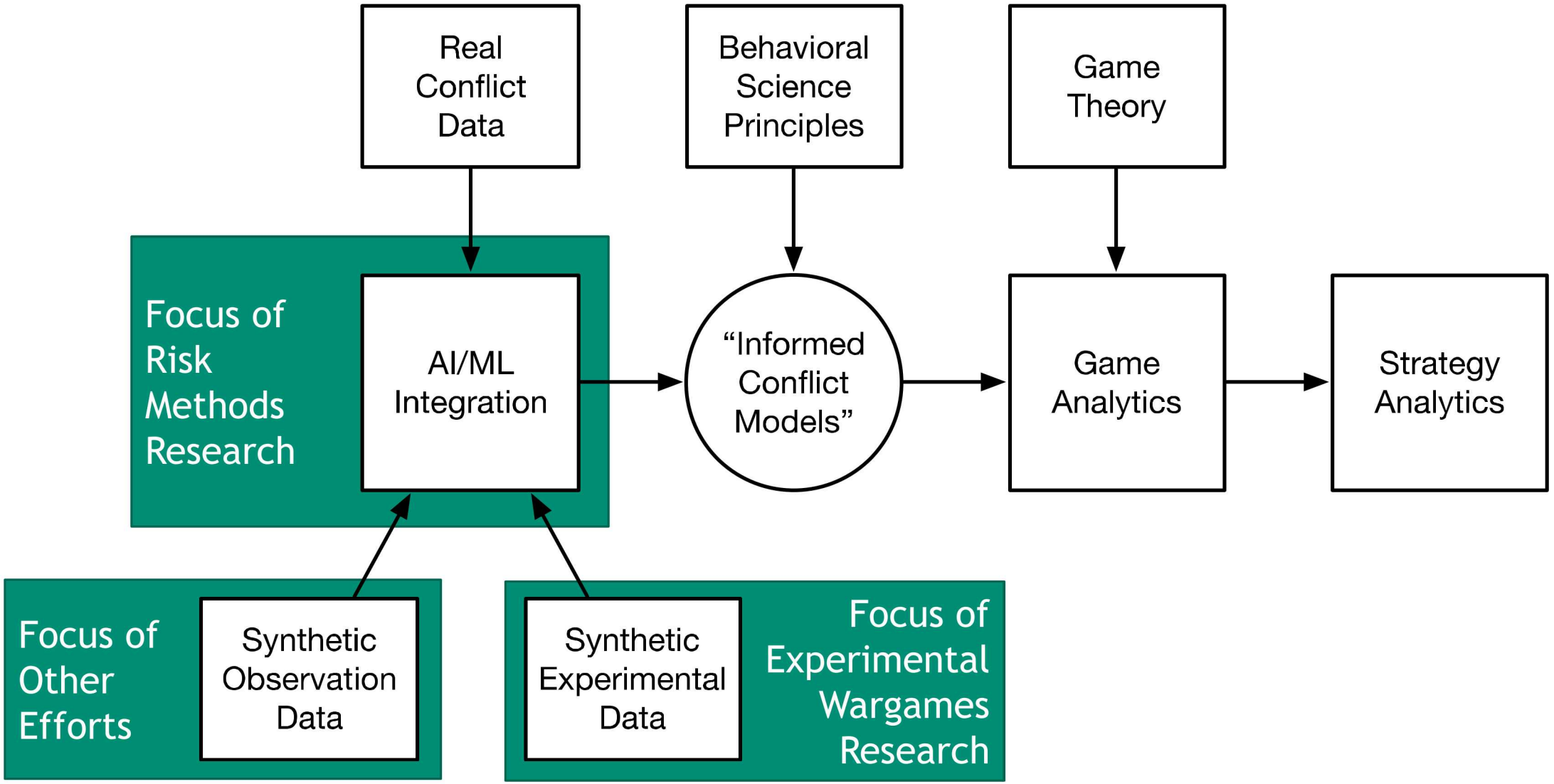
Improving analytic capabilities for studying modern conflict is part of a larger research vision.



Deterrence is fundamentally a simple concept, but understanding it and its implications, is a complex and difficult problem.

The interpretation and application of the fundamental concepts of deterrence have shaped policy, conflict, and the international order for decades (if not centuries). This has literally shaped the modern world.

We, as scholars and researchers, must build new tools, do analysis, and create novel mechanisms that allow us to explore and develop deterrence theory.