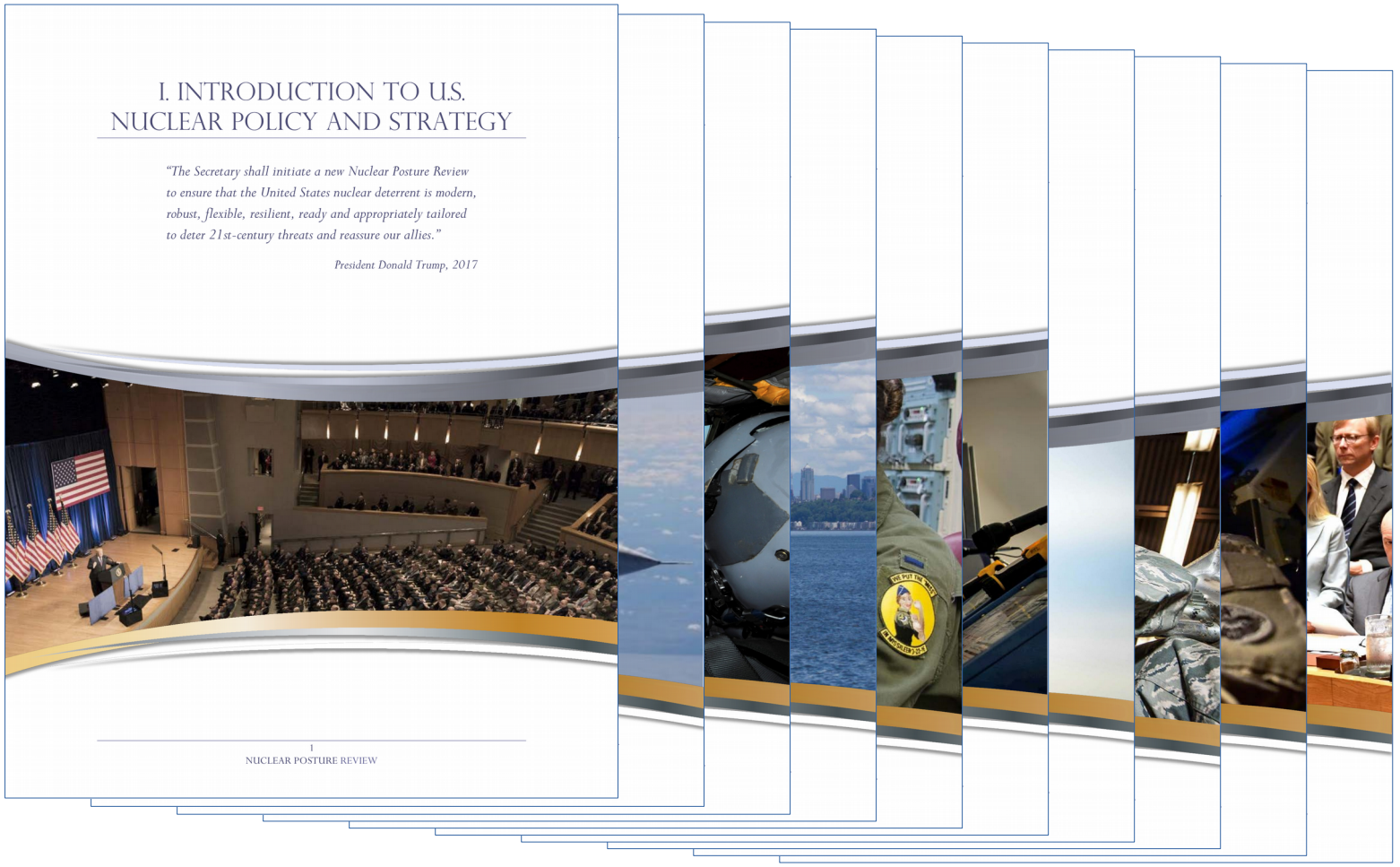
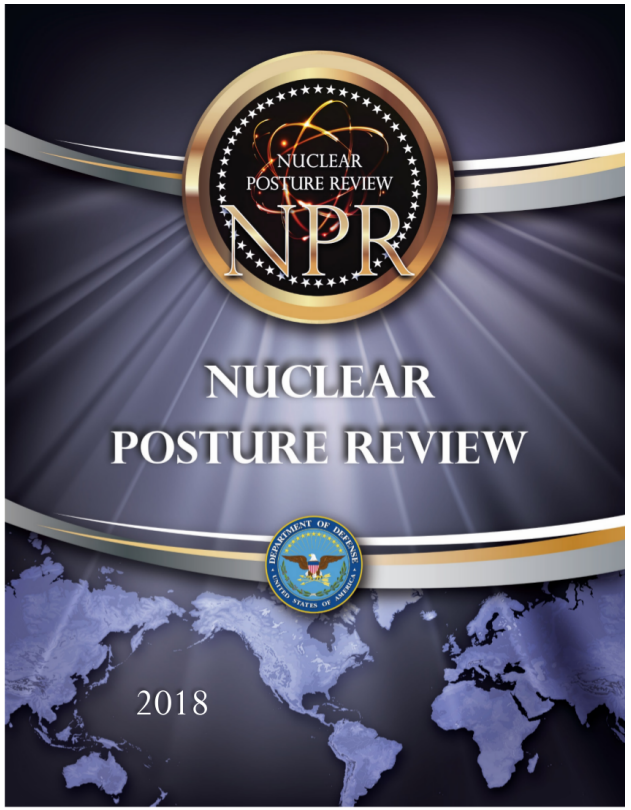
The 2018 Nuclear Posture Review



Cole D. Pruitt
Radiochemistry Group, WUSTL



Requested Jan 17, 2017
Released Feb 2, 2018

Previous NPRs:
1994 (classified)
2001 (classified)
2010 (public)

CONTENTS

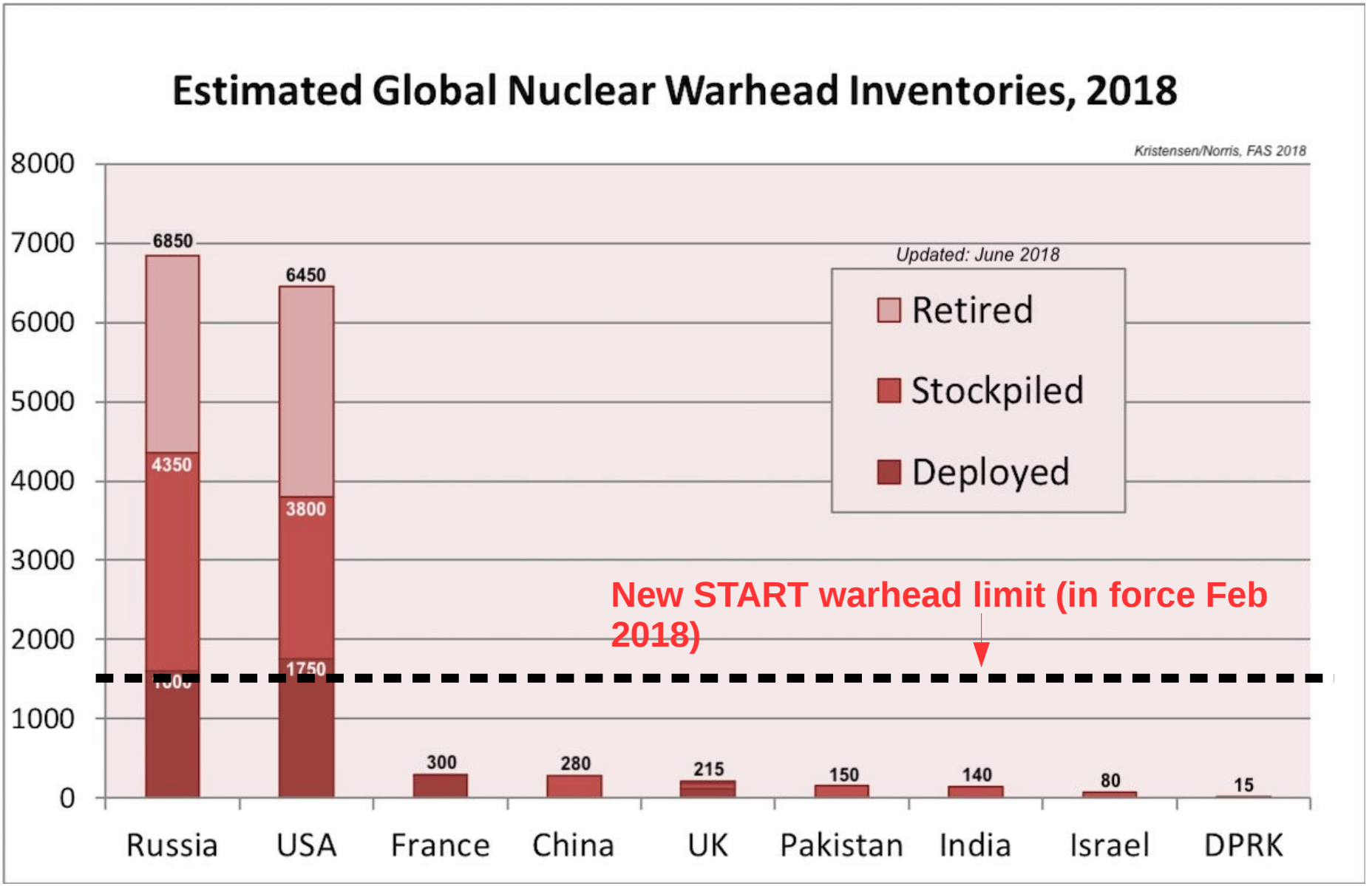
"A periodic review of United States nuclear capabilities, strategic plans, objectives, and concerns, initiated by the president and prepared by the Department of Defense."

1. Current forces and infrastructure

2. Recapitalization campaign, the "Program of Record" (DoD/DOE modernization)

3. Assessment of risks and international threat environment

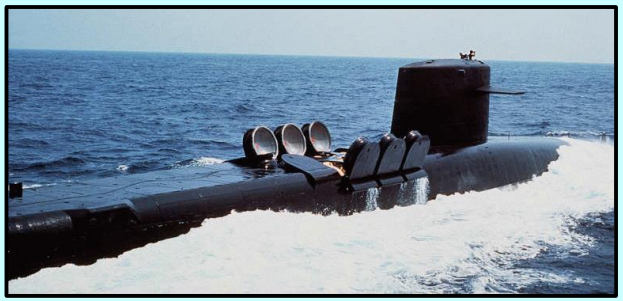
4. Objectives and strategic posturing



"This review rests on a bedrock truth: nuclear weapons have and will continue to play a critical role in deterring nuclear attack and in preventing large-scale conventional warfare between nuclear-armed states for the foreseeable future." - Secretary of Defense Mattis [2018 NPR, p. III]

The 2018 US Nuclear Triad

SSBNs (14 Ohio-class)



Source: globalsecurity.org

- Each has 20 Trident II SLBMs w/ up to 8 MIRVed warheads
- 12 at sea, 2 at port at any time
- Launch range: 6100 naut. mi.
- Cost per boat: $2 billion (1990s)
- Scheduled retirement: 2030s

ICBMs (400 Minuteman IIIs)

Source: military-today.com

- 200 MIRV-capable, 200 singletons
- Deployed at USAF bases in MT, ND, and WY
- Launch range: ~8000 miles
- Cost per missile: $7 million (1970s)
- Scheduled retirement: after 2030

Strategic Bombers (20 B-2As, 46 B-52Hs)

Image credit: USAF, Tech. Sgt. Justin D. Pyle.

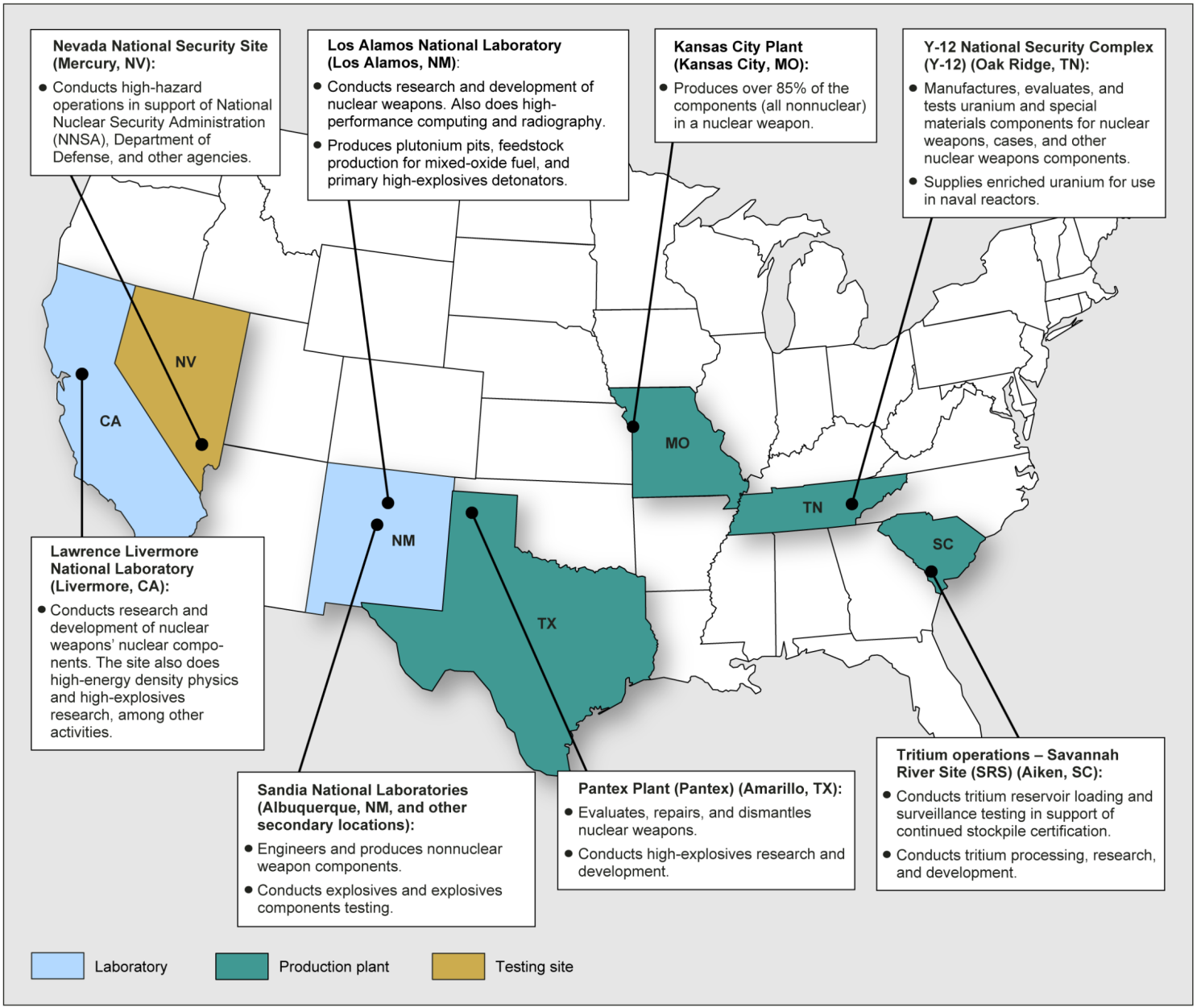
- B-2s operate from Whiteman AFB (MO); B-52s from LA & ND
- Flight range: 6100 naut. mi.
- Cost per B-2A: $2 billion (incl. operation, through 2004)
- Scheduled retirement: 2030s (B-2A), 2050 (B-52H)

ICBMs provide responsiveness, SLBMs provide survivability, and bombers provide flexibility and recall capability [1].

Admiral James O. Ellis, Jr.
former commander of STRATCOM

Warhead	Description	Yield (kTs)	Number deployed	Total available	Delivery vehicle
W80-1	Dial-a-yield cruise missile	5-150	~200	528	B52-H Stratofortress
B61-7/-11	Dial-a-yield bomb	0.3-340	~100	452	B-2A Spirit
B83-1	Dial-a-yield bomb, most powerful in arsenal	~10-1200			
B61-3/-4	Dial-a-yield, tactical use	0.3-170	150 (NATO)	300	F-15E, F-16
W76-0/-1	Most numerous in arsenal	100	~890	1536	Trident II via SSBN
W88	Most modern in arsenal	455		384	
W87	Comparable to W88	300	~200	200	Minuteman III (ICBM)
W78	MIRV-targetable	335	~200	600	Minuteman III (ICBM)

Figure 1: National Nuclear Security Administration (NNSA) Nuclear Weapons Design Laboratories, Production Plants, and Testing Sites



Sources: National Nuclear Security Administration; Map Resources (map). | GAO-15-331

1. Current forces and infrastructure

2. Recapitalization campaign, the "Program of Record" (DoD/DOE modernization)

3. Assessment of risks and international threat environment

4. Objectives and strategic posturing

DOD NUCLEAR ENTERPRISE FUNDING

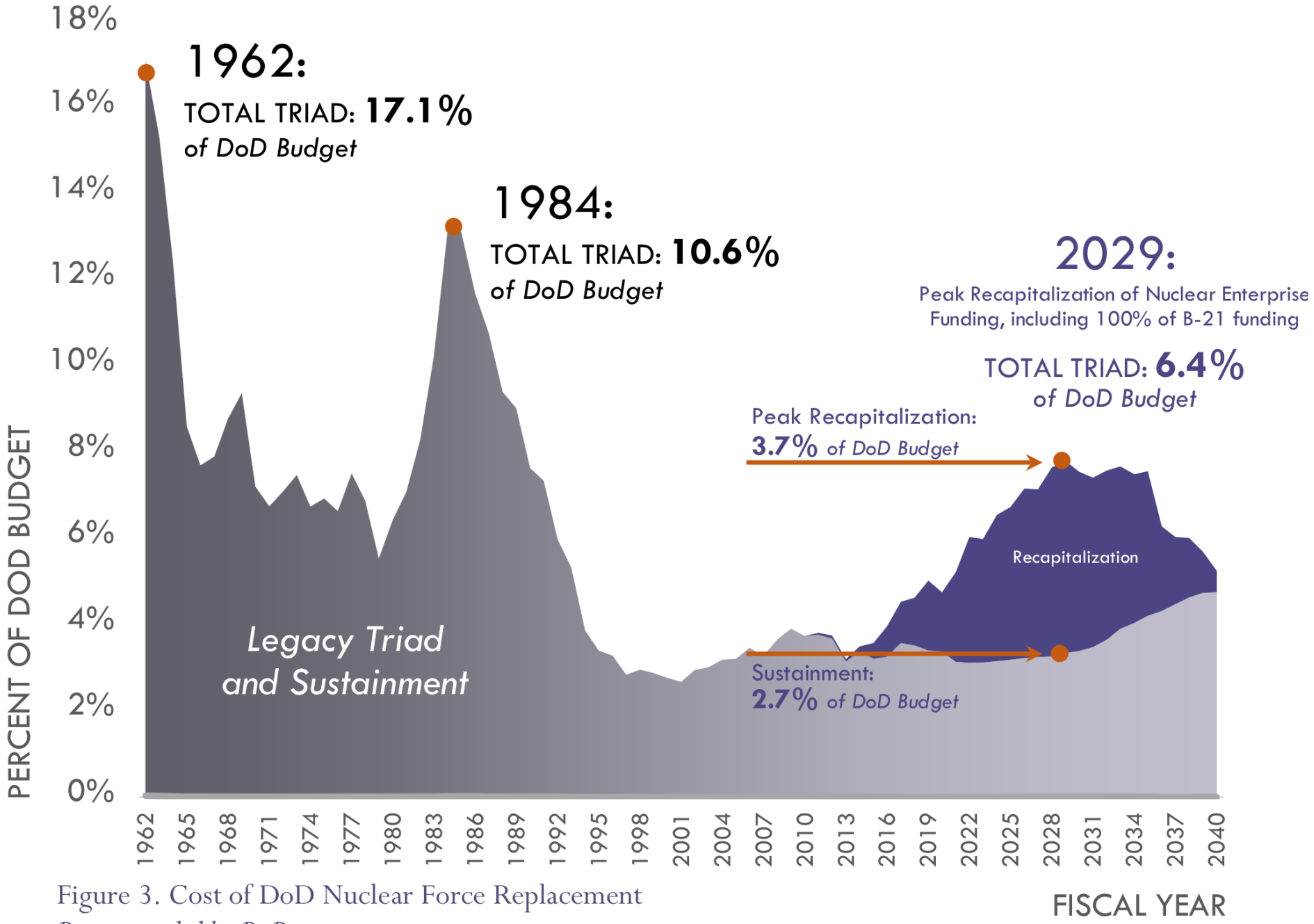
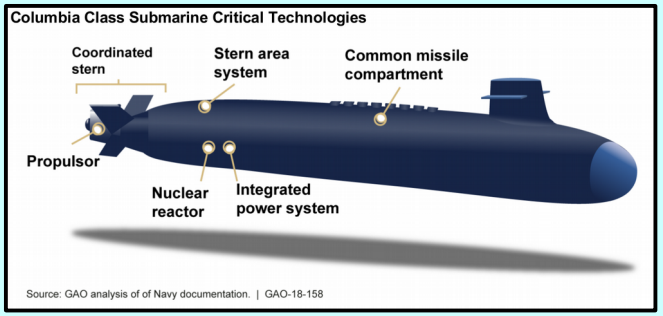


Figure 3. Cost of DoD Nuclear Force Replacement
Data provided by DoD

[2018 NPR, p. 52]

The Future US Nuclear Triad

SSBNs (12 COLUMBIA-class)



Source: GAO-18-158, Dec 2017

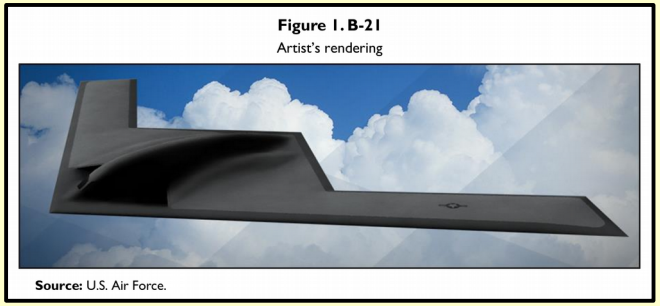
- Contract awarded a year ago today to General Dynamics Electric Boat ($5.1 B)
- Construction starts 2021
- Scheduled first delivery: 2031
- GAO: “Critical technologies remain unproven”, likely delays + cost ballooning

ICBMs (GBSD)

Source: Lockheed Martin. Accessed at nps.gov.

- USAF awarded Tech. Matur. and Risk Reduction contracts Aug 2017 (Boeing & Northrop Grumman)
- Incremental, modular approach rather than complete re-design
- Sticking w/ silos (not mobile)
- Scheduled delivery: late 2020s

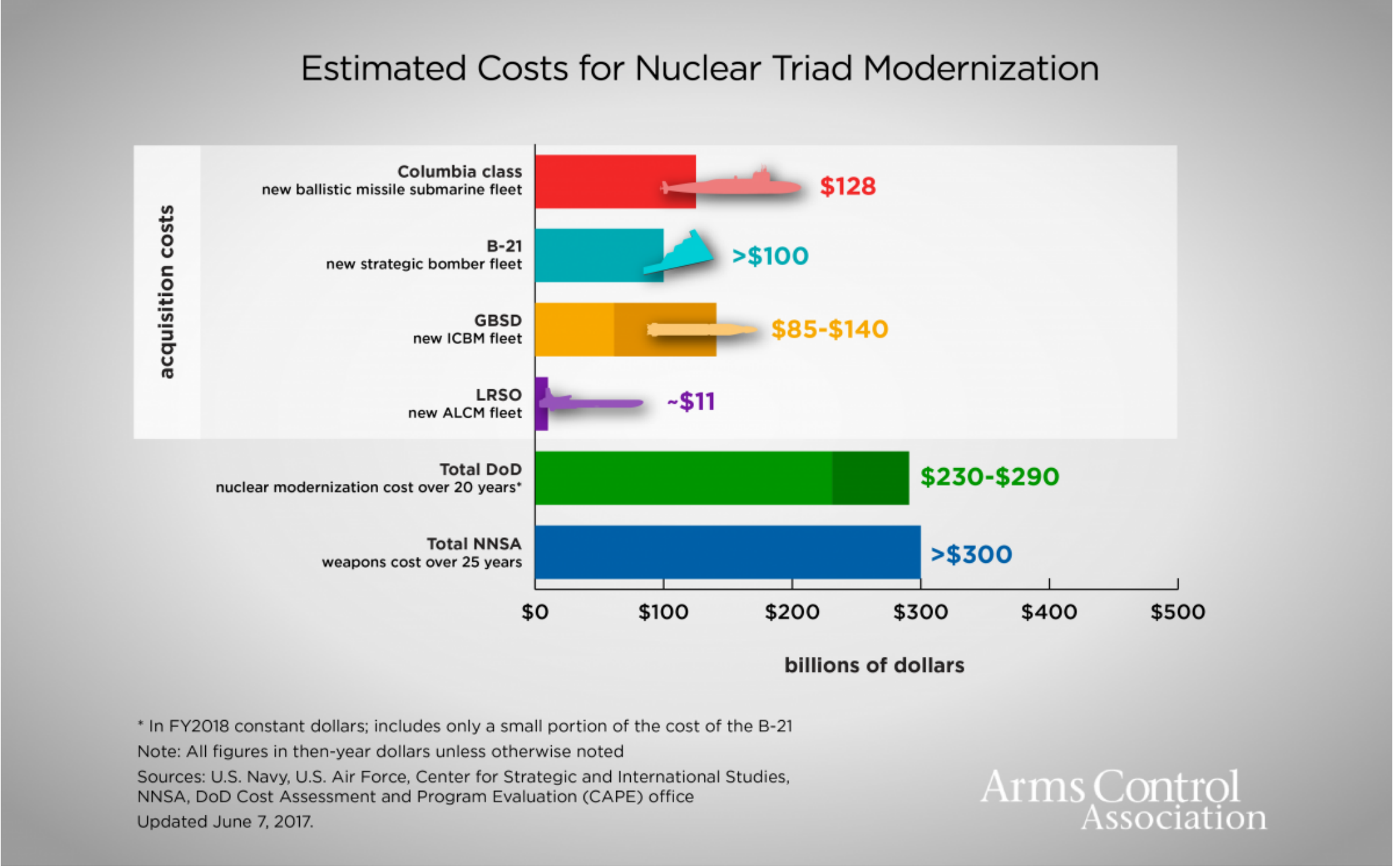
Strategic Bombers (B-21 Raider)



From CRS report R44436, June 2017

- 2006 QDR requests new bomber by 2018 (20 years early) Congress disagrees in 2010
- By design, $550 million/plane (amortized over 100 planes)
- NG awarded contract, Oct 2015
- Projected IOC: late 2020s

Given the criticality of effective U.S. nuclear deterrence to the safety of the American people, allies and partners there is no doubt that the sustainment and replacement program should be regarded as both necessary and affordable. [2018 NPR, p. XI]



Total price tag from 2017-2046: $1,200 billion (2018 dollars) [FAS]

Excerpts from NPR "wish list"

DoD and NNSA will develop for deployment a low-yield SLBM warhead to ensure a prompt response option that is able to penetrate adversary defenses.

…controversial decision. Can't tell a low-yield from a high-yield warhead in the air!

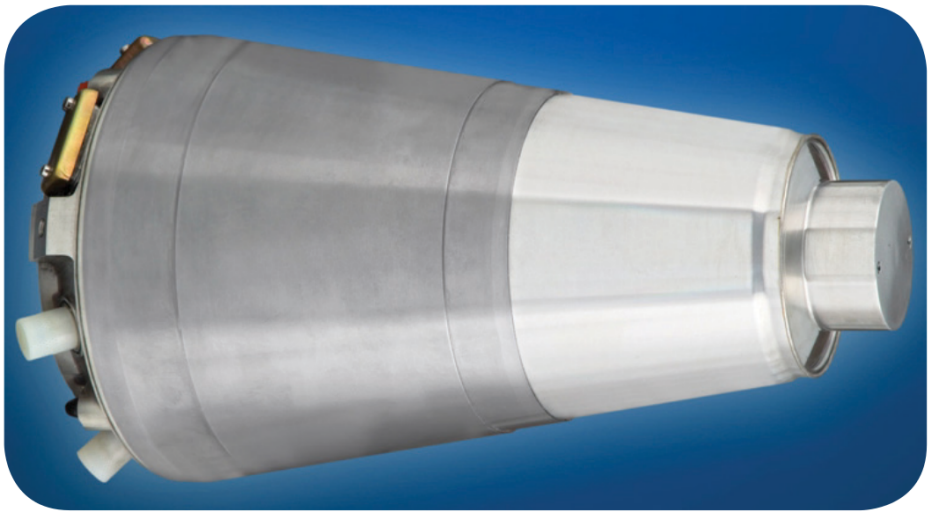
In addition to this near-term step, for the longer term the United States will pursue a nuclear-armed SLCM, leveraging existing technologies to help ensure its cost effectiveness.

…reversing 2010 NPR decision whereby Tomahawk cruise missile was retired, between 2010-2013

- Completing the W76-1 LEP by Fiscal Year (FY) 2019; ...including "Super Fuse" (next slides)
- Completing the B61-12 LEP by FY2024; ...new tail kits for guided bombs (a first!), for $10 B
- Completing the W88 alterations by FY2024; ...explosives and AF&F replacement (like W76-1)
- Sustaining the B83-1 past its currently planned retirement date until a suitable replacement is identified; and, …reversing Obama-era decision to retire

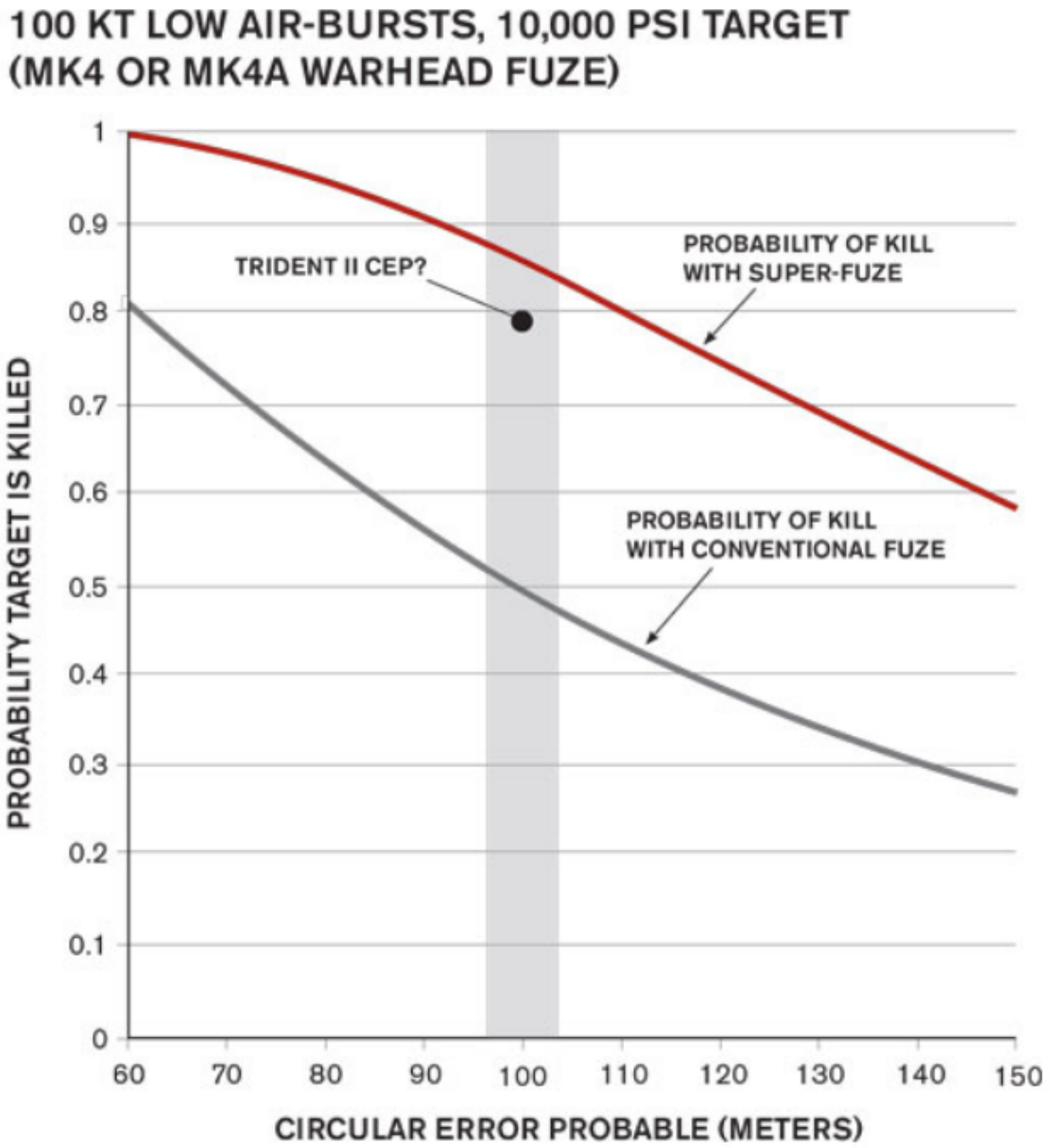
[2018 NPR p. XII, XIV-XV, 54-55, 61]

W76-1 LEP



W76-1 Arming, Fuzing and Firing assembly.

- Refurbishment of W76-0 (SLBM warhead), extending service life from 20 years to 60 years. Part of U.S. Navy's W76-1/Mk4A modernization program since 2009.
- "The W76-1 LEP is fully consistent with the U.S. commitment not to develop new nuclear warheads." [NNSA W76-1 LEP Factsheet, Nov 2017]
- Three-quarters done by Nov. 2016 [NNSA W76-1 LEP Factsheet, Nov 2017]
- "Will complete W76-1 LEP by FY 2019" [2018 NPR, p. XIV, p. 61]



$$P_B \sim \frac{\sqrt[3]{Yield}}{Distance^3}$$

For purposes of US SLBMs:

For Russian hard targets (e.g., ICBM silos), US *needs less than half as many warheads* to guarantee the same destruction probability

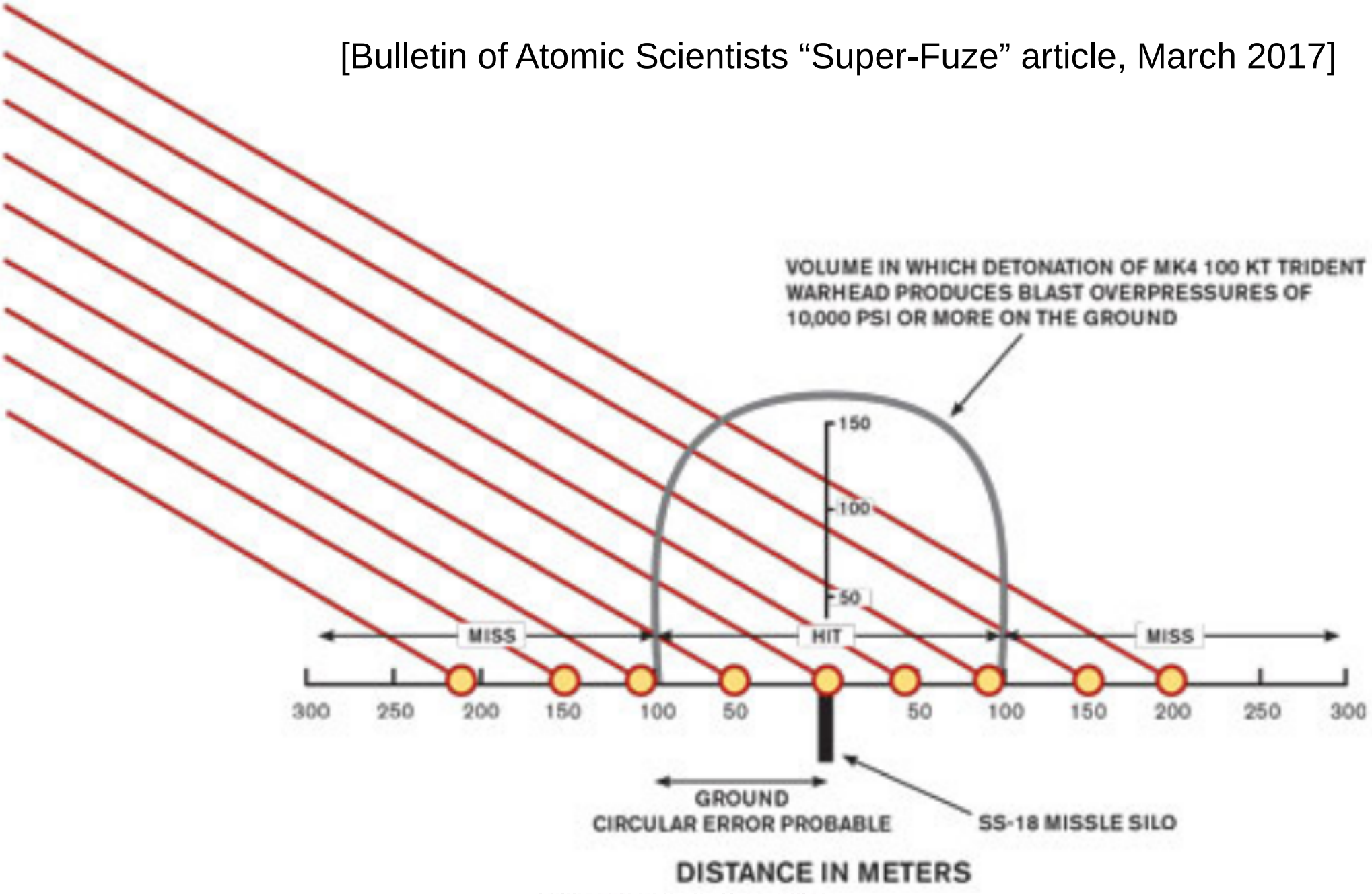
Multiple Independent Re-entry Vehicle (MIRV) technology

Eight dummy warheads from a single Peacekeeper missile (since retired) during a DoD test.

Image Credit: David James Paquin. Accessed on Wikipedia [ref]

DETONATION SPREAD: CONVENTIONAL BALLISTIC MISSILE FUZE

[Bulletin of Atomic Scientists “Super-Fuze” article, March 2017]



Excerpts from NPR “wish list”

- Provide the enduring capability and capacity to produce plutonium pits at a rate of no fewer than 80 pits per year by 2030. A delay in this would result in the need for a higher rate of pit production at higher cost. ...more on this in next slides
- Ensure that current plans to reconstitute the U.S. capability to produce lithium compounds are sufficient to meet military requirements. ...^{6}LiD + n → α + t + d + 5 MeV → 2α + n + 22.6 MeV
- Fully fund the Uranium Processing Facility and ensure availability of sufficient low-enriched uranium to meet military requirements. …Navy actively examining LEU for reactors since 2015
- Ensure the necessary reactor capacity to produce an adequate supply of tritium to meet military requirements. …see above. t + d in core of primary used to implement “dial-a-yield”
- Maintain and enhance the computational, experimental, and testing capabilities needed to annually assess nuclear weapons. …US has signed but not ratified CTBT. Testing moratorium in effect. 2001 NPR against ratification, 2010 NPR for CTBT ratification.

Plutonium pit manufacture at LANL

"Provide the enduring capability and capacity to produce plutonium pits at a rate of no fewer than 80 pits per year by 2030. A delay in this would result in the need for a higher rate of pit production at higher cost." [2018 NPR, p. XV, p. 64]

"...nearly all current stockpile pits having been produced from 1978-1989." [2018 NPR, p. 62]

NNSA National Nuclear Security Administration

Plutonium Pit Production Mission

"An effective, responsive, and resilient nuclear weapons infrastructure [that can] adapt flexibly to shifting requirements" - *2018 Nuclear Posture Review*

Future **Recapitalized infrastructure to produce 80 pits per year in 2030 across two NNSA sites**

To meet stockpile requirements, NNSA's recommended alternative is to repurpose the Mixed Oxide Fuel Fabrication Facility (MOX) at the Savannah River Site (SRS) to produce 50 pits per year with an enduring mission of at least 30 pits per year at Los Alamos National Laboratory (LANL)

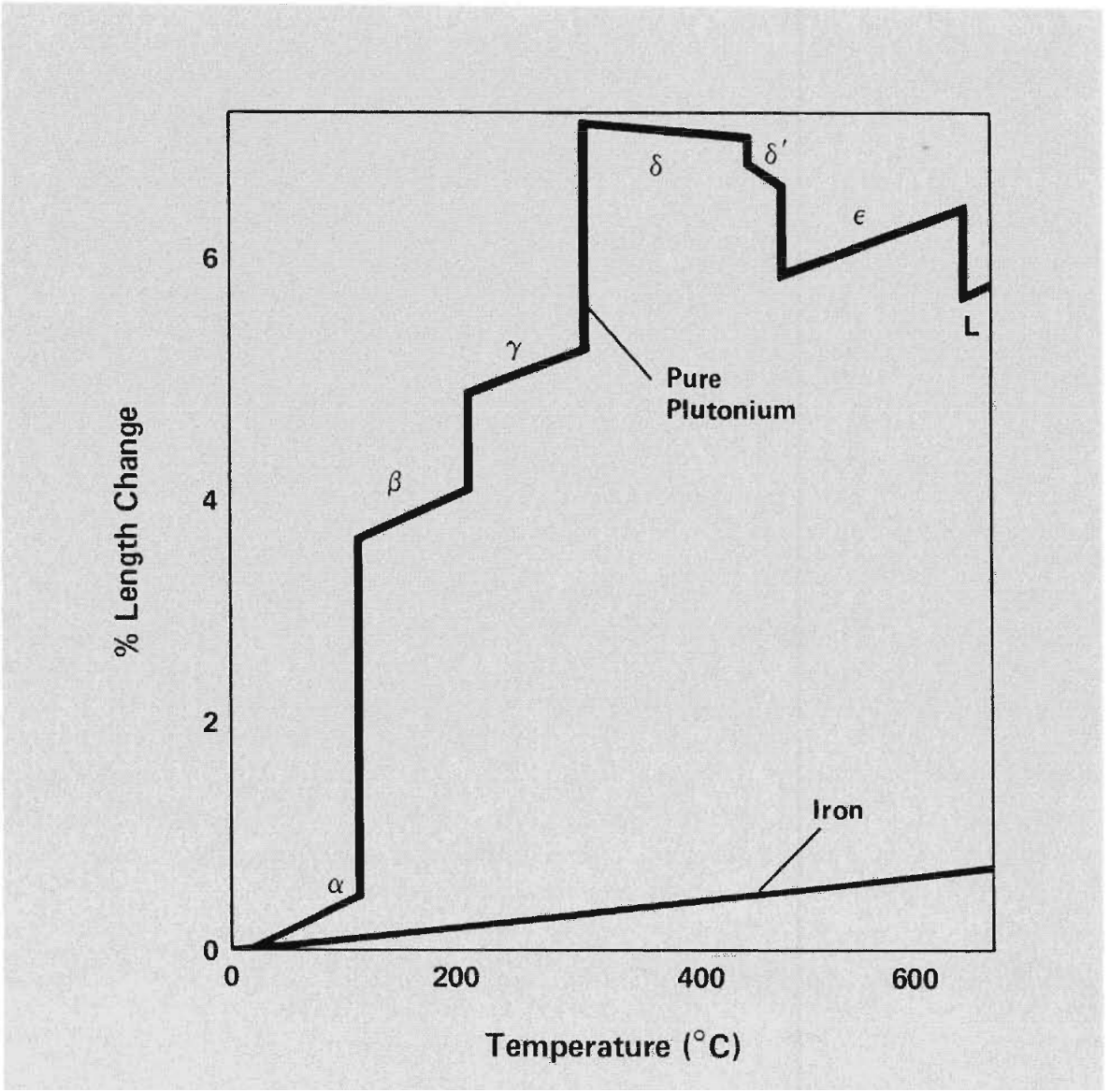
- Maintains LANL as the Nation's *Plutonium Center of Excellence for R&D*
- Is the lowest risk approach
- Improves resiliency, flexibility, and redundancy by not relying on a single site
- Meets requirements of Nuclear Weapons Council and direction of 2018 Nuclear Posture Review

Mixed Oxide Fuel Fabrication Facility at Savannah River Site

Photo from LANL Press Release (April 2012).

Excerpted from NNSA Fact Sheet (May 2018). Source: energy.gov

Plutonium chemistry



	Crystal Structure	Density (g/cm^3)
α	Simple Monoclinic	19.86
β	Body-Centered Monoclinic	17.70
γ	Face-Centered Orthorhombic	17.14
δ	Face-Centered Cubic	15.92
δ′	Body-Centered Tetragonal	16.00
ϵ	Body-Centered Cubic	16.51
L	Liquid	16.65

Trivalent metals (Al^{3+}, Ga^{3+}) stabilize δ-phase.

$^{27}Al(\alpha,n)^{30}P$ reaction with 5.244 MeV α-decay from ^{239}Pu, making unwanted neutrons!

$^{69,71}Ga(\alpha,n)^{72,74}As$ OK – coulomb barrier has gone up, BE curve leveled off

Plutonium phase diagram

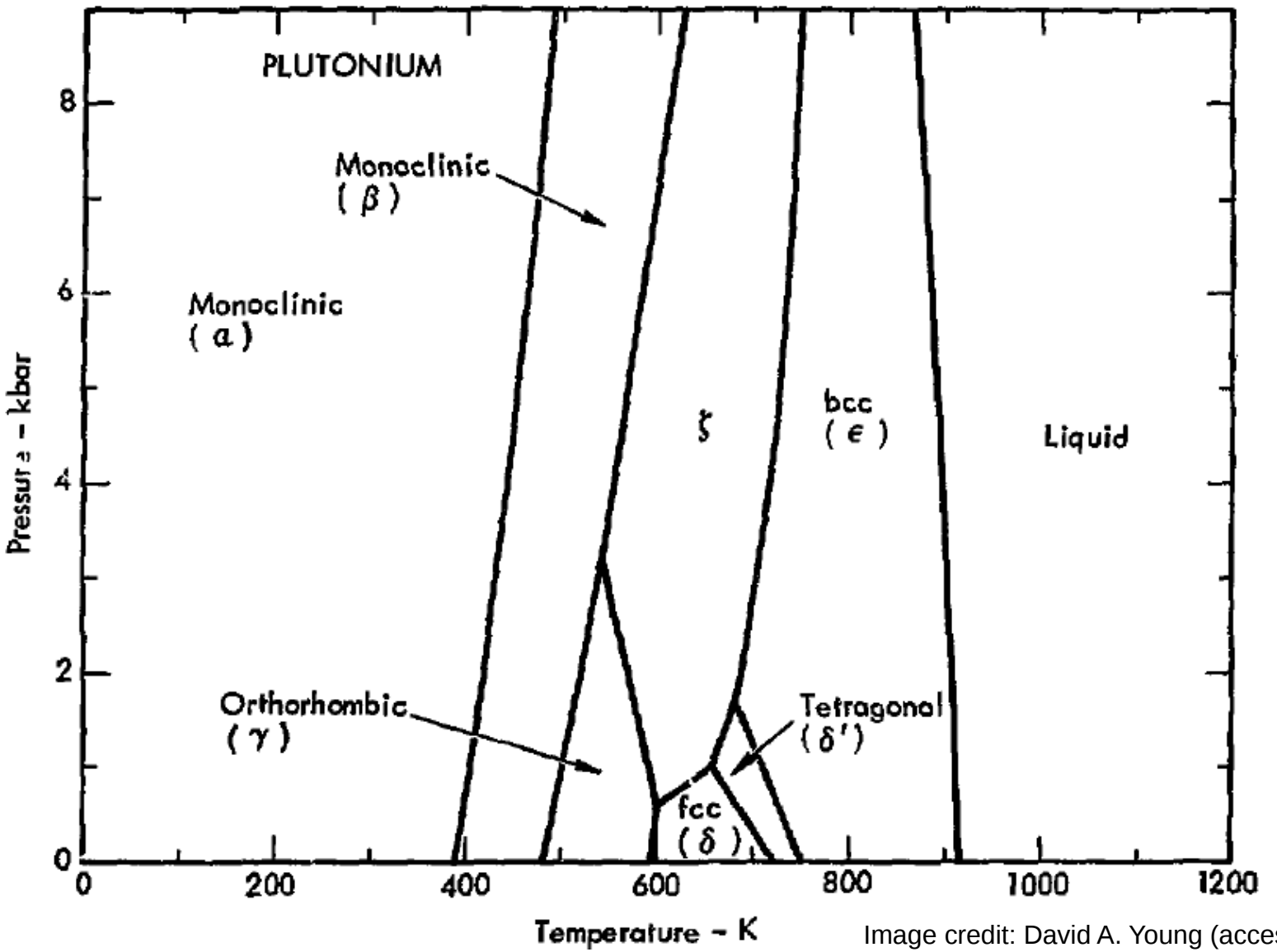
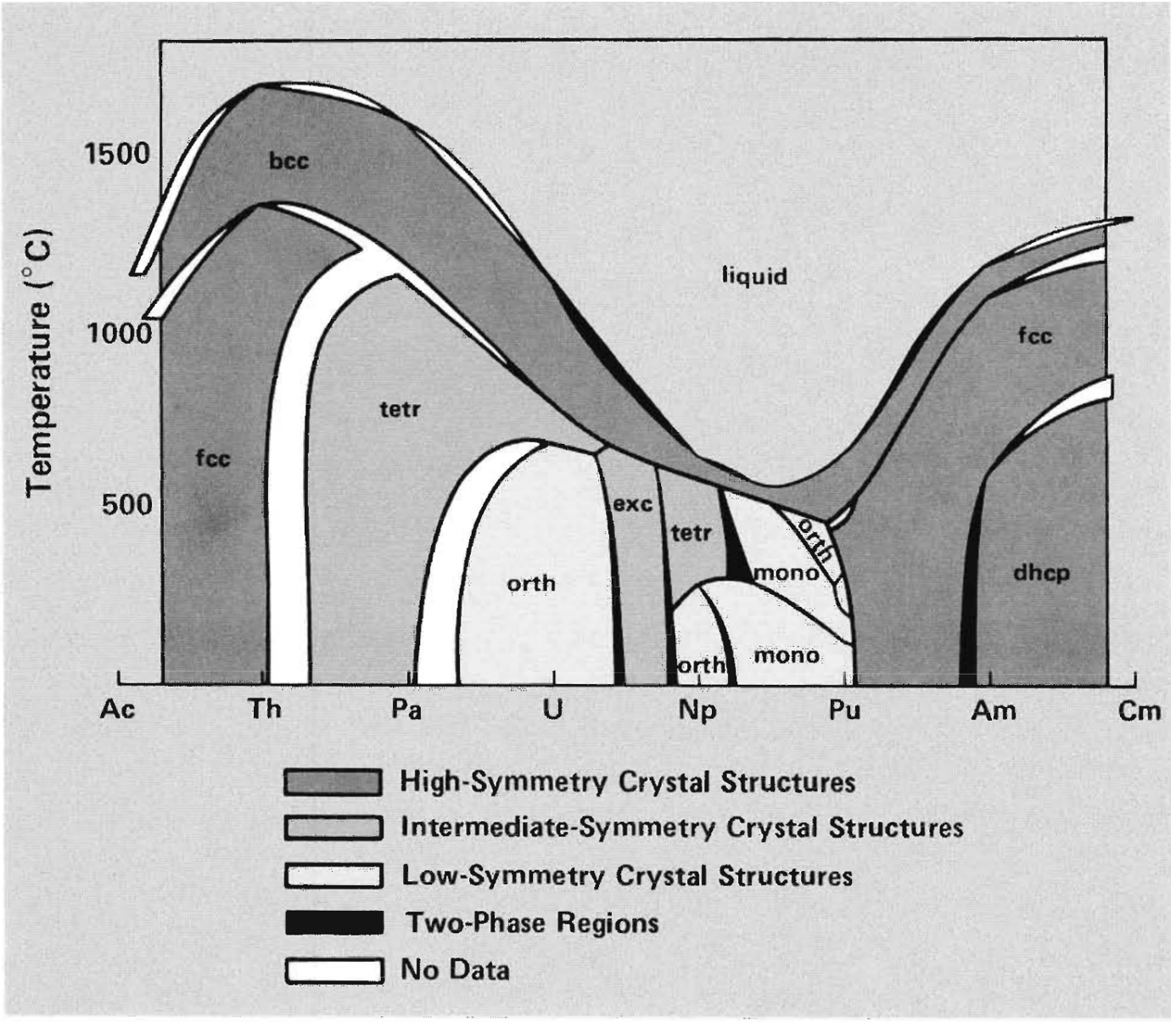


Image credit: David A. Young (accessed at osti.gov)



5f electrons are KEY to actinide chemistry:

Pu config = $[Rn]7s^2 5f^6$

f-electrons not as localized through Pu → can bond, leading to 3 dramatic effects:

1. Symmetry reduced
2. Phases increased
3. MP decreased

How to explain?

1. f-orbitals: odd parity
2. threshold effects
3. liquid allows rotation

Source: “Plutonium: A Wartime Nightmare but a Metallurgist’s Dream”. Los Alamos Science, Spring/Winter 1983

1. Current forces and infrastructure

2. Recapitalization campaign, the "Program of Record" (DoD/DOE modernization)

3. Assessment of risks and international threat environment

4. Objectives and strategic posturing

Assessment of Risks

"The U.S Joint Chiefs of Staff recently assessed that the emerging security environment, 'can be described by simultaneous and connected challenges — contested norms and persistent disorder.'" [2018 NPR, p. 6]

"Until the 'fundamental transformation of the world political order' takes place, U.S. nuclear weapons remain necessary to prevent war and safeguard the Nation." [NPR 2018, p. 18]

"Given the increasing prominence of nuclear weapons in potential adversaries' defense policies and strategies, and the uncertainties of the future threat environment, U.S. nuclear capabilities and the ability to quickly modify those capabilities can be essential to mitigate or overcome risk, including the unexpected." [2018 NPR, p. IX]

"Since 2010, we have seen the return of Great Power competition." [2018 NPR, p. 6]

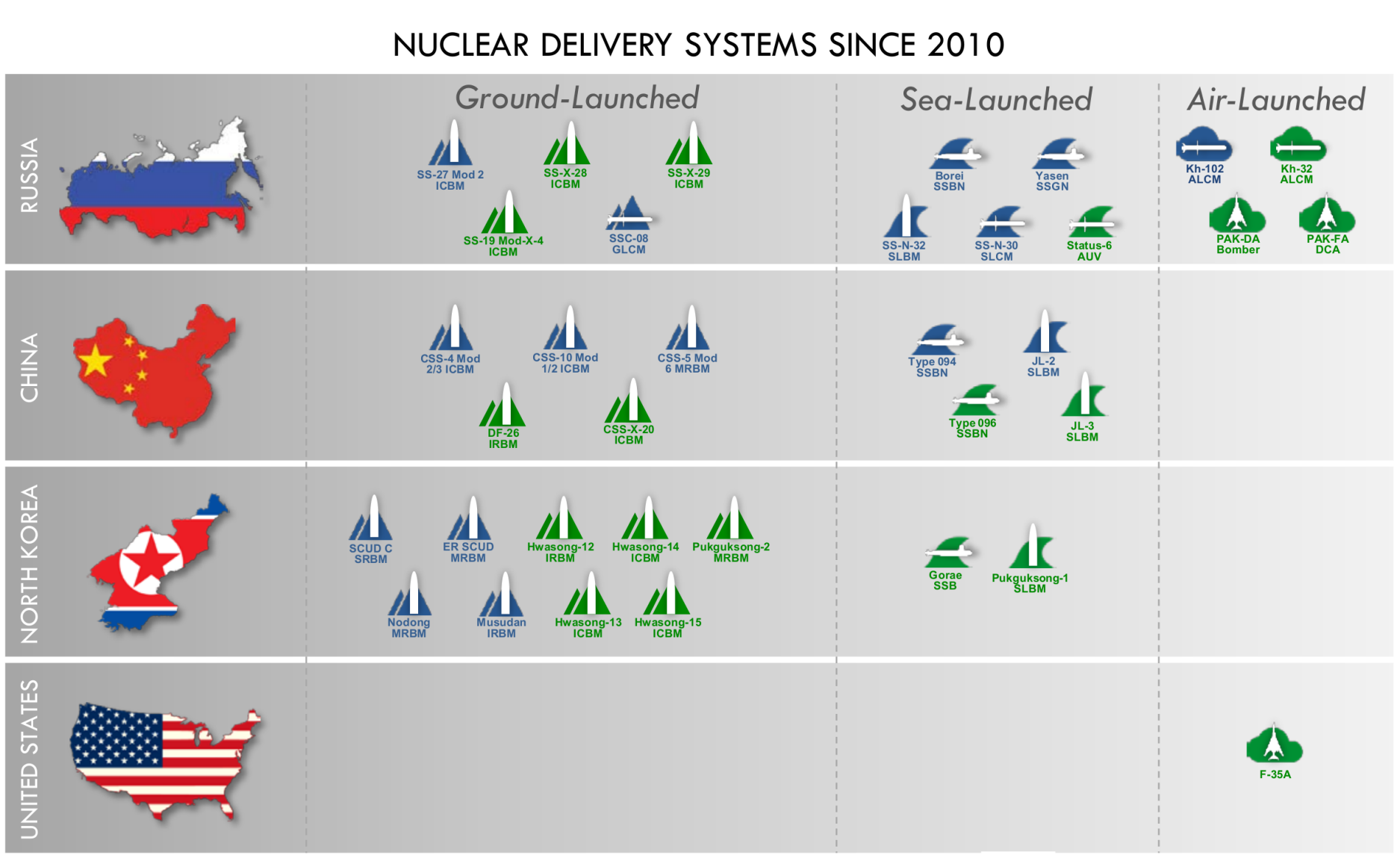
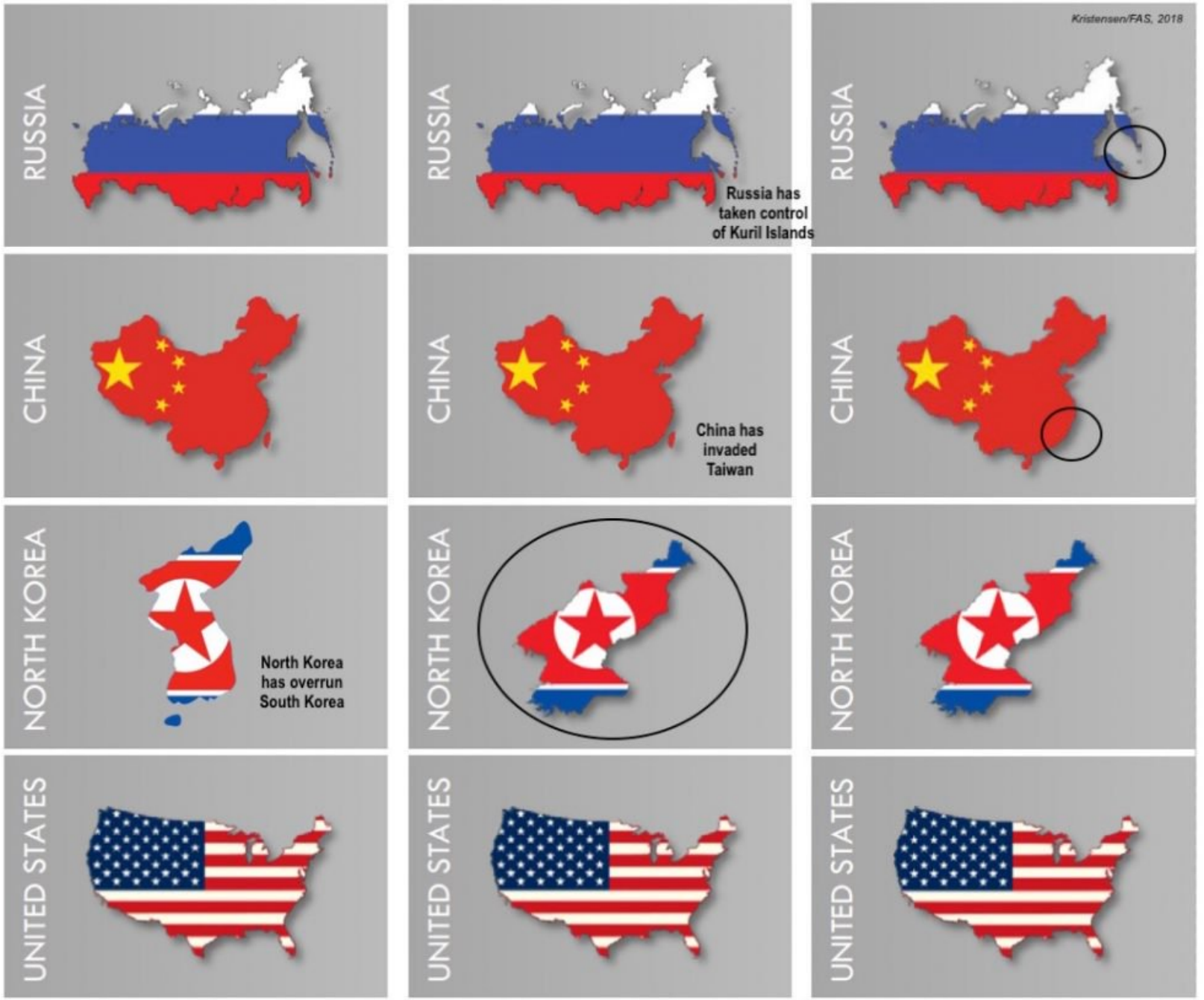


Figure 1. Nuclear Delivery Systems Since 2010
Data provided by the DoD

"In addition, for over two decades the US has deployed no nuclear capabilities..." [2018 NPR, p. 2]

"Don't Know Much About Geography" - Nuclear Posture Review Map Corrections



Final draft report leaked to and published by Huffington Post on January 11, 2018

First official public DOD version published February 2, 2018

Second official public DOD version published February 3, 2018

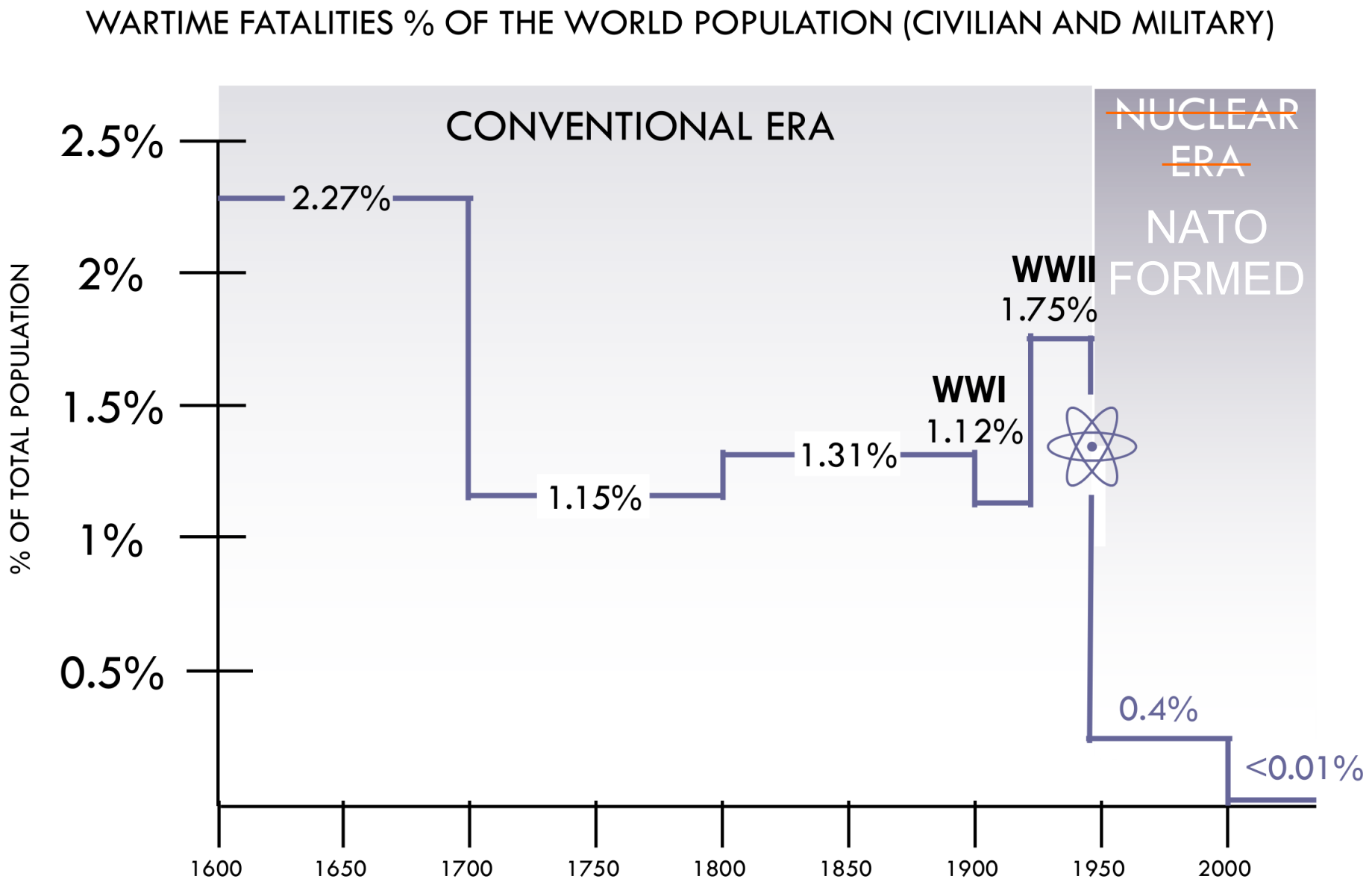


Figure 2. Wartime Fatalities Percentage of World Population
Data from the DoD Historical Office

1. Current forces and infrastructure

2. Recapitalization campaign, the "Program of Record" (DoD/DOE modernization)

3. Assessment of risks and international threat environment

4. Objectives and strategic posturing

US Nuclear Posture

- Deterrence of nuclear and non-nuclear attack;
- Assurance of allies and partners;
- Achievement of U.S. objectives if deterrence fails; and
- Capacity to hedge against an uncertain future.

[2018 NPR, p. VII]

1. Preventing nuclear proliferation and nuclear terrorism;
2. Reducing the role of U.S. nuclear weapons in U.S. national security strategy;
3. Maintaining strategic deterrence and stability at lower nuclear force levels;
4. Strengthening regional deterrence and reassuring U.S. allies and partners; and
5. Sustaining a safe, secure, and effective nuclear arsenal.

[2010 NPR, p. 2]

Articulation of U.S. Declaratory Policy on Potential Use of Nuclear Weapons

The United States would only consider the employment of nuclear weapons in extreme circumstances to defend the vital interests of the United States, its allies, and partners. Extreme circumstances could include significant non-nuclear strategic attacks. Significant non-nuclear strategic attacks include, but are not limited to, attacks on the U.S., allied, or partner civilian population or infrastructure, and attacks on U.S. or allied nuclear forces, their command and control, or warning and attack assessment capabilities.

The United States will not use or threaten to use nuclear weapons against non-nuclear weapons states that are party to the NPT and in compliance with their nuclear non-proliferation obligations.

Given the potential of significant non-nuclear strategic attacks, the United States reserves the right to make any adjustment in the assurance that may be warranted by the evolution and proliferation of non-nuclear strategic attack technologies and U.S. capabilities to counter that threat.

[2018 NPR, p. 21]

- The United States will continue to strengthen conventional capabilities and reduce the role of nuclear weapons in deterring non-nuclear attacks, with the objective of making deterrence of nuclear attack on the United States or our allies and partners the sole purpose of U.S. nuclear weapons. [2010 NPR, p. 17]

The United States will not seek Senate ratification of the Comprehensive Nuclear Test Ban Treaty, but will continue to observe a nuclear test moratorium that began in 1992. This posture was adopted with the understanding that the United States must remain ready to resume nuclear testing if necessary to meet severe technological or geopolitical challenges.

[2018 NPR, p. 63]

- The United States will meet its commitment under Article VI of the NPT to pursue nuclear disarmament and will make demonstrable progress over the next five to ten years.

[2010 NPR, p. 16]

- Building on NPR analysis, the United States agreed with Russia to New START limits of 1,550 accountable strategic warheads, 700 deployed strategic delivery vehicles, and a combined limit of 800 deployed and non-deployed strategic launchers.

[2010 NPR, p. ix]

- The United States will not conduct nuclear testing, and will pursue ratification and entry into force of the Comprehensive Nuclear Test Ban Treaty.

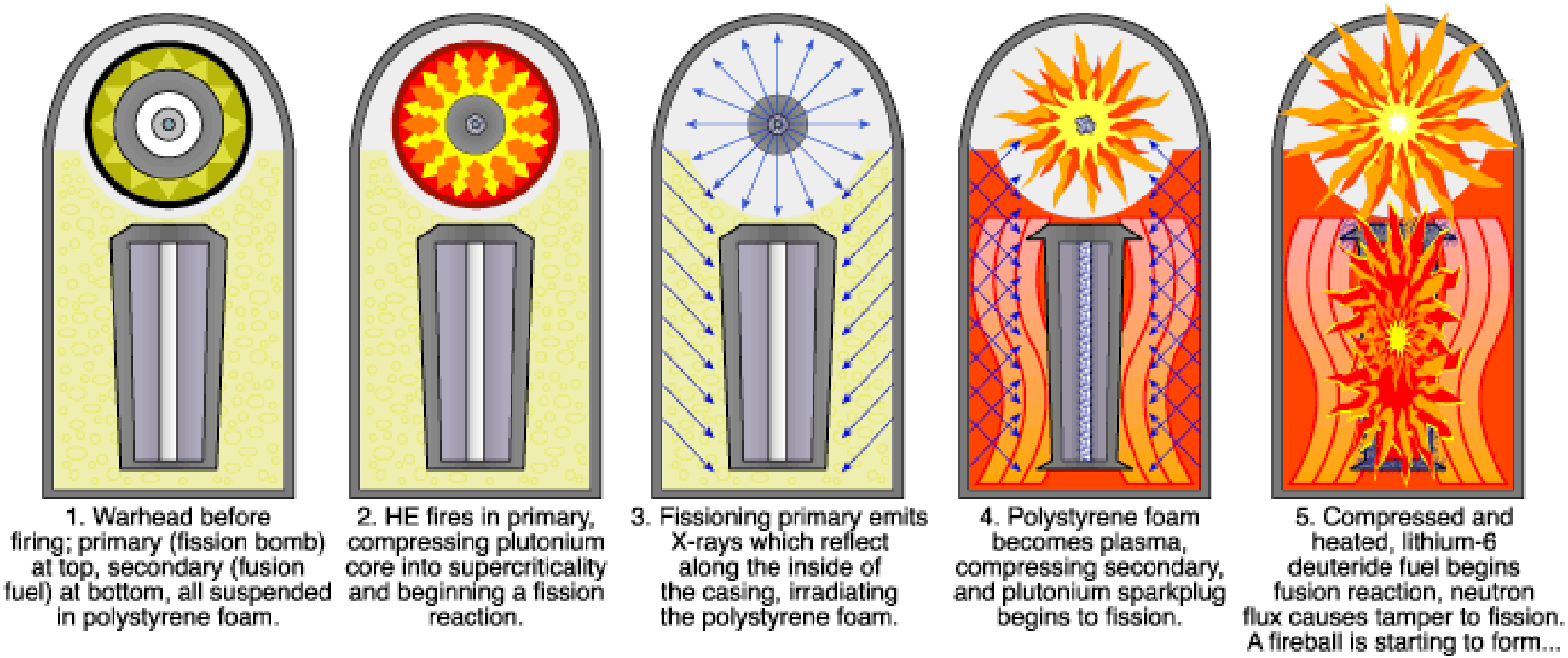
[2010 NPR, p. 38]


WORLD-WIDE DELIVERY
IN 30 MINUTES OR LESS
MINUTEMAN II
OR YOUR NEXT ONE IS
FREE
NO-LONE ZONE
TWO-MAN
CONCEPT
MANDATORY

References

1. Hebert, Adam. The Future Missile Force. *Air Force Magazine*. October 2005.
2. “United States nuclear forces, 2018”. March 5, 2018, published online by Bulletin of Atomic Scientists.
3. “Plutonium: A Wartime Nightmare but a Metallurgist’s Dream.” Winter/Spring 1983, Los Alamos Science publication.

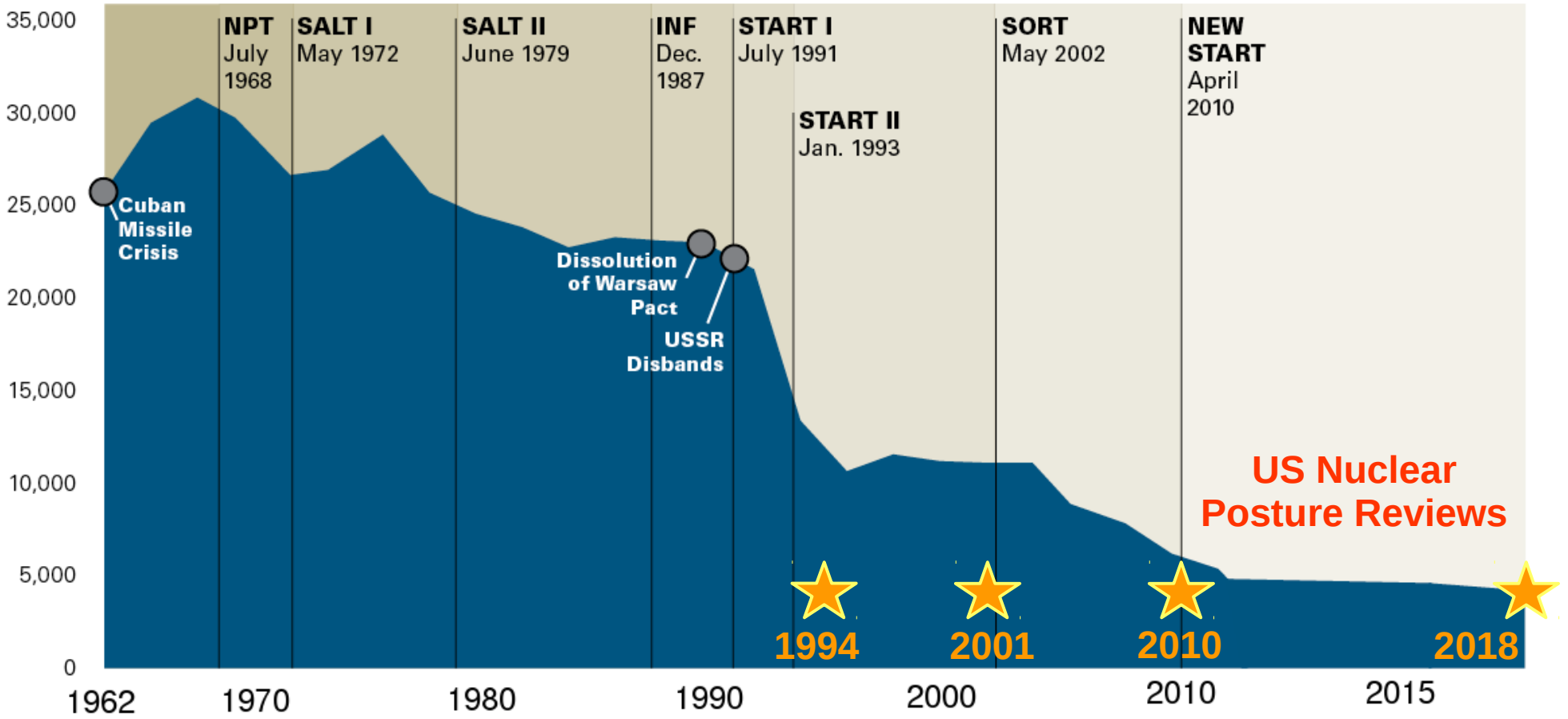
Teller-Ulam two-stage design



Teller-Ulam hydrogen bomb firing sequence, modified from Howard Morland, The Secret that Exploded (Random House, 1981). Accessed on Wikimedia Commons, uploaded by user fastfission.

U.S. Nuclear Weapons Stockpile, 1962-2017

Since the late-1960s, the United States and Russia have signed a series of nuclear arms treaties that have contributed to steep cuts in their active and inactive nuclear warhead stockpiles.



Sources: U.S. Department of State, U.S. Department of Defense, Arms Control Association. Updated: January 19, 2017.

DoD and NNSA will develop for deployment a low-yield SLBM warhead to ensure a prompt response option that is able to penetrate adversary defenses.

…controversial decision. Can't tell a low-yield from a high-yield warhead in the air!

In addition to this near-term step, for the longer term the United States will pursue a nuclear-armed SLCM, leveraging existing technologies to help ensure its cost effectiveness.

…reversing 2010 NPR decision whereby TLAM-N was retired between 2010-2013

- Completing the W76-1 LEP by Fiscal Year (FY) 2019; ...including "Super Fuse" (next slides)
- Completing the B61-12 LEP by FY2024; ...new tail kits for guided bombs (a first!), for $10 B
- Completing the W88 alterations by FY2024; ...explosives and AF&F replacement
- Synchronizing NNSA's W80-4 life extension, with DoD's LRSO program and completing the W80-4 LEP by FY2031; ...LRSO warhead revamp at LLNL and Sandia
- Advancing the W78 warhead replacement one year to FY19 to support fielding on GBSD by 2030 and investigate the feasibility of fielding the nuclear explosive package in a Navy flight vehicle; ...related to "3+2" plan for interoperable warhead
- Sustaining the B83-1 past its currently planned retirement date until a suitable replacement is identified; and, …reversing Obama-era decision to retire

[2018 NPR p. XII, XIV-XV, 54-55, 61]

Stockpile Stewardship and LEP: time management

"The principal capability tasks to be executed under NNSA's responsibility to maintain a safe, secure, and reliable U.S. nuclear weapons stockpile without nuclear-explosion testing are cyclic in nature, matched to various time scales:

1) decadal aging rates of stockpile components and advances in applicable knowledge and technology
2) multi-year production/assembly/testing cycles;
3) annual assessment, surveillance, and dismantlement activities; and
4) rapid response to significant finding investigations, or international events"

JASON report JSR-14-Task-006E Executive Summary, Jan 2015

- **Lifetimes of today's nuclear warheads could be extended for decades, with no anticipated loss in confidence, by using approaches similar to those employed in LEPs to date .**
- **The surveillance program is becoming inadequate. Continued success of stockpile stewardship requires implementation of a revised surveillance program.**

We conclude this section with a concern. All options for extending the life of the nuclear weapons stockpile rely on the continuing maintenance and renewal of expertise and capabilities in science, technology, engineering, and production unique to the nuclear weapons program.

JASON report JSR-09-334E Executive Summary, Sept 2009

Plutonium manufacture at Rocky Flats

Plutonium button produced at Rocky Flats.
Source: rockyflatsmuseum.org

U.S. Fish & Wildlife Service

Rocky Flats

National Wildlife Refuge | Colorado

Source: fws.gov website

- Open from 1952-1992, 20 mi from Denver, CO
- Used wrought-processing (rolling and pressing) and pouring molds (casting) to produce up to 1000 pits a year [LANL press release, April 2012]
- Raided by 80 FBI agents June 6, 1989 and huge environmental violations documented. Plutonium production suspended; Rockwell lost contract.
- 1992 plea agreement: Rockwell pleads guilty to 10 federal environmental crimes, largest hazardous waste fine in history: $18.1 million.
- Cleanup “finished” in 2005.
- Since 2007, a National Wildlife Refuge (surrounding the DoE Superfund site)
- 10 miles of hiking trails just opened Sept 15, 2018!