

2008 NAE Frontiers in Engineering Conference

Nuclear Deterrence in the 21st Century: The Role of Science and Engineering

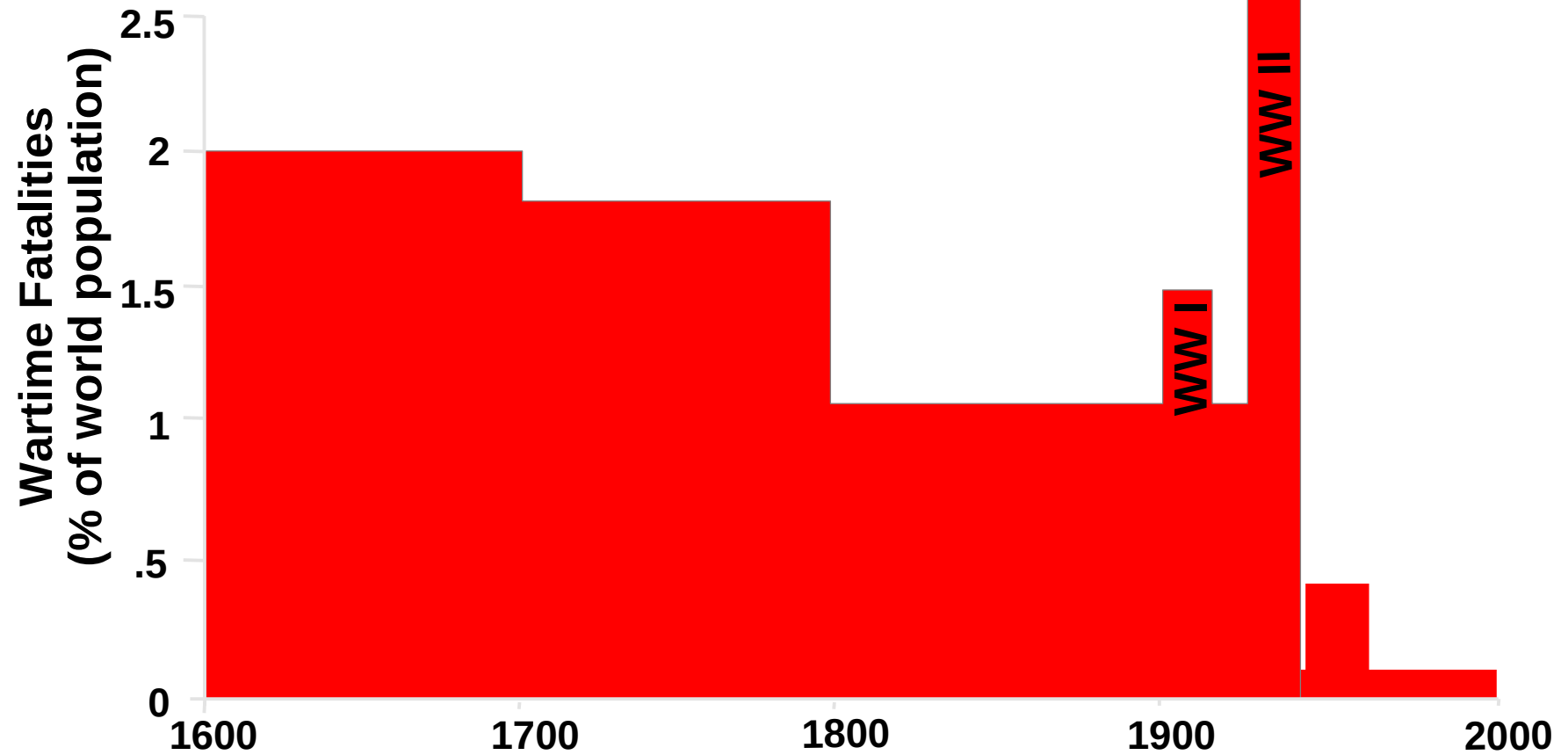
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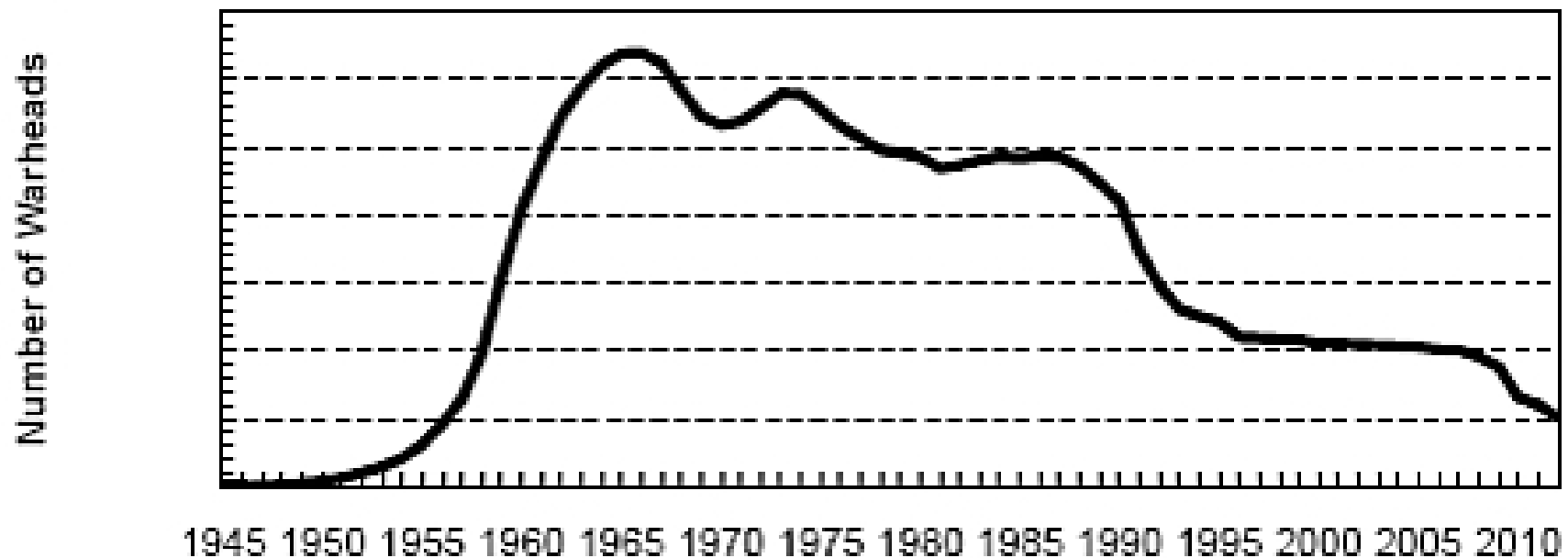
September 20, 2008



Wartime Fatalities



The Number of United States Nuclear Weapons Has Decreased since 1965



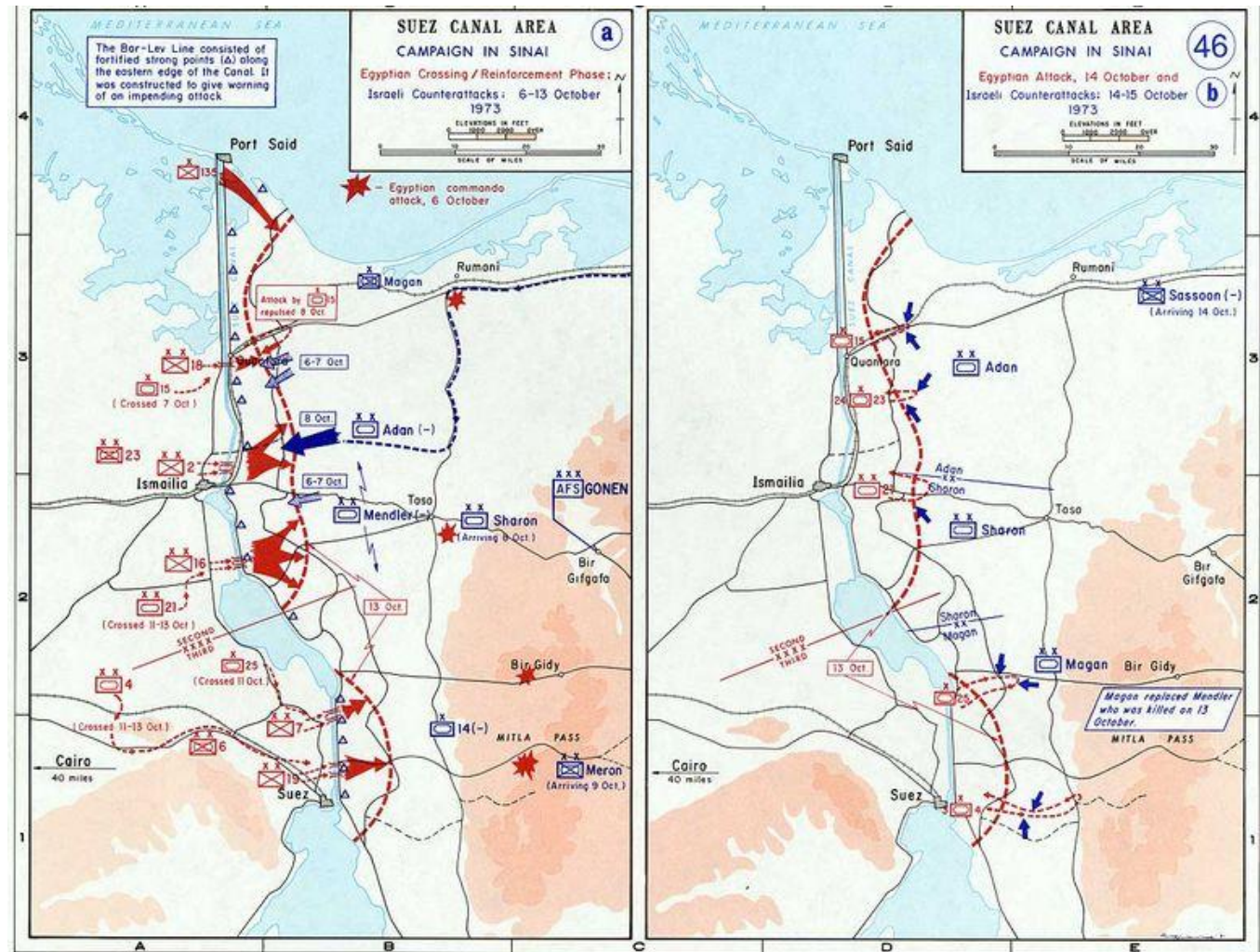
2008 Stockpile is ~10% of the 1965 peak

Non-use of nuclear weapons has continued respect for the “nuclear taboo”

Yom Kippur War,
October 6-26, 1973



Initial Israeli counterattack on Oct. 8 was a disaster. Defensive standoff ensued while Egypt brought in reserves.



A systems-analysis approach: strategic security and the role of nuclear weapons

Motivated by our joint work on the Reliable Replacement Warhead. Could we use the same, design-to-requirements approach to look at deterrence?

Sandia

Linda Branstetter, Ed Hoover, Kevin O'Brien, Adam Slavin

Los Alamos

Joe Martz, Patrice Stevens

Approach: a requirements-based matrix assessment of options for protecting strategic security. Note: we're at a draft stage now, *work still in progress*

Methodology:

- 1) state broad-based criteria, refine definitions, and group into 5 areas
- 2) provide a wide spectrum of postures and strategies which are evaluated
- 3) score each strategy against each criteria
 - Exceeds Meets Partially Meets Fails (with + or —)
- 4) Compile overall scores, varying weighting of criteria to look at resilience of strategies

Criteria and Strategies

Criteria covered 5 Broad areas:

- protect vital United States national security interests – 8 total specific
- provide needed national technical capabilities – 8 total
- lower nuclear risks – 11 total
- enhance United States standing and reputation – 6 total
- benefit society – 4 total

37 criteria were stated and evaluated in total

We examined 7 paradigms spanning a wide range of possibilities:

- Nuclear Supremacy
- Mutual Assured Destruction
- Tailored Deterrence
- Threshold Deterrence
- Capability-Based Deterrence
- Virtual Deterrence
- Deterrence Without Nuclear Weapons

We did not try to predict the future. Presumed the world situation as it sits today.

A closer look at paradigms

Nuclear Supremacy

Large reliance on nuclear capabilities, new weapon options and effects, and diverse and redundant deployment options. Includes conventional strike capabilities

Mutual Assured Destruction

Cold-war strategy in which capable, minutes-ready nuclear forces are deployed and intended to counter a peer-adversary and remain survivable in the event of a first strike, surprise attack.

Tailored Deterrence

Based on Elaine Bunn's article (Can deterrence be tailored? Strategic Forum, 225, Jan 2007). Careful examination of each potential threat, and a proportionate, broad-spectrum response is deployed spanning nuclear, conventional, economic, and diplomatic options.

Threshold Deterrence

UK Cold War Model. An identified, specific asset of an adversary is held at certain risk, no effort to remain proportionate to adversary forces.

A closer look at paradigms (cont)

Capability-Based Deterrence

Presumes that sufficient time is available to counter an emergent or recidivist adversary (at least several years). Relies on agile and confident capability to produce nuclear stockpile in conjunction with bilateral deployed and reserve stockpile reductions. Retains weapons complex and a small, ready force to counter most potential threats.

Virtual Deterrence

Moves away from deployed weapons to components, parts, and systems in storage and available for reassembly. Emphasizes controlled storage of components and parts, and does not develop new weapons or factories.

Deterrence Without Nuclear Weapons

Explicitly does away with US Nuclear weapons stockpile in an accelerated time frame. Efforts are made to induce other states to do the same, but is unilateral in nature. Moves protection of US interests to non-nuclear means including enhanced conventional forces, economic, and diplomatic.

Draft Evaluation Results

	Nat'l Security Interests	Nat'l Technical Capabilities	Lower Nuclear Risks	Enhance US Reputation	Benefit Society		Equally Weighted		Selectively
Nuclear Supremacy	54	32	37	3	6		54%		64%
Mutually Assured Destruction (MAD)	21	51	35	12	12		59%		60%
Tailored deterrence	48	47	52	27	20		90%		92%
Threshold deterrence	17	32	45	15	12		54%		52%
Capability-based deterrence	35	55	50	30	18		88%		89%
Virtual deterrence ("emphasizes parts over factory")	21	21	43	21	9		52%		51%
Deterrence without nuclear weapons (zero nuclear weapons)	6	10	35	24	0		33%		31%

Relative Weight

10

8

5

6

4

Draft Evaluation Results

	Natl Security Interests	Natl Technical Capabilities	Lower Nuclear Risks	Enhance US Reputation	Benefit Society		Equally Weighted	Selectively
Nuclear Supremacy	54	32	37	3	6		54%	41%
Mutually Assured Destruction (MAD)	21	51	35	12	12		59%	52%
Tailored deterrence	48	47	52	27	20		90%	87%
Threshold deterrence	17	32	45	15	12		54%	54%
Capability-based deterrence	35	55	50	30	18		88%	85%
Virtual deterrence ("emphasizes parts over factory")	21	21	43	21	9		52%	54%
Deterrence without nuclear weapons (zero nuclear weapons)	6	10	35	24	0		33%	38%

Relative Weight

4

3

8

10

10

Some Interesting Observations

Two options score significantly higher than others

Tailored Deterrence

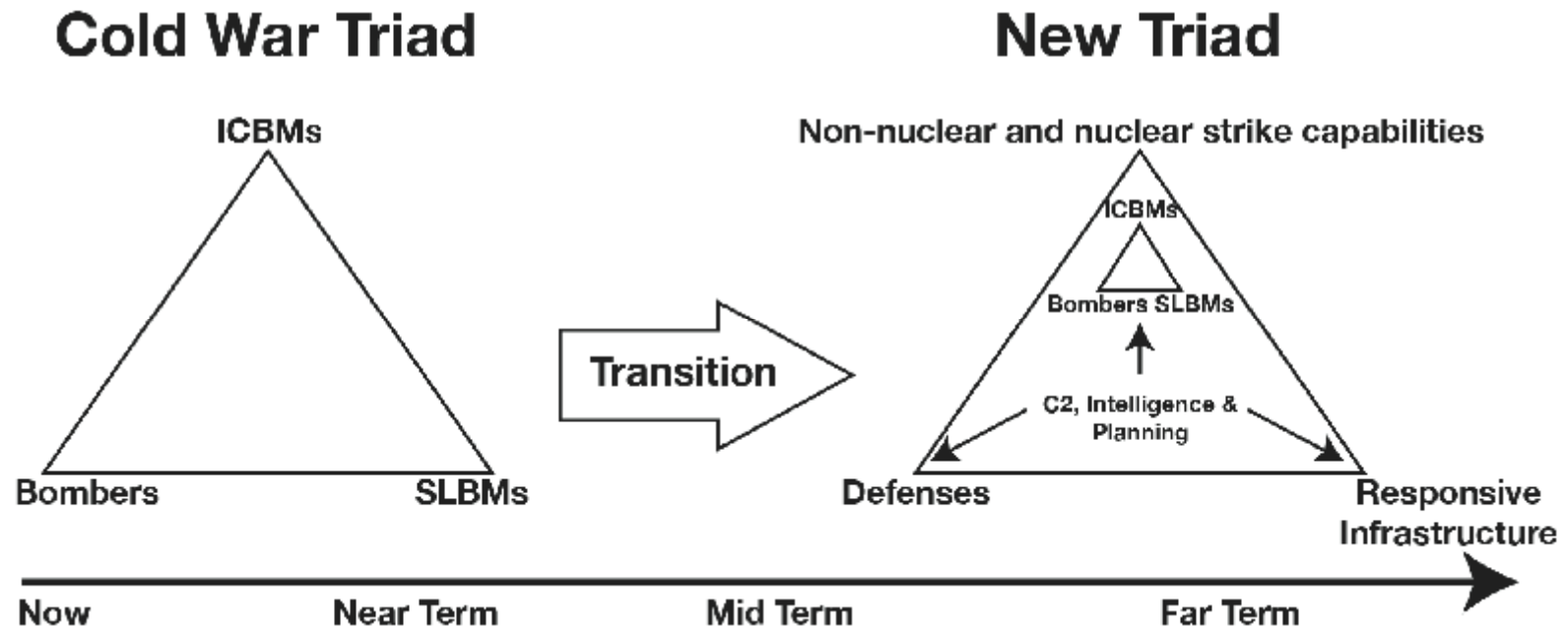
Capability Based Deterrence

These 2 options are robust and insensitive to weighting of the criteria

Other options do vary with weighting, particularly those at the extremes

This is work in progress, these illustrative results are provisional and subject to change.

Deterrence by Capability as Nuclear Policy



From the 2001 Nuclear Posture Review

Capability-Based Deterrence

Two elements are essential in enablement of this strategy:

Agility & Confidence

This are both technical requirements. Science and Engineering will dominate.

Agility

Essential to respond on a time-frame which is faster than an adversary could develop and deploy a potential threat

- numerous analyses of possible threats
- only 2 would require a rearmament of substantial level
 - recidivist Russia
 - expansionist China
- ~decade warning (versus minutes during Cold War)

Enabled by changes in both the weapons complex and the stockpile

Complex Transformation

Reliable Replacement Warhead – RRW

Life Extension Programs - LEPs

Capability-Based Deterrence (cont)

Confidence

Convince ourselves, our allies, and our adversaries that the capability is credible and will work when and if required.

Key element: enable continued cessation of nuclear testing

Also ensures that it won't work when NOT required.

Safety/Security/Use Control = "Surety"

challenging scenarios post 9/11

goal: no nuclear yield; limited nuclear material dispersal

Many critical elements are immature:

high-energy density physics

numeric issues in calculations

lack of data on high-rate and extreme materials properties

many others...

- RRW Hydrotest, Sept 2006

Deterrence by Capability in Action?

- “Because our nuclear weapons stockpile is decreasing, the United States' future deterrent cannot be based on the old Cold War model of the number of weapons. Rather, it must be based on the *capability* to respond to any national security situation, and make weapons only if necessary.”

– NNSA Administrator Tom D'Agostino, December 17, 2007

Deterrence by Capability in Action (2) ?

“Once we establish a responsive infrastructure, *and demonstrate a capability to produce warheads* on a timescale in which geopolitical threats could emerge, and can respond in a timely way to technical problems in the stockpile, then we can go much further in reducing non-deployed warheads “

- Jerry Paul, Deputy Administrator, NNSA, Presentation to the Council on Foreign Relations, May 25, 2005

Conclusion

Capability-based deterrence, a better way?

Use advances in our understanding and agility to protect our security.

“More-so our work itself, than the products of our work, to protect security.”