

# Module 6: Nuclear Arsenals

**ACDIS** program in arms control &  
domestic and international security



Part 1: Overview

# Phys 280 Session 17

## Module 6 – Nuclear Arsenals

RE4v1 due tomorrow, 4-1 at 10pm

→ RPV1 due next week, 4-8 !!

Extra credit assignment – ACDIS Seminar 4-14, 5pm, Coble Hall

## Golden Dome - A Scientific and Technical Assessment

Fred Lamb, Physics UIUC, Chair of the APS missile defense study

### Abstract:

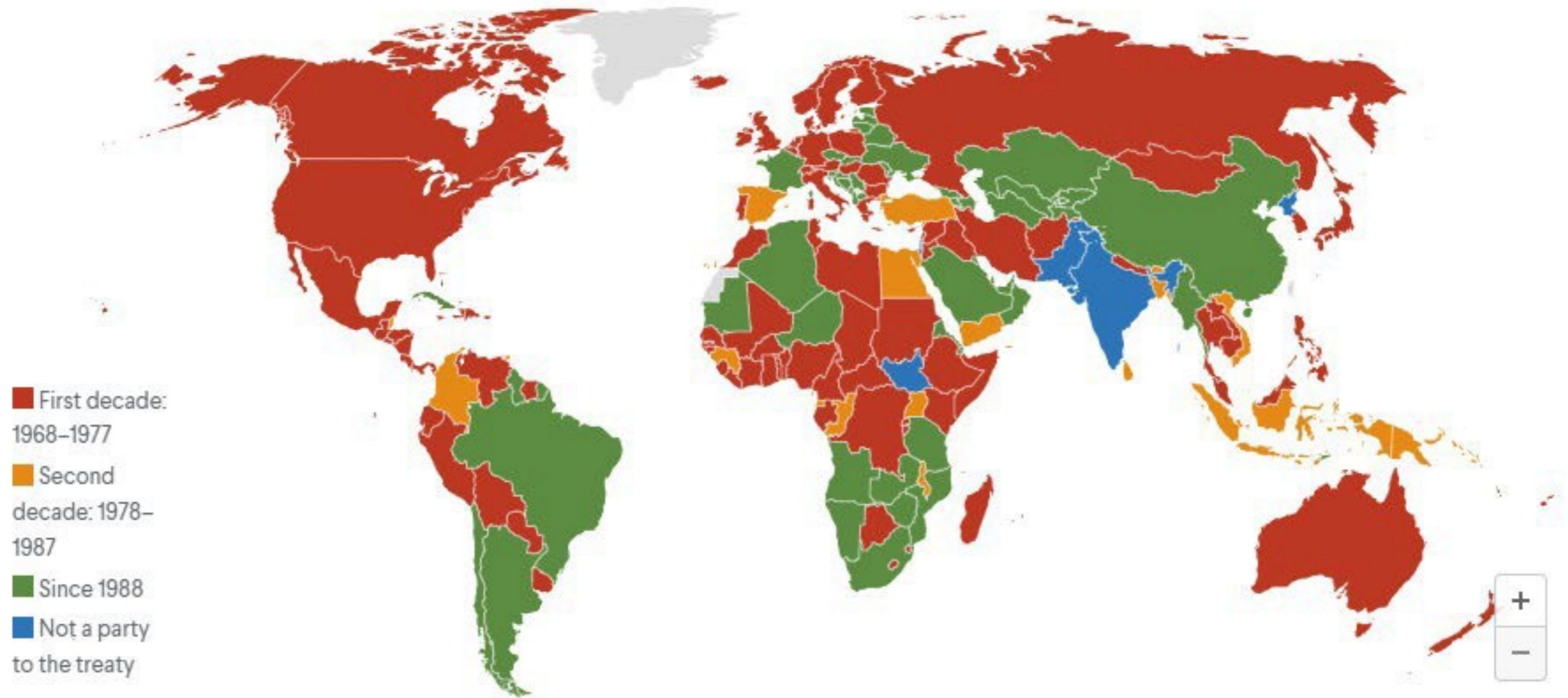
In May 2025, President Trump approved the Defense Department's architecture and implementation plan for "Golden Dome"—a multilayered defense system with ground-, sea-, and space-based components intended to protect the United States and its allies and their armed forces against attack by aircraft, ballistic missiles, hypersonic glide vehicles, cruise missiles, and drones fired at anytime from anywhere by any adversary, including peer and near-peer adversaries. This goal is clearly beyond reach anytime soon. Even attempting to create such a system would cost hundreds of billions of dollars or more and have other serious consequences.



# Status of Nuclear Nonproliferation Treaty

## Nuclear Nonproliferation Treaty Ratification

Most of the world has ratified the United Nations' signature treaty on limiting nuclear weapons since the treaty was first signed in 1968.



Note: North Korea acceded to the treaty in 1985 but withdrew in 2003.

Source: [United Nations](#). • [Get the data](#)

Modified Graphic From: [CFR, World 101](#)

**World101**  
From the Council on Foreign Relations



# Chain of Proliferation

The New York Times

December 9, 2008

## A Chain Reaction of Proliferation

"The Nuclear Express," a new book on the history of the atomic age, describes the interlocking web of influence and espionage behind the proliferation of nuclear technology.

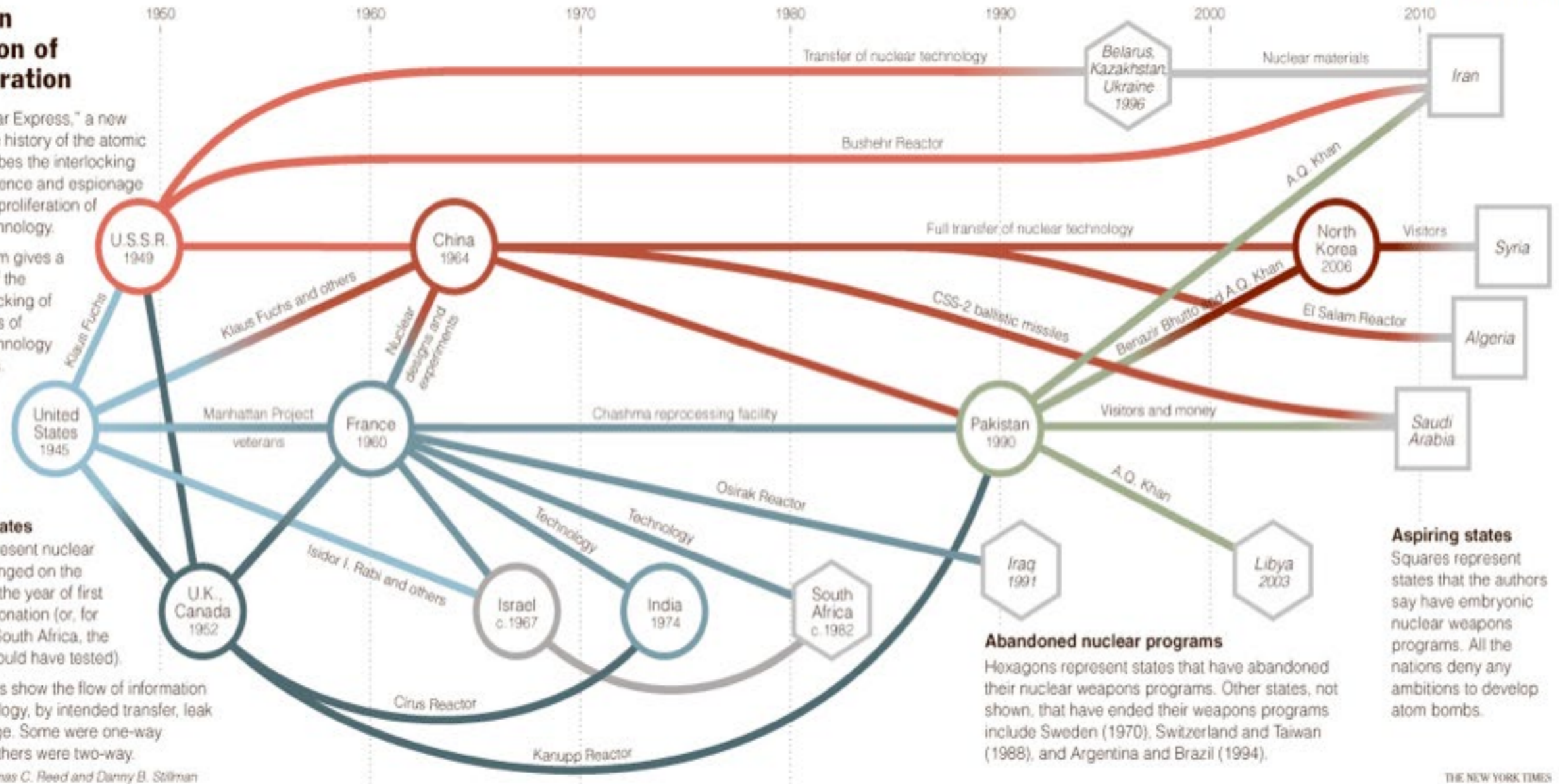
This diagram gives a summary of the authors' tracking of the transfers of nuclear technology and secrets.

### Nuclear states

Circles represent nuclear states, arranged on the timeline by the year of first nuclear detonation (or, for Israel and South Africa, the year they could have tested).

Connections show the flow of information and technology, by intended transfer, leak or espionage. Some were one-way transfers; others were two-way.

Sources: Thomas C. Reed and Danny B. Stillman



### Aspiring states

Squares represent states that the authors say have embryonic nuclear weapons programs. All the nations deny any ambitions to develop atom bombs.

### Abandoned nuclear programs

Hexagons represent states that have abandoned their nuclear weapons programs. Other states, not shown, that have ended their weapons programs include Sweden (1970), Switzerland and Taiwan (1988), and Argentina and Brazil (1994).

THE NEW YORK TIMES

RECOMMEND

This article has been revised to reflect the following correction:

**Correction: December 15, 2008**

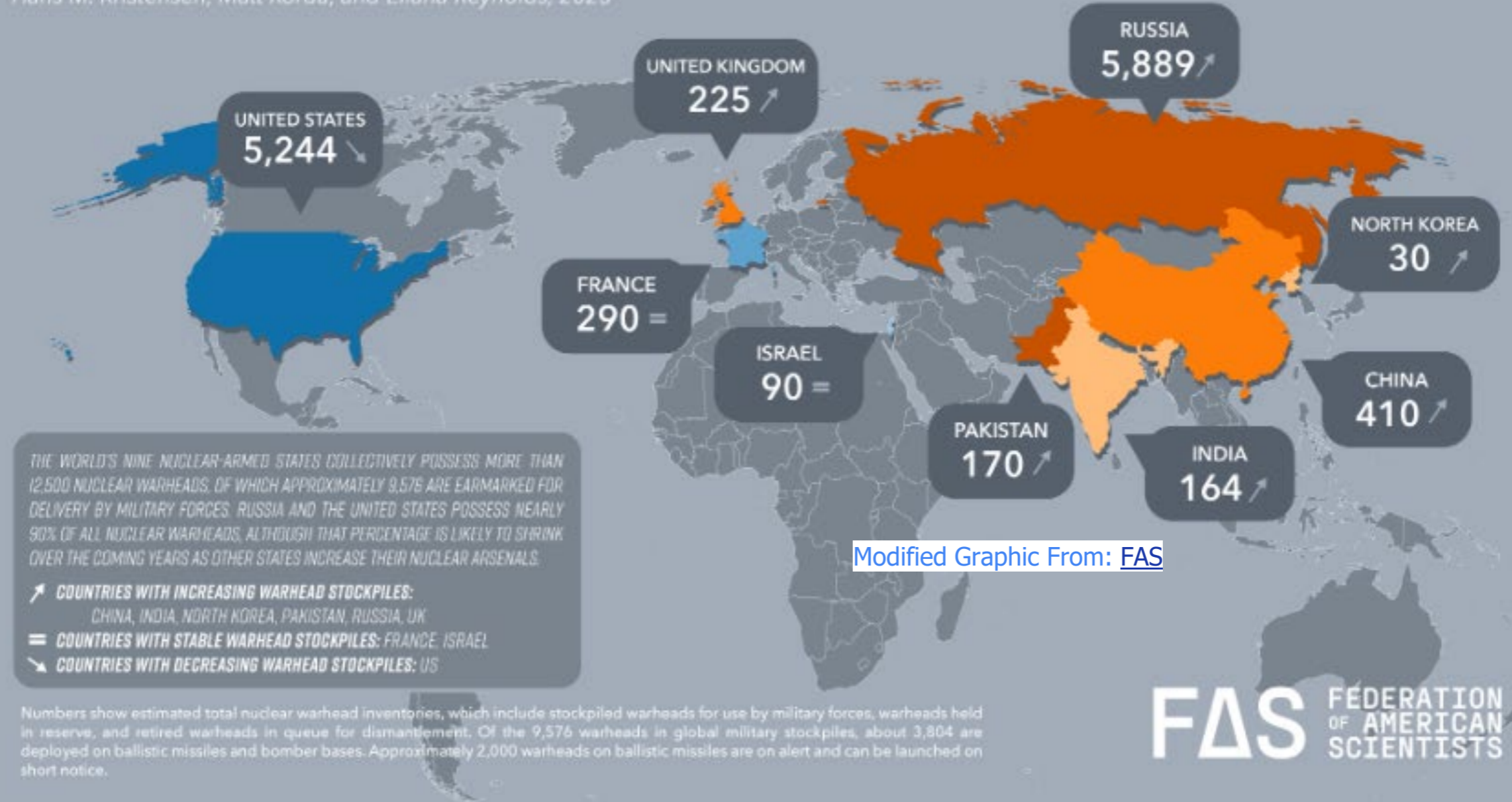
A chart last Tuesday with an article about the proliferation of the atomic bomb, showing the exchange of nuclear information and technology between countries, misidentified the type of reactor that India acquired from Canada, which allowed India to make fuel for its first nuclear test. It was a CIRUS reactor, not a Candu reactor.



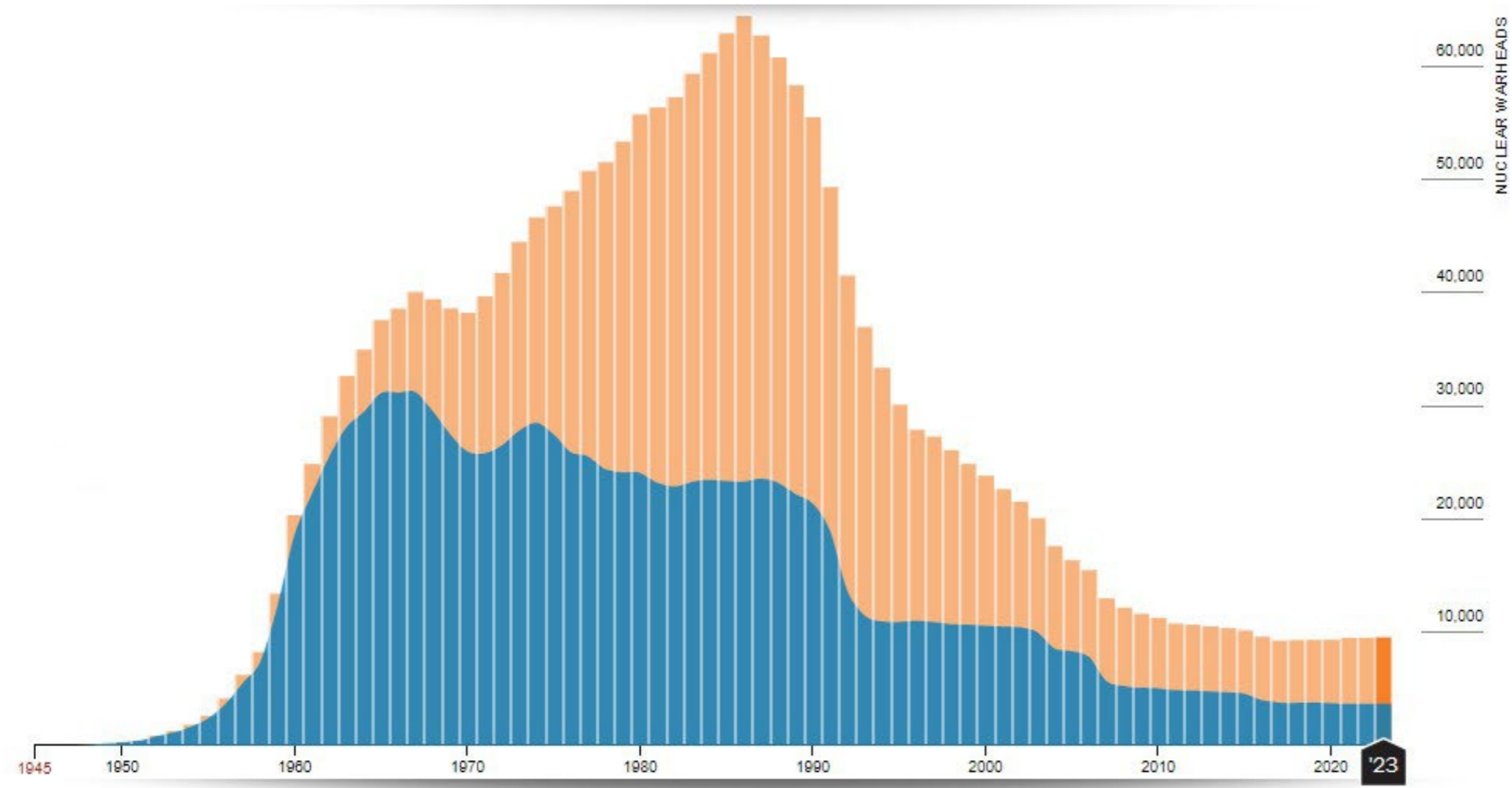
# 2023 Trends in Nuclear Warhead Inventories (Deployed + Stored)

## ESTIMATED GLOBAL NUCLEAR WARHEAD INVENTORIES, 2023

Hans M. Kristensen, Matt Korda, and Eliana Reynolds, 2023



# Nuclear Weapons Stockpiles 1945-2023



← 9,576 in 2023

STOCKPILED WARHEAD COUNT BY YEAR

CLICK A FLAG TO HIDE OR REVEAL

COMPARATIVE CUMULATIVE

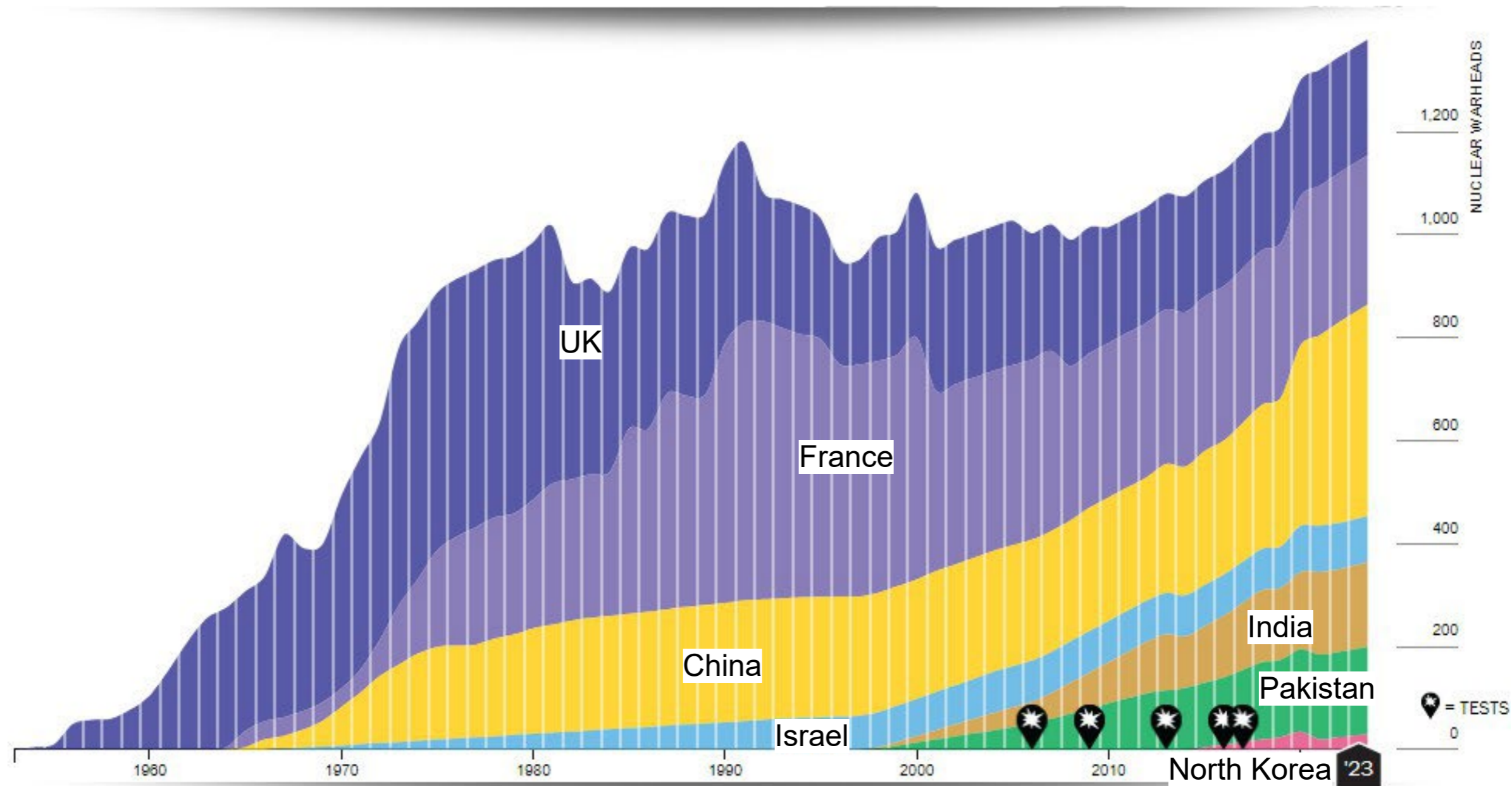
Country	Count
Global	9,576
US	3,708
Russia	4,489
UK	225
France	290
China	410
India	90
Pakistan	164
North Korea	170
Israel	30

Source: The Bulletin of the Atomic Scientists



9,576 Nuclear weapons in Military Stockpiles in 2023

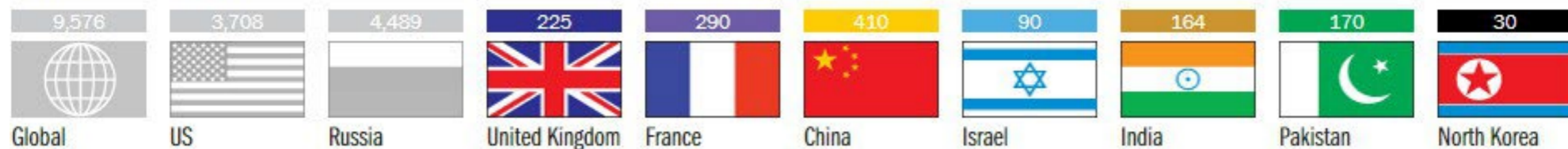
# World Nuclear Weapons Stockpile 1945-2023



STOCKPILED WARHEAD COUNT BY YEAR

CLICK A FLAG TO HIDE OR REVEAL

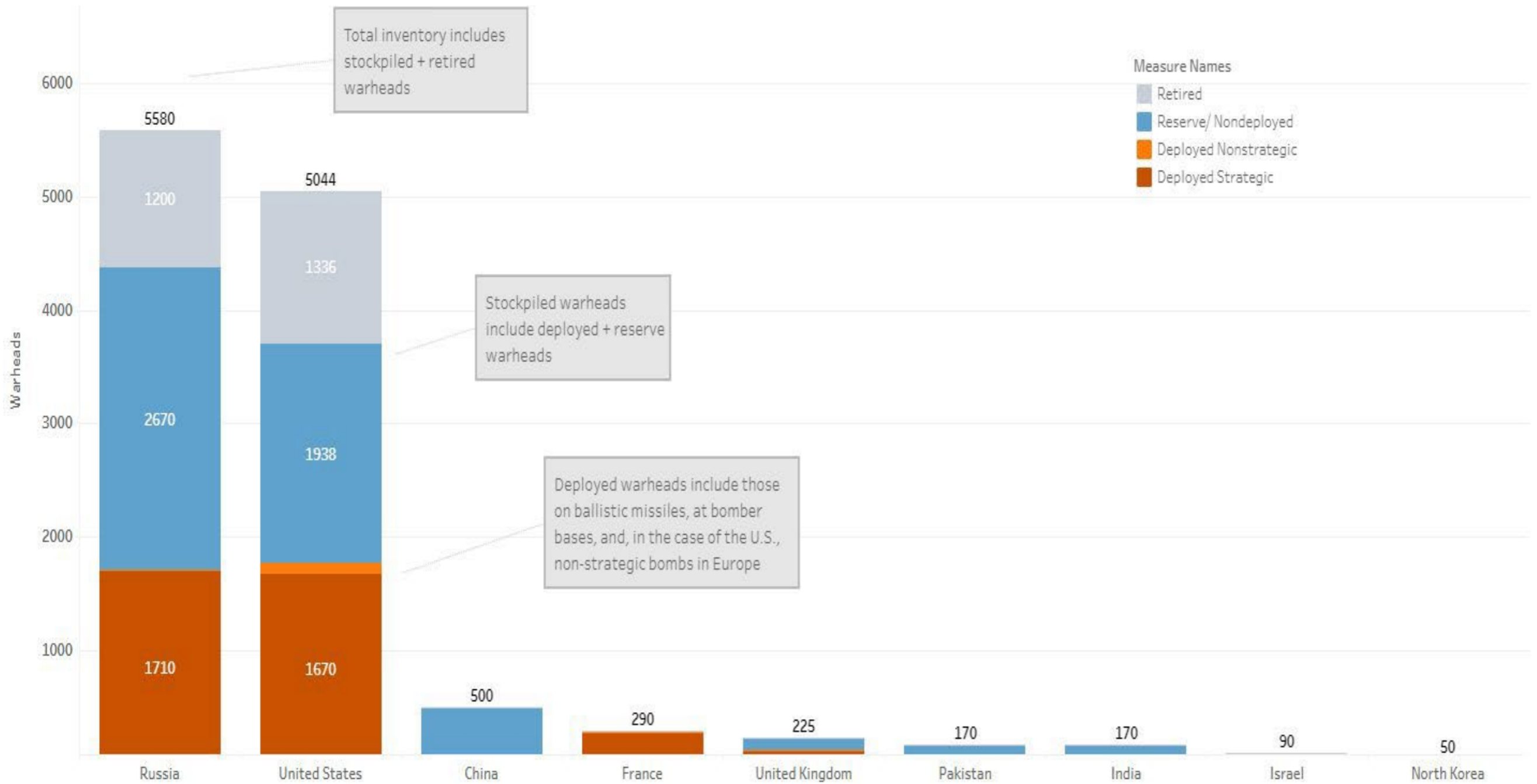
COMPARATIVE CUMULATIVE



Source: *The Bulletin of the Atomic Scientists' Nuclear Notebook*, written by Hans M. Kristensen, Matt Korda, and Eliana Johns, Federation of American Scientists



# Breakdown of the Nuclear Weapons Stockpile (2023)



# Impact Technology Has on Evaluation of Nuclear Arsenals

Bulletin  
of the  
Atomic  
Scientists

## Modernization is undermining strategic stability: The burst-height compensating super-fuze

Hans M. Kristensen, Matthew McKinzie, Theodore A. Postol

The US nuclear forces modernization program has been portrayed to the public as an effort to ensure the reliability and safety of warheads in the US nuclear arsenal, rather than to enhance their military capabilities. In reality, however, that program has implemented revolutionary new technologies that will vastly increase the targeting capability of the US ballistic missile arsenal. This increase in capability is astonishing—boosting the overall killing power of existing US ballistic missile forces by a factor of roughly three—and it creates exactly what one would expect to see, if a nuclear-armed state were planning to have the capacity to fight and win a nuclear war by disarming enemies with a surprise first strike.



(/bio/hans-m-kristensen)

**HANS M. KRISTENSEN**  
**(/BIO/HANS-M-KRISTENSEN)**

Kristensen is the director of the Nuclear Information Project with the Federation of American Scientists (FAS) in Washington, DC. His work



# How US nuclear force modernization is undermining strategic stability: The burst-height compensating super-fuze

Hans M. Kristensen, Matthew McKinzie, Theodore A. Postol

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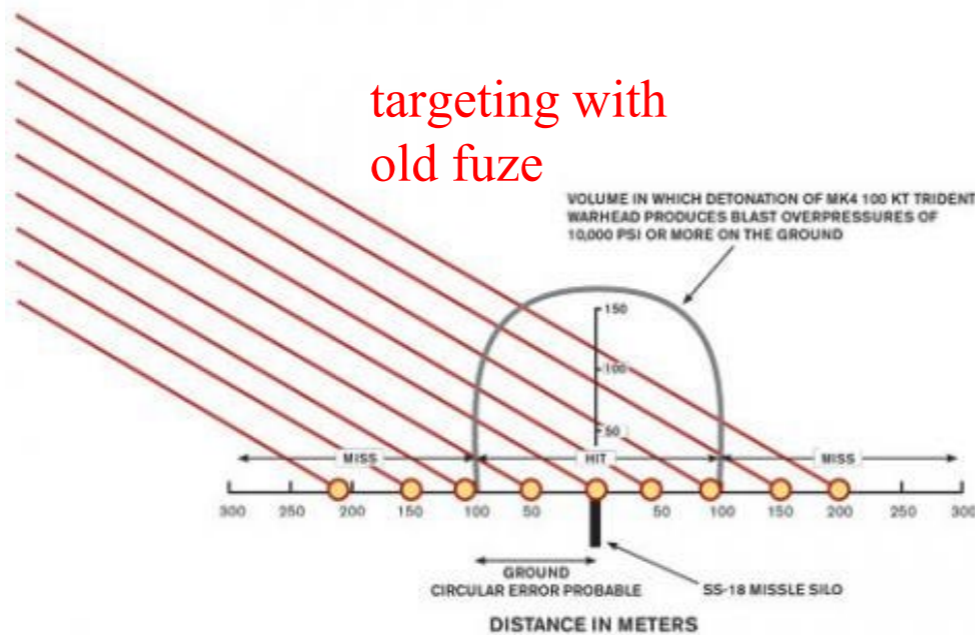
(/bio/hans-m-kristensen)

**HANS M. KRISTENSEN**  
**(/BIO/HANS-M-KRISTENSEN)**

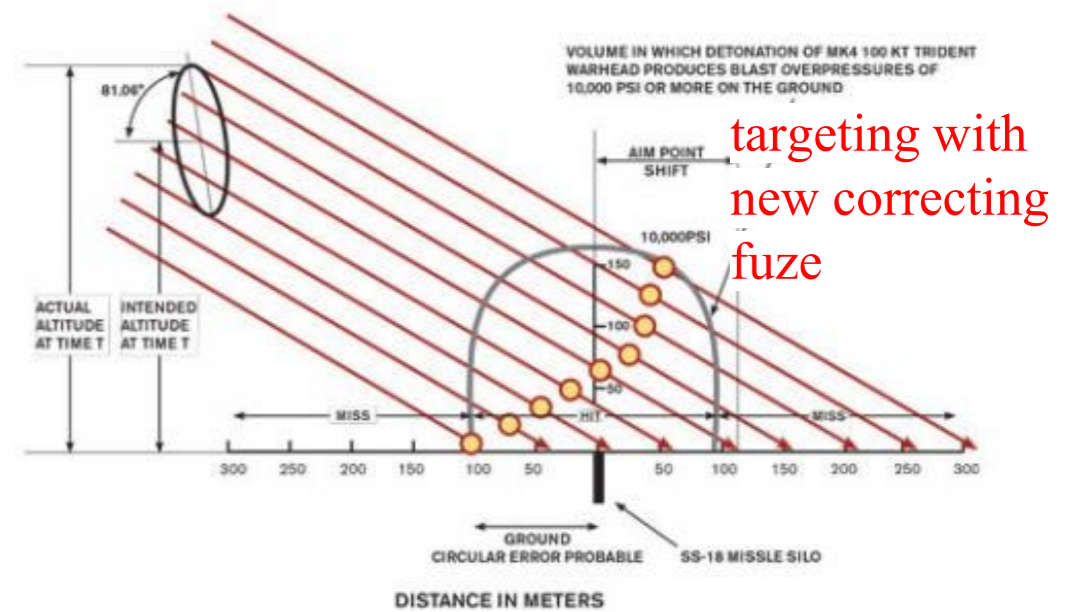
Kristensen is the director of the Nuclear Information Project with the Federation of American Scientists (FAS) in Washington, DC. His work

# Impact Technology Has on Evaluation of Nuclear Arsenals

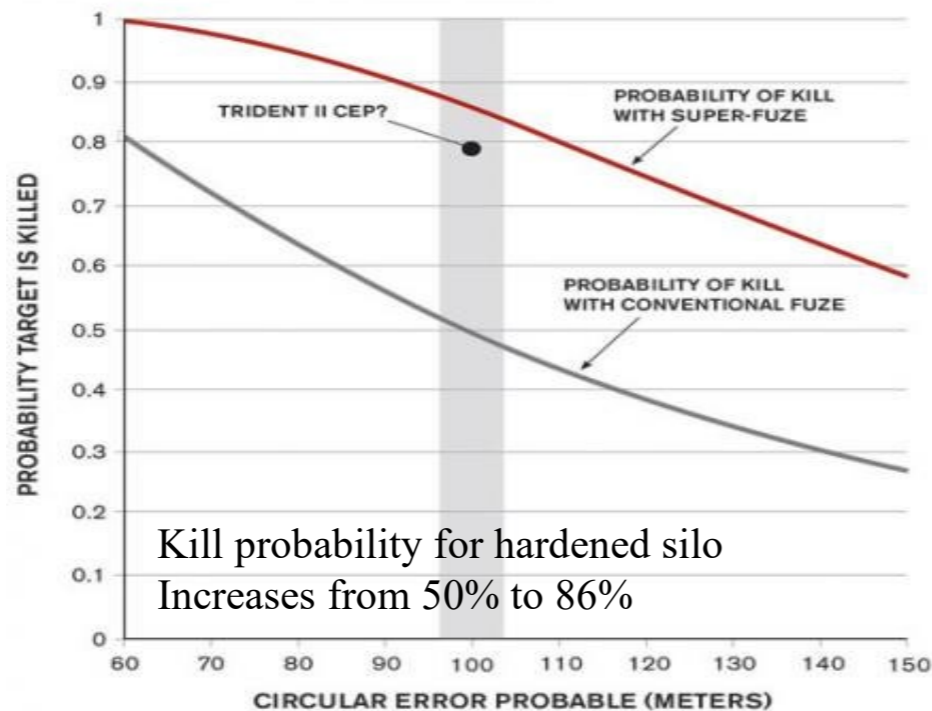
DETONATION SPREAD: CONVENTIONAL BALLISTIC MISSILE FUZE



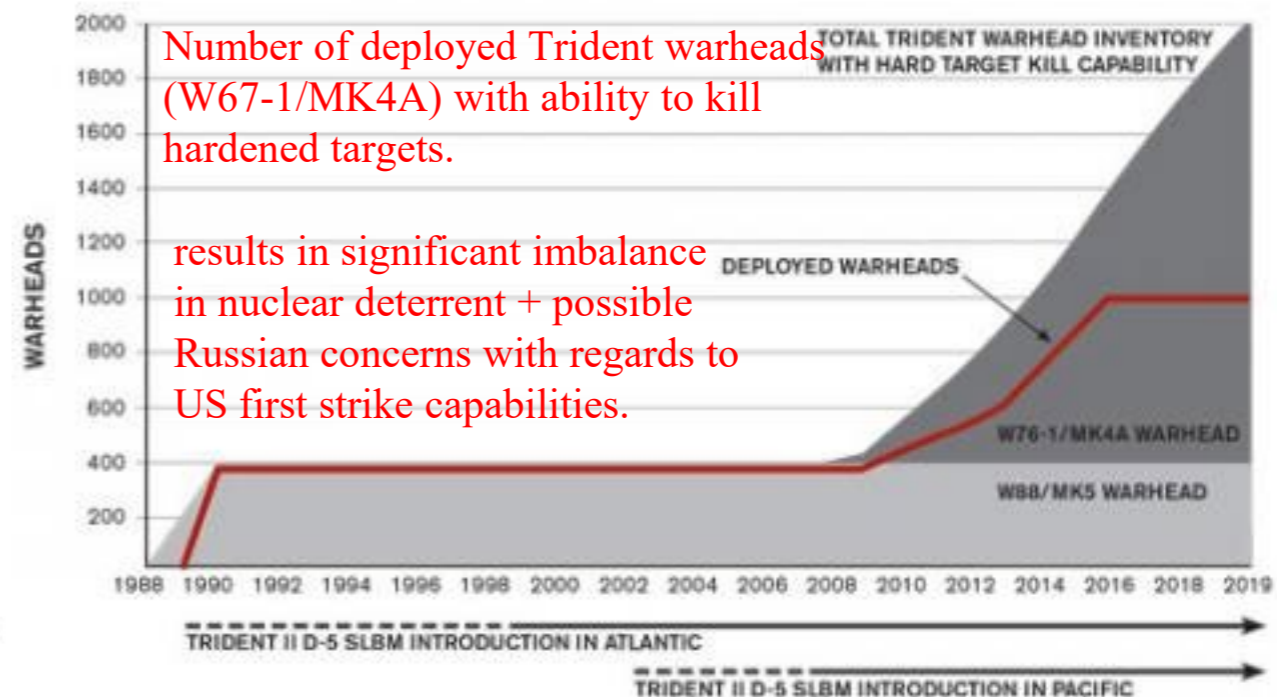
DETONATION SPREAD: SUPER-FUZE



100 KT LOW AIR-BURSTS, 10,000 PSI TARGET (MK4 OR MK4A WARHEAD FUZE)



HARD TARGET KILL-CAPABLE WARHEADS ON US BALLISTIC MISSILE SUBMARINES



# Global Nuclear Weapon Inventory 2023 (Important)

NPT Nuclear Weapon States	Amount of Weapons	Trend	Expectations
US	5,244	Decreasing	Increased spending between 2023 and 2032
UK	225	Increasing	Projected by 2025 to be no more than 260
China	410	Increasing	Over 1,000 by 2030, 1,500 by 2035; fastest-growing
France	290	Equal	
Russia	5,889	Increasing	
Non NPT Nuclear Weapons States	Amount of Weapons		
Pakistan	170	Increasing	
Israel	90	Equal	
India	164	Increasing	
North Korea	30	Increasing	inflated, but by 2027 151-242

Source: Status of World Nuclear Forces, Written by Hans M. Kristensen and Matt Korda, Federation of American Scientists



# Nuclear Warheads on Alert

## Estimated Nuclear Alert Forces, 2017

Country	Stockpiled Warheads	Alert Warheads	
United States	4,000	852	21% of Stockpile on Alert ICBMs: 392, SSBNs: 460
Russia	4,300	897	21% of Stockpile on Alert ICBMs: 686, SSBNs: 211
France	300	80 <sup>a</sup>	27% of Stockpile on Alert SSBNs: 80
Britain	215	40 <sup>a</sup>	19% of Stockpile on Alert SSBNs: 40
China	270	0	Warheads are not mated with delivery systems
Pakistan	140	0	Warheads are not mated with delivery systems
India	120	0	Warheads are not mated with delivery systems
Israel	80	0	Warheads are not mated with delivery systems
North Korea	(10-20)	(0)	Warheads are not mated with delivery systems
<b>Total</b>	<b>9,425<sup>b</sup></b>	<b>1,869</b>	

Source: Hans Kristensen, FAS, Alert Status of Nuclear Weapons



# Historic Strategic Nuclear Arms Control Agreements

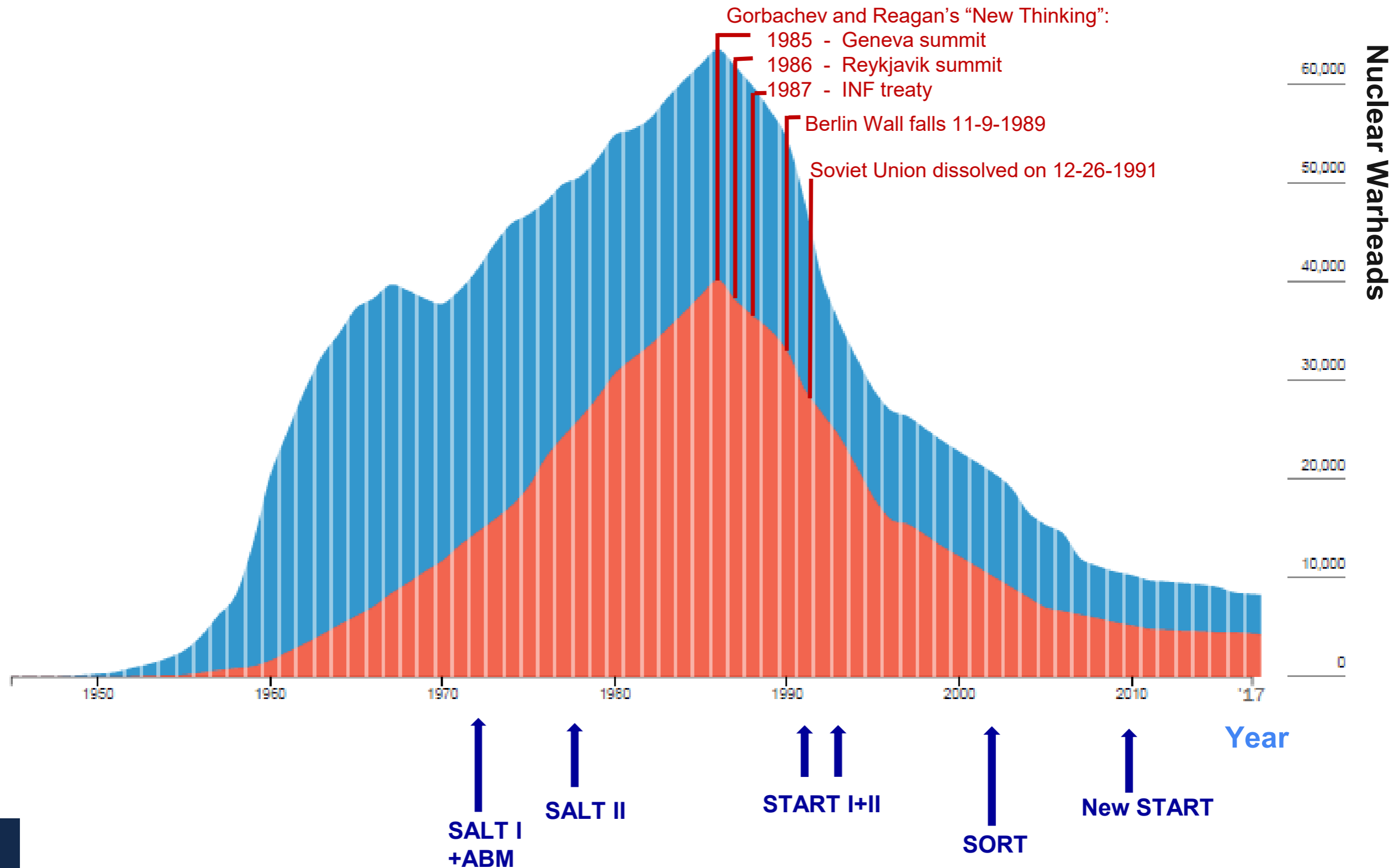
Strategic Nuclear Arms Control Agreements								
	SALT I	SALT II	INF Treaty	START I	START II	START III	SORT	New START
Status	Expired	Never Entered Into Force	In Force*	Expired	Never Entered Into Force	Never Negotiated	Replaced by New START	Expired
Deployed Warhead Limit	N/A	N/A	N/A	6,000	3,000-3,500	2,000-2,500	1,700-2,200	1,550
Deployed Delivery Vehicle Limit	US: 1,710 ICBMs & SLBMs USSR: 2,347	2,250	Prohibits ground-based missiles of 500-5,500 km range	1,600	N/A	N/A	N/A	700
Date Signed	May 26, 1972	June 18, 1979	Dec. 8, 1987	July 31, 1991	Jan. 3, 1993	N/A	May 24, 2002	April 8, 2010
Date Ratified, U.S.	Aug. 3, 1972	N/A	May 28, 1988	Oct. 1, 1992	Jan. 26, 1996	N/A	March 6, 2003	Dec. 22, 2010
Ratification Vote, U.S.	88-2	N/A	93-6	93-6	87-4	N/A	95-0	71-26
Date Entered Into Force	Oct. 3, 1972	N/A	June 1, 1988	Dec. 5, 1994	N/A	N/A	June 1, 2003	Feb. 5, 2011
Implementation Deadline	N/A	N/A	June 1, 1991	Dec. 5, 2001	N/A	N/A	N/A	Feb. 5, 2018
Expiration Date	Oct. 3, 1977	N/A	unlimited duration	Dec. 5, 2009	N/A	N/A	Feb. 5, 2011	Feb. 5, 2026

Currently there are no strategic nuclear arms control agreements in place

Source: Arms Control Association "Strategic Nuclear Arms Control Agreements"



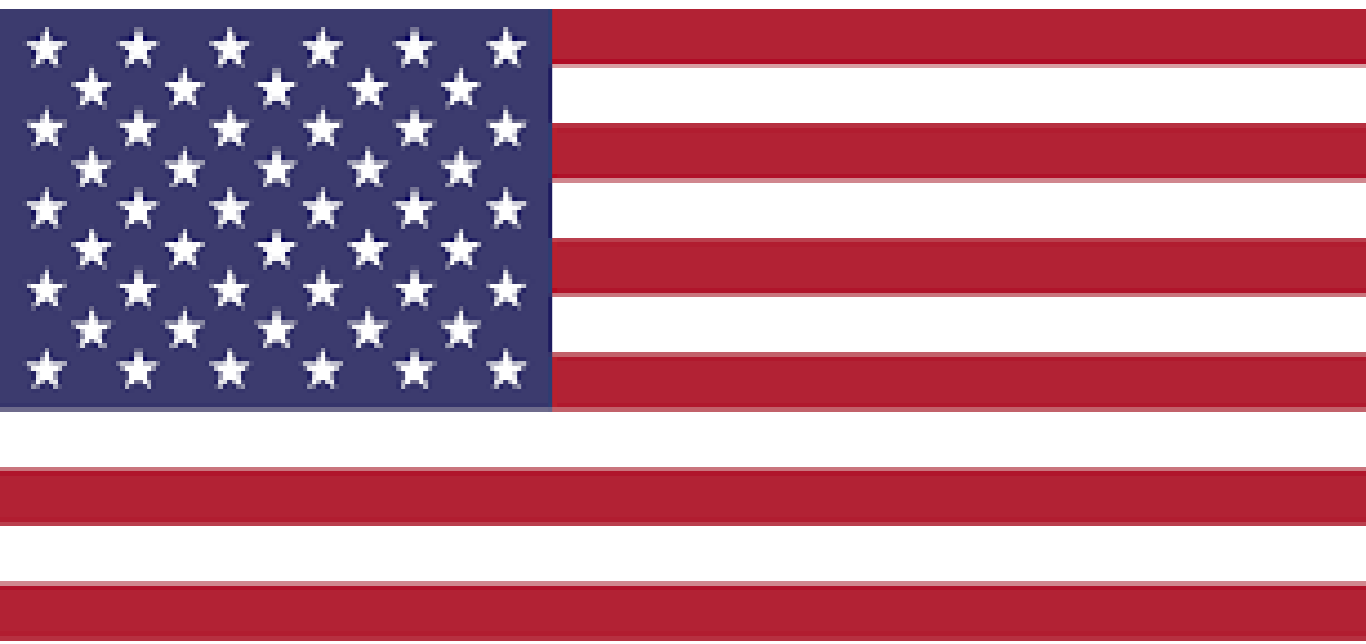
# World Nuclear Weapons Stockpile



Source: Federation of Atomic Scientists, Nuclear Notebook, Hans Kristensen



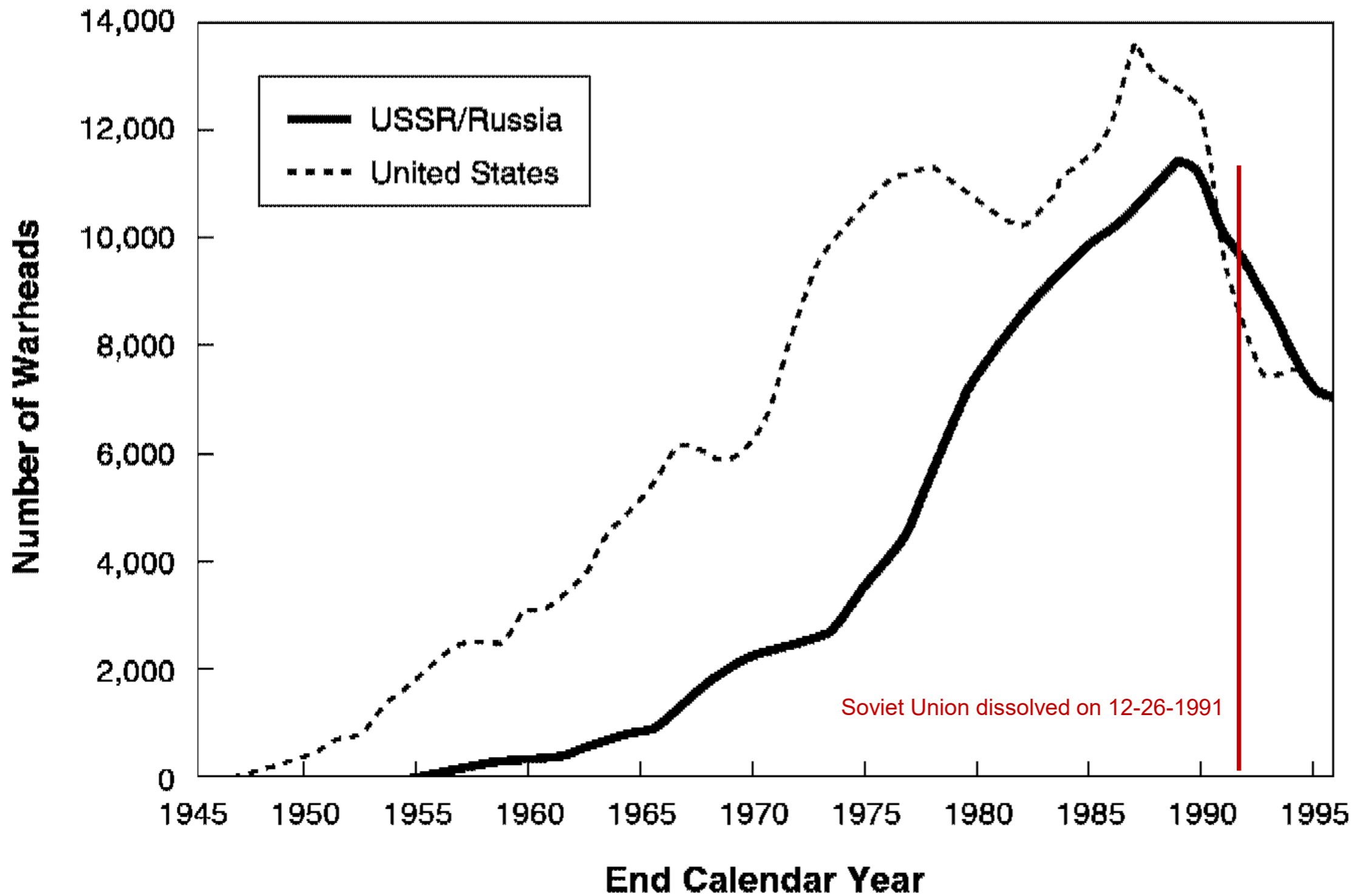
# Module 6: Arsenals



## Sec 1 Arsenals of the US and SU/Russia



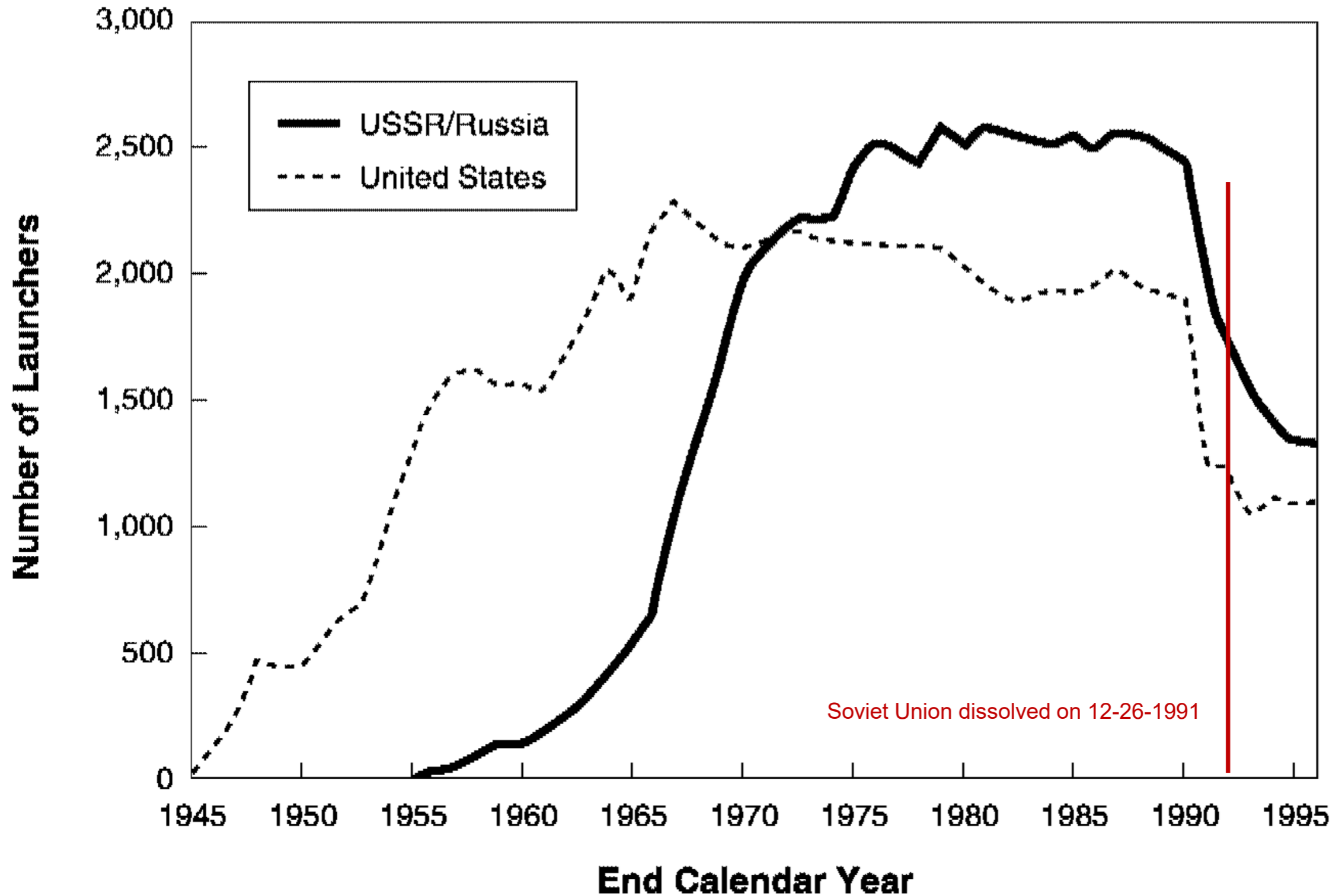
# Evolution of US and SU-Russian Strategic Nuclear Warhead Numbers



Soviet Union dissolved on 12-26-1991

Source: NRDC (Nov. 2002)

# Evolution of US and SU-Russian Strategic Nuclear Launcher Numbers

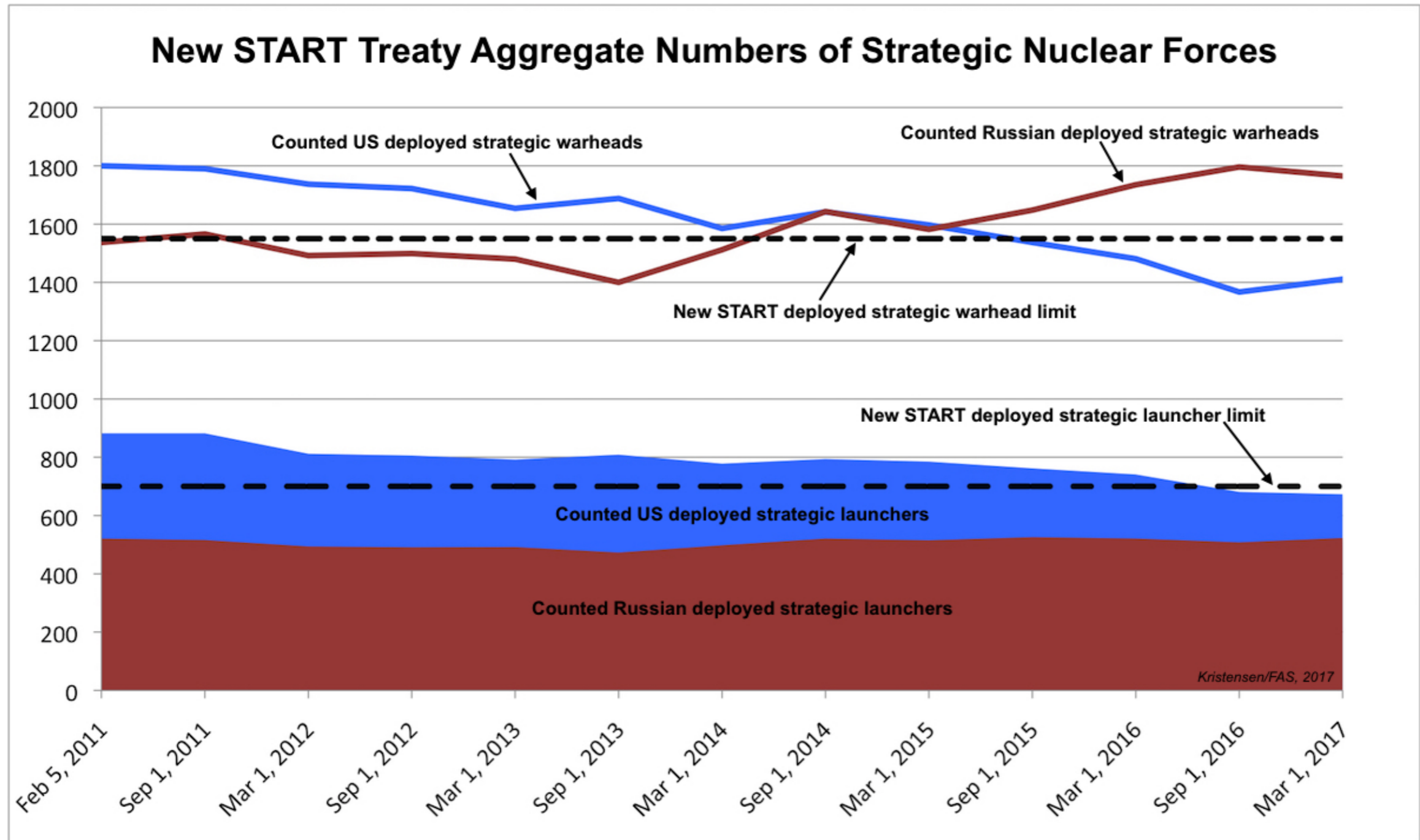


Soviet Union dissolved on 12-26-1991

Source: NRDC (Nov. 2002)



# US and Russian Warheads after New START



Source: Federation of American Scientists



# 2018 Estimate of US Forces Under New START

**Table 2. U.S. Strategic Nuclear Forces under New START**

(Estimated Current Forces and Potential New START Forces)

		Estimated Forces, 2010		Planned Forces Under New START <sup>a</sup>		
		Launchers	Warheads	Total Launchers	Deployed Launchers	Warheads
ICBM	Minuteman III	399	N/A	454	400	400
SLBM	Trident	212	N/A	280	240	1,090
Bomber	B-52	38		46	42	42
Bomber	B-2	11	49	20	18	18
<b>Total</b>		<b>660</b>	<b>1393</b>	<b>800</b>	<b>700</b>	<b>1,550</b>

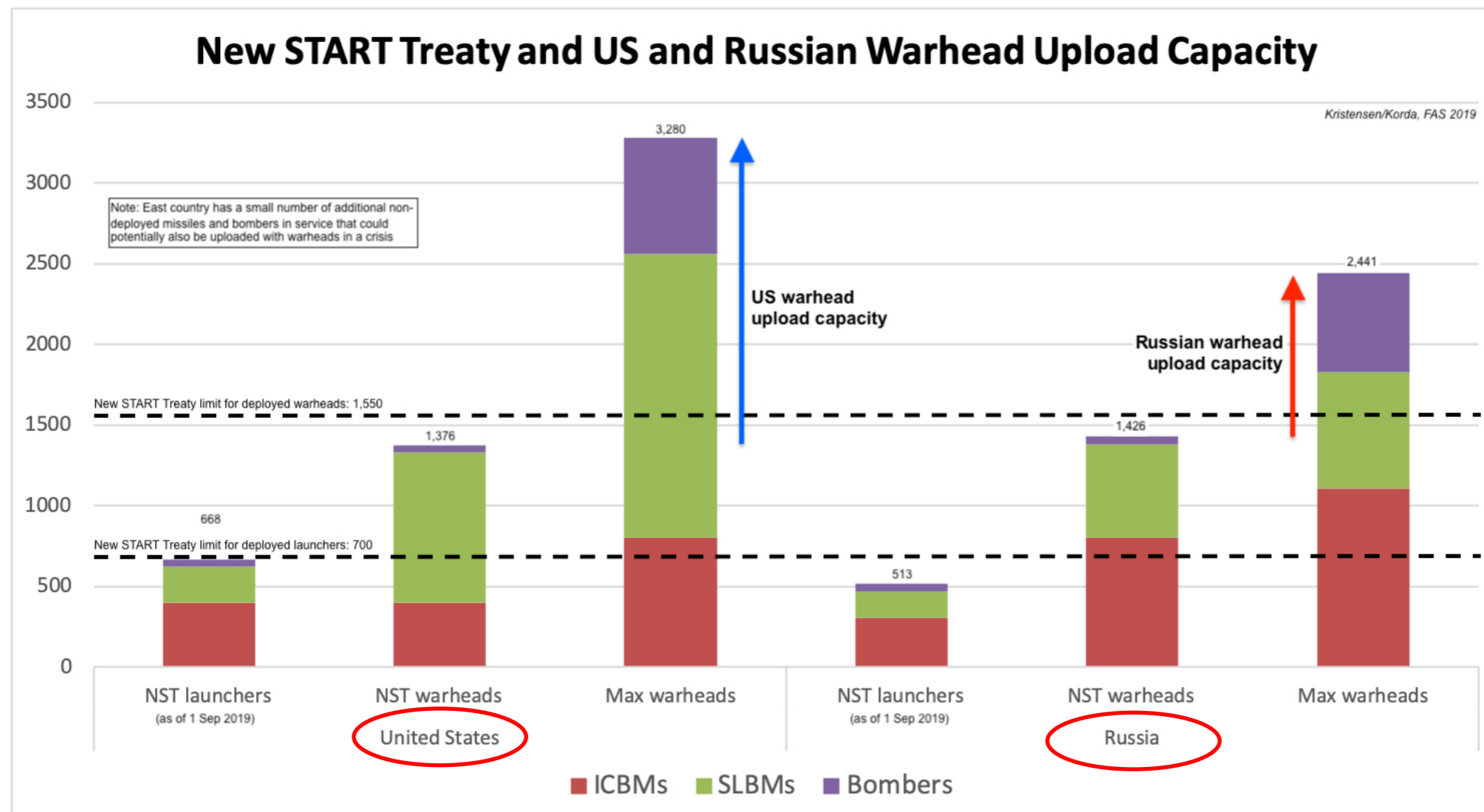
Source for 2018 data: US Strategic Forces Under New Start (2018), Arms Control Association



# Capacity of Existing Strategic Delivery Systems US vs Russia

from Matt Korda and Hans M. Kristensen, FAS

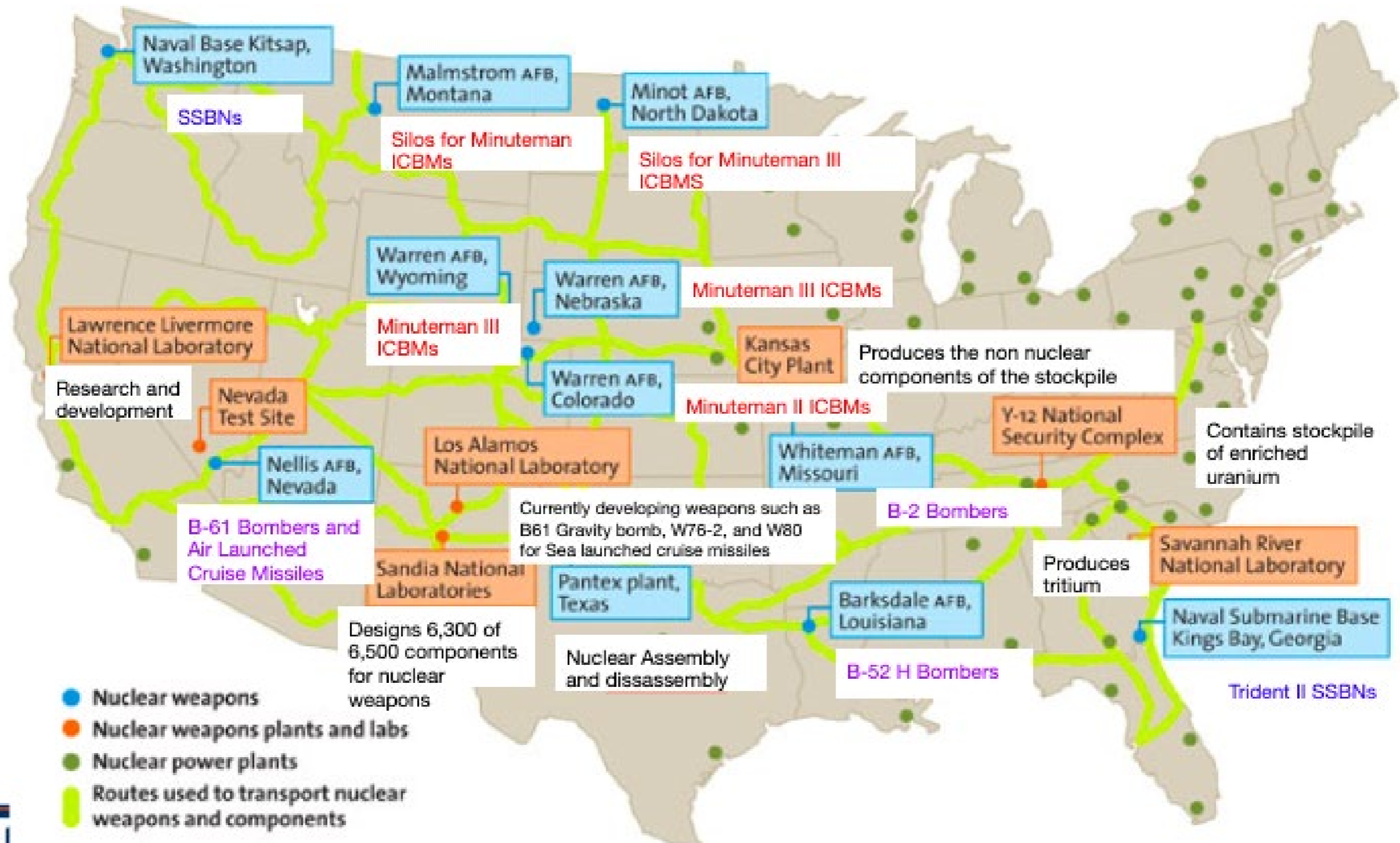
Without New START there would be no remaining limit on nuclear arsenals (for the first time since 1972). Both, Russia and the US could increase the arsenal of warheads without adding delivery systems. The imbalance in the upload possible +1700 for the US and + 950 for Russia easily could trigger investments into new delivery systems and thus a costly arms race.



# U.S. and Russian “Tactical” Weapons in Europe

- The U.S. is thought to have 150 tactical nuclear weapons based in Europe, in the form of aerial bombs.
- Most are based in Italy and Turkey, but some are based in Germany, Belgium, and the Netherlands.
- Russia is thought to have about 2,000 operational “tactical” nuclear weapons in its arsenal.
- At the peak in 1971, 7100 U.S. tactical weapons were stationed in Europe: removed for concerns with regards to decision process of escalating conventional conflict and for security risks arising from political terrorism in Europe.

# Nuclear Labs, Plants, and Weapons locations (2017)



# Specific Warheads at Each Nuclear Weapons Facility (2019)

Rank	State/Country	Warheads	Remarks
<i>United States</i>			
1	New Mexico	2,485 <sup>a</sup>	Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC) Occasionally at Los Alamos National Laboratory Occasionally at Sandia National Laboratories
2	Washington	1,620 <sup>b</sup>	Strategic Weapons Facility Pacific (SWFPAC) Naval Submarine Base Kitsap (SSBNs)
3	Georgia	1,100 <sup>c</sup>	Strategic Weapons Facility Atlantic (SWFLANT) Naval Submarine Base Kings Bay (SSBNs)
4	North Dakota	350	91 <sup>st</sup> Missile Wing silos for Minuteman III ICBMs Minot AFB weapons storage area (ICBMs/B-52s)
5	Montana	150	341 <sup>st</sup> Missile Wing silos for Minuteman III ICBMs Malmstrom AFB weapons storage area
6	Missouri	100	Whiteman AFB weapons storage area
7	Texas	80	Pantex Plant (warhead assembly and dismantlement) <sup>d</sup>
8	Nebraska	72	90 <sup>th</sup> Missile Wing silos for Minuteman III ICBMs
9	Colorado	44	90 <sup>th</sup> Missile Wing silos for Minuteman III ICBMs
10	Wyoming	34	90 <sup>th</sup> Missile Wing silos for Minuteman III ICBMs F.E. Warren AFB weapons storage area
11	California	few	Occasionally at Lawrence Livermore National Laboratory
<i>Europe</i>			
1	Turkey	50	Incirlik AB weapons storage vaults <sup>e</sup>
2	Italy	40	Aviano AB weapons storage vaults Ghedi AB weapon storage vaults
3	Belgium Germany Holland	20 20 20	Kleine Brogel AB weapon storage vaults Büchel AB weapon storage vaults Volkel AB weapon storage vaults

Source: Hans M. Kristensen and Matt Korda, United States Nuclear Forces (2019), Bulletin of the Atomic Scientists



# 2022 U.S. Nuclear Posture Review

<https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF>



The highest U.S. nuclear policy and strategy priority is to deter potential adversaries from nuclear attack of any scale. However, deterring nuclear attack is not the sole purpose of nuclear weapons. Given the diverse threats and profound uncertainties of the current and future threat environment, U.S. nuclear forces play the following critical roles in U.S. national security strategy. They contribute to the:

- 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.
- Commitment to nuclear weapons modernization program.
- No nuclear threat to NPT non-nuclear weapon states

These roles are complementary and interrelated, and the adequacy of U.S. nuclear forces must be assessed against each role and the strategy designed to fulfill it. Preventing proliferation and denying terrorists access to finished weapons, material, or expertise are also key considerations in the elaboration of U.S. nuclear policy and requirements. These multiple roles and objectives constitute the guiding pillars for U.S. nuclear policy and requirements.



# 2018 U.S. Nuclear Posture Review on Tactical Weapons in Europe

## Non-Strategic Nuclear Weapons

During the Cold War, the United States possessed large numbers and a wide range of non-strategic nuclear weapons, also known as theater or tactical nuclear weapons. However, we have since retired and dismantled almost all of those weapons. Current U.S. non-strategic nuclear forces consist exclusively of B61 gravity bombs carried by F-15E DCA, supported by responsive air refueling aircraft. Several NATO allies also provide DCA capable of delivering U.S. forward-deployed nuclear weapons. The forthcoming B61-12 gravity bomb will replace earlier versions of the B61, and be available for these DCA beginning in 2021.

U.S. and NATO DCA, together with U.S. gravity bombs, are forward deployed in European NATO countries. Their forward presence contributes significantly to the deterrence of potential adversaries and the assurance of allies. Their presence is a clear deterrence signal to any potential adversary that the United States possesses the forward-deployed capability to respond to escalation. If necessary, the United States has the ability to deploy DCA and nuclear weapons to other regions, such as Northeast Asia.



Sandia National Laboratory mechanical engineer adjusts a microphone for an acoustic test on a B-61-12 system.

Source: 2019 Nuclear Posture Review



# Modernization of US Nuclear Arsenal – Beginnings

*From NPR:*

## Obama's Nuclear Paradox: Pushing For Cuts, Agreeing To Upgrades

MAY 25, 2016 · 3:20 PM ET

By Philip Ewing



President Obama, speaking in Prague in 2009, said: "I state clearly and with conviction America's commitment to seek the peace and security of a world without nuclear weapons." While Obama has pushed for a reduction in nuclear arms throughout his presidency, he has also agreed to an expensive upgrade of America's aging nuclear arsenal.

Charles Dharapak/AP

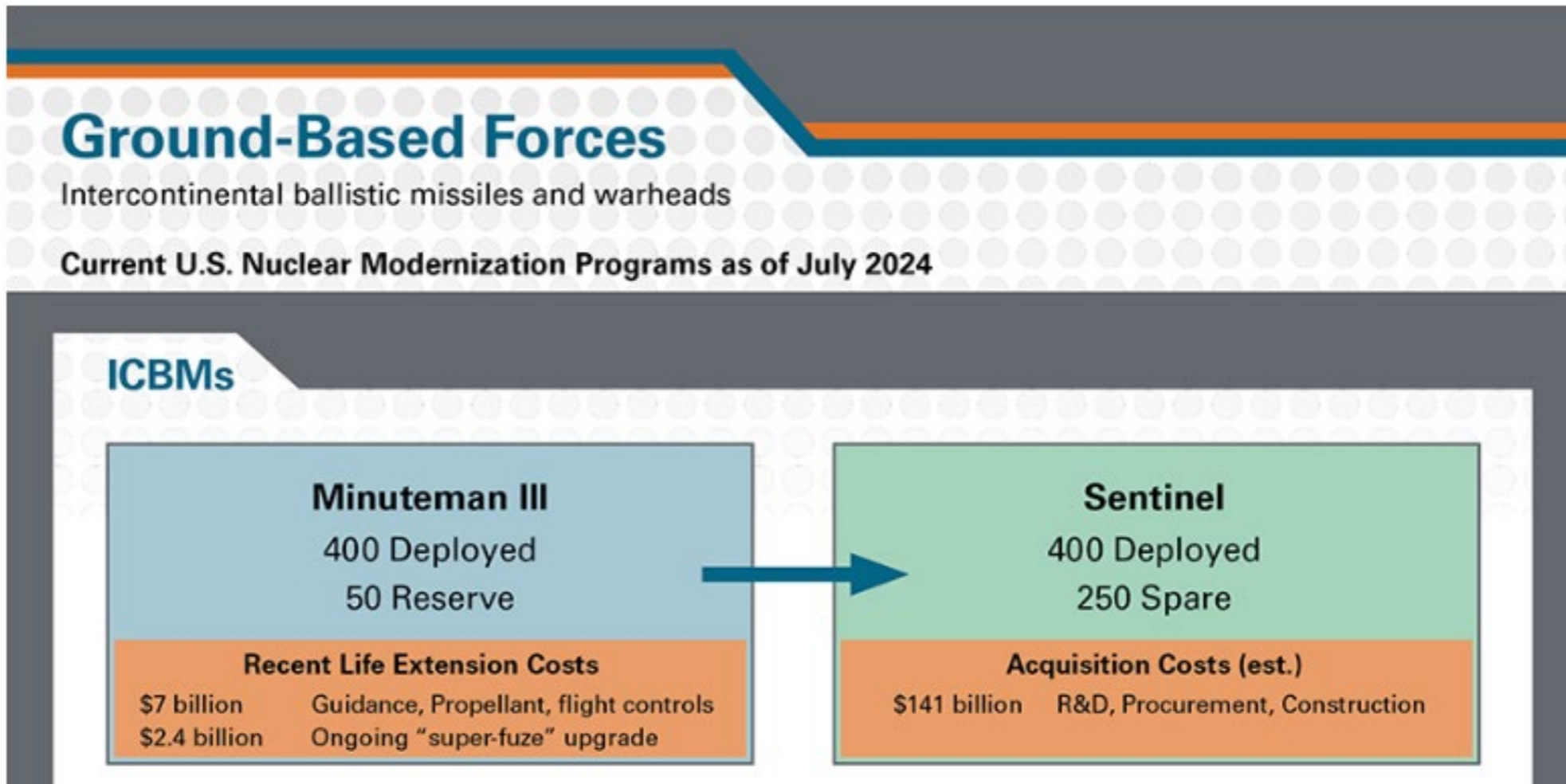
President Obama came into office with a dream of a world without nuclear weapons, and he's sure to touch on this theme Friday when he becomes the first sitting U.S. president to visit Hiroshima, site of the world's first atomic bombing.

Yet Obama also has put the U.S. on course to spend around \$1 trillion on upgrading its nuclear arsenal over the next three decades, critics say.

**Today – strong congressional support!**  
27

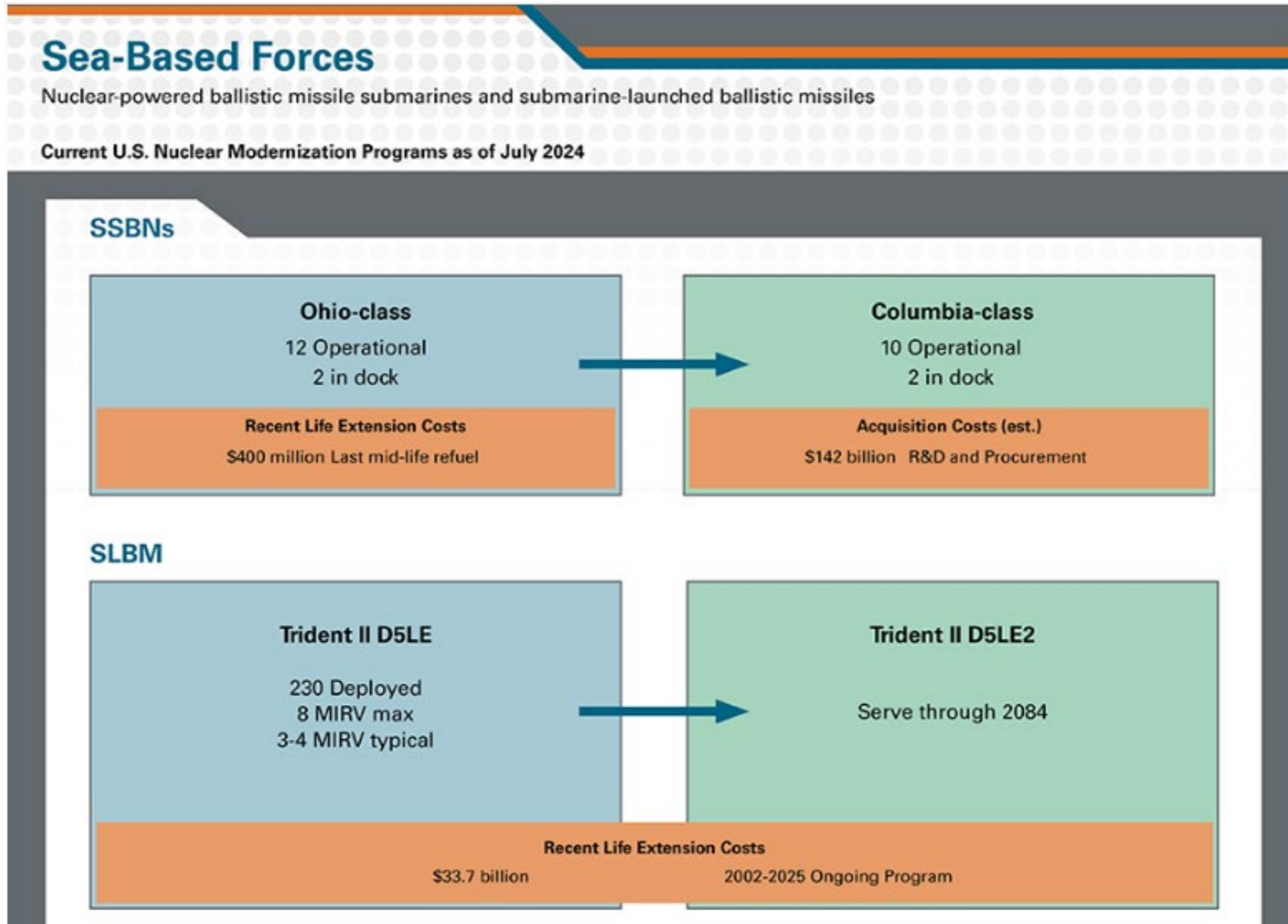
# Modernization of US Nuclear Arsenal – Ground-Based

from Xiadon Liang, ACA, August 2024



# Modernization of US Nuclear Arsenal – Sea-Based

from Xiadon Liang, ACA, August 2024



# Modernization of US Nuclear Arsenal – Bomber-Based

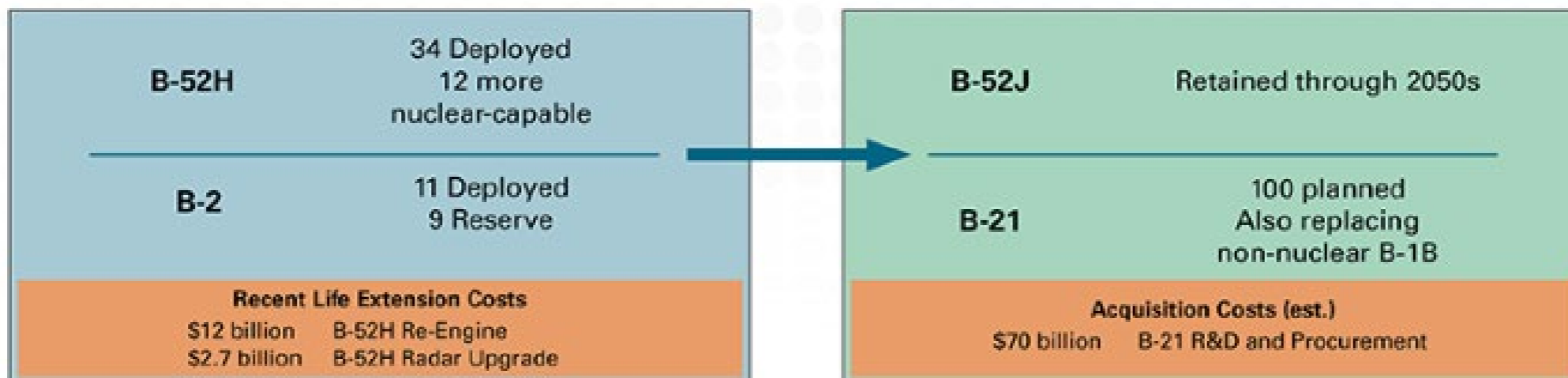
from Xiadon Liang, ACA, August 2024

## Bomber Force

Strategic bombers, gravity bombs, cruise missiles, and warheads

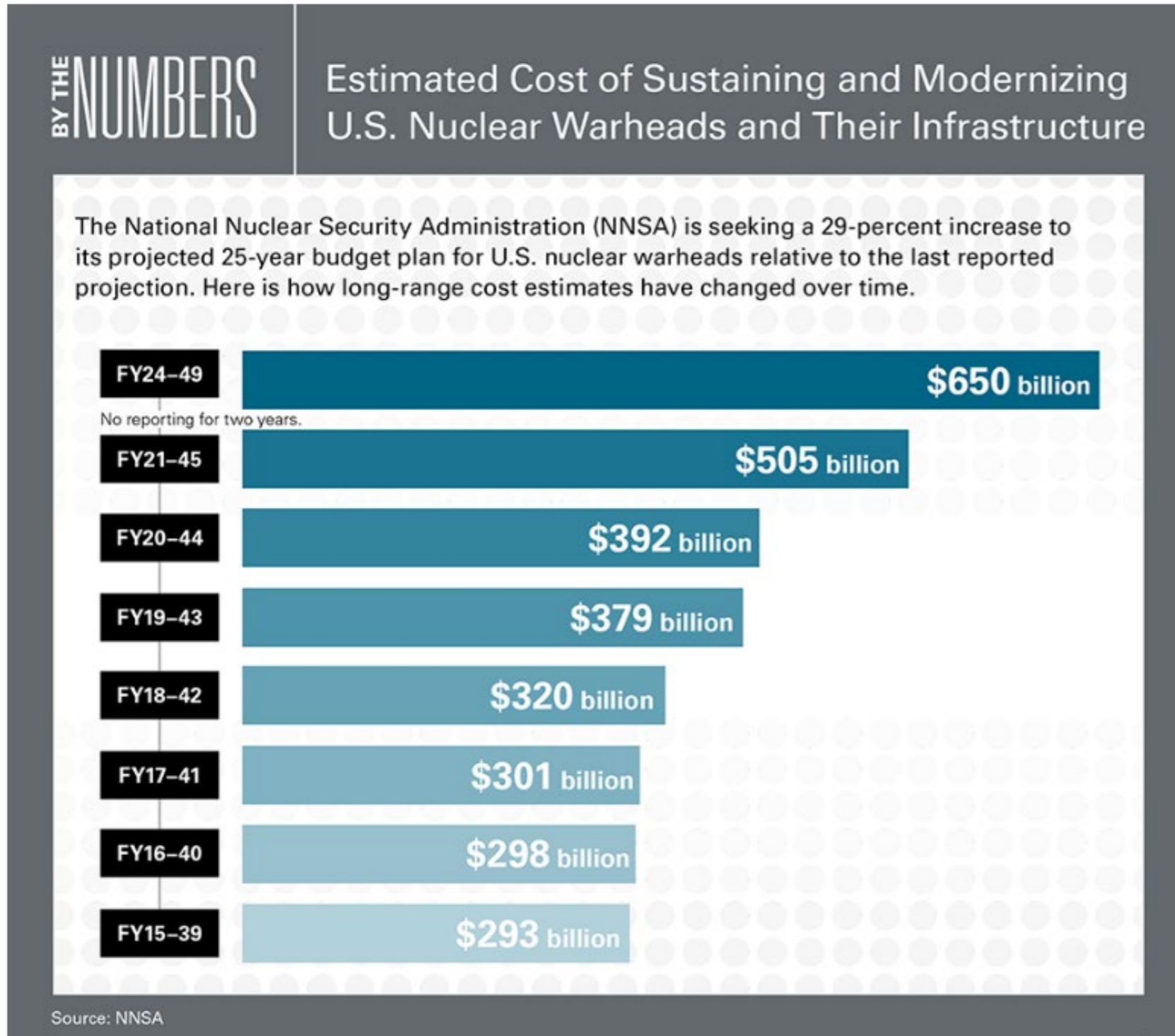
Current U.S. Nuclear Modernization Programs as of July 2024

### Bombers



# Modernization of US Nuclear Arsenal – War Heads

from Xiadon Liang, ACA, August 2024



**Current estimate for 25-year cost of the modernization program: > \$1.1 Trillion**



# Analysis: Iran likely transferred highly enriched uranium to Isfahan before the June strikes

*Satellite imagery shows that Iran could have transferred to Isfahan up to 540 kilograms—possibly all—of its highly-enriched uranium inventory before the June strikes last year.*

By François Diaz-Maurin

March 29, 2026

Working with a team of visual investigators that included the *Bulletin*, the French newspaper *Le Monde* has analyzed a previously unreported satellite image of the Iranian nuclear site at Isfahan, showing a large truck loaded with containers. In a [Le Monde article](#) published Saturday, experts said they could not be certain what the containers held. But the timing of the image, the type of load, and other indirect evidence suggest that Iran may have placed a significant quantity of highly enriched uranium—possibly all of its inventory—at the facility ahead of the June 2025 strikes by Israel and the United States against Iranian nuclear sites.

The International Atomic Energy Agency (IAEA) has mentioned the possible presence of highly enriched uranium at the Isfahan nuclear complex several times—a presence implicitly acknowledged by Iran's own [recent declarations](#). The IAEA has made [multiple requests](#) but was unable to access the underground tunnel complex at Isfahan, which was spared during Israeli and American military strikes in June. The satellite image could be the first publicly available evidence of the presence of highly enriched uranium at Isfahan.

According to *Le Monde* investigators, who have reviewed many satellite images of the entrance to Isfahan and other Iranian nuclear sites, it is the first time they have seen this type of convoy at the facility. *Le Monde* informed the *Bulletin* about the image on March 19. What follows is a detailed visual and technical analysis supporting my assessment that the cargo may have been highly enriched uranium.



South tunnel entrance of the Isfahan Underground complex near the Isfahan Nuclear Technology Center, Iran

South tunnel entrance of the Isfahan underground complex near the Isfahan Nuclear Technology Center, Iran. (Bulletin / Google Earth)

A very high-resolution satellite image shows a truck loaded with 18 containers likely transporting highly enriched uranium in front of the south tunnel entrance at the Isfahan underground complex in Iran (32.585522° N, 51.814933° E) on June 9, 2025. (Credit: Bulletin / Airbus Pleiades)



AIRBUS | Bulletin of the Atomic Scientists

A very high-resolution satellite image shows a truck loaded with 18 containers likely transporting highly enriched uranium in front of the south tunnel entrance at the Isfahan underground complex in Iran (32.585522° N, 51.814933° E) on June 9, 2025. (Credit: Bulletin / Airbus Pleiades)

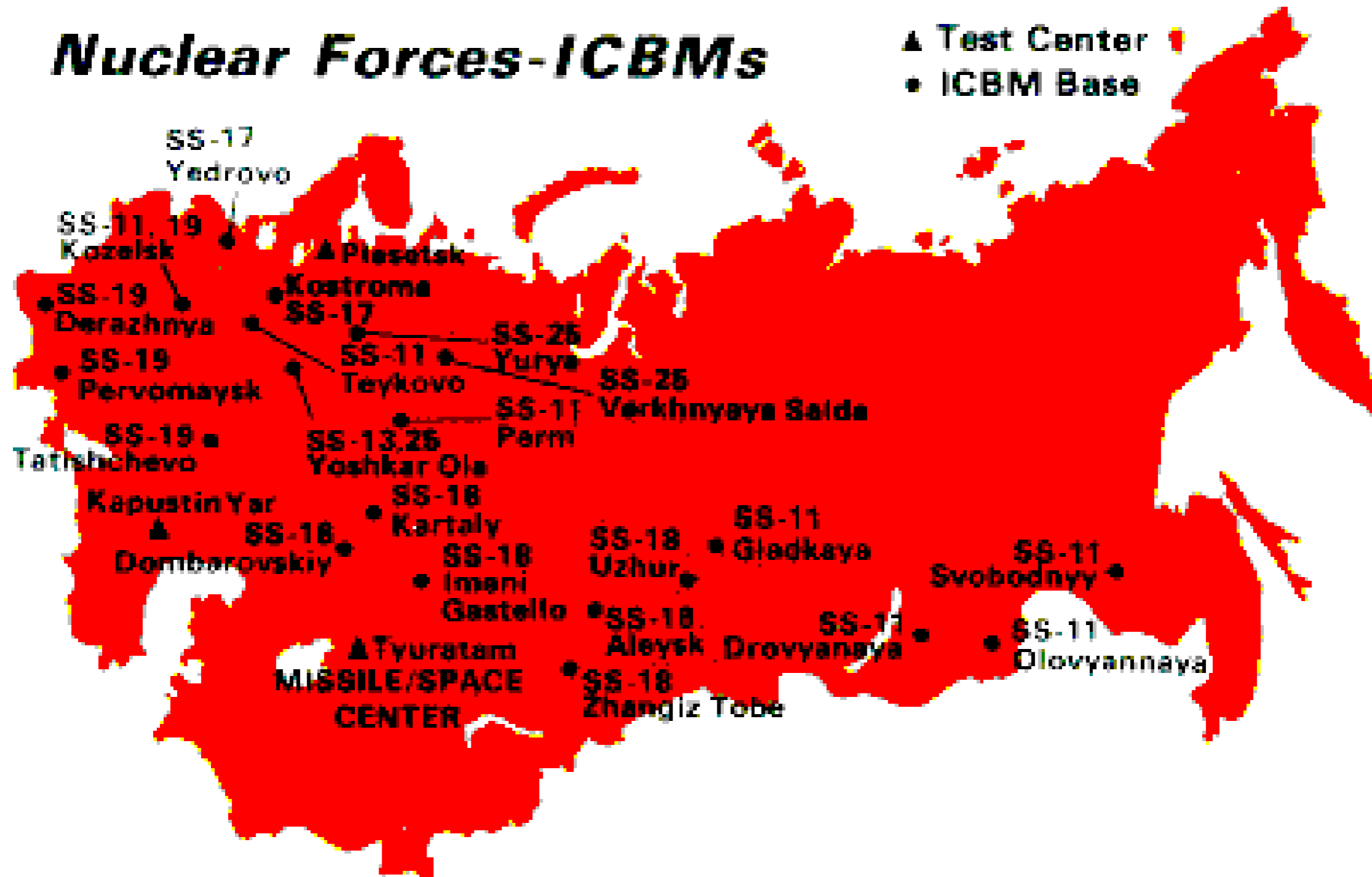
# Russian Nuclear Laboratory and Stockpile Locations



Carnegie Endowment for International Peace, *Deadly Arsenals* (2002), [www.ceip.org](http://www.ceip.org)

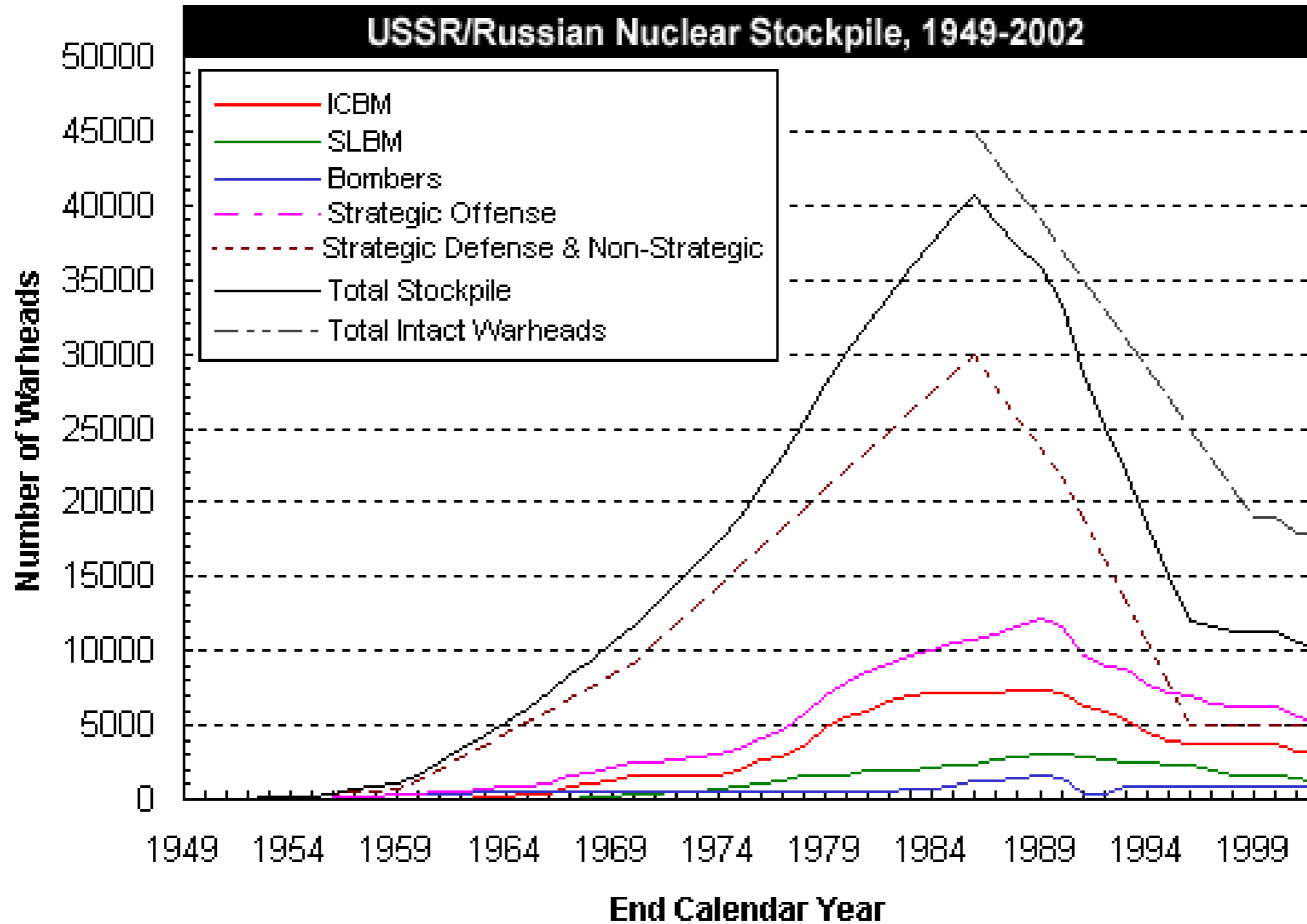


# Russian ICBM locations



Source: FAS, Steven Aftergood

# SU-Russian Nuclear Warheads



Source: NRDC (Nov. 2002)



# Recent Evolution of Russian Nuclear Forces

Evolution of Russian total warheads is very similar to the evolution of US nuclear forces  
(because of START and New START limits).

Unlike the US, for geopolitical reasons Russia deploys more warheads on its ICBMs than on its SLBMs.



# Russian Nuclear Forces



**Russian SS-27 Road-Mobile Launcher**

# Russian Nuclear Forces ICBMs (2019)

	Russian		Year	Warheads	Total
Type/name	Designation	Launchers	Deployed	x yield (kilotons)	Warheads
<i>Strategic offensive weapons</i>					
<b>ICBMs</b>					
SS-18 M6 Satan	RS-20V	46	1988	10 × 500/800 (MIRV)	460 <sup>a</sup>
SS-19 M3 Stiletto	RS-18 (UR-100NUTTH)	20 <sup>b</sup>	1980	6 × 400 (MIRV)	120 <sup>c</sup>
SS-19 M4	? (Avangard)	-	(2019)	1 × HGV	-
SS-25 Sickle	RS-12M (Topol)	63	1988	1 × 800	63 <sup>d</sup>
SS-27 Mod 1 (mobile)	RS-12M1 (Topol-M)	18	2006	1 × 800?	18
SS-27 Mod 1 (silo)	RS-12M2 (Topol-M)	60	1997	1 × 800	60
SS-27 Mod 2 (mobile)	RS-24 (Yars)	99	2010	4 × 100? (MIRV)	396 <sup>e</sup>
SS-27 Mod 2 (silo)	RS-24 (Yars)	12	2014	4 × 100? (MIRV)	48
SS-X-27 Mod ? (rail)	Barguzin	-	-	4 × 100? (MIRV)	-
SS-X-28 (mobile)	RS-26 (Yars-M)	-	-	4 × 100? (MIRV)	-
SS-X-29 (silo)	RS-28 (Sarmat)	-	(2020)	10 × 500? (MIRV)	-
<b>Subtotal</b>		<b>318</b>			<b>1165<sup>f</sup></b>

Source: Bulletin of Atomic Scientists, Russian Nuclear Forces (2019), Hans Kristensen and Robert Norris



# Russian Nuclear Forces Cont. (2019)

Type/Name	Designation	Launchers	Year Deployed	Warhead Yield	total
<b>SLBMs</b>					
SS-N-18 M1 Stingray	RSM-50	1/16	1978	3 × 50 (MIRV)	48 <sup>g</sup>
SS-N-23 M1	RSM-54 (Sineva)	6/96	2007	4 × 100 (MIRV) <sup>h</sup>	384 <sup>i</sup>
SS-N-32	RSM-56 (Bulava)	3/48	2014	6 × 100 (MIRV)	288 <sup>j</sup>
<b>Subtotal</b>	<b>10/160<sup>k</sup></b>				<b>720<sup>l</sup></b>
<b>Bombers/weapons</b>					
Bear-H6	Tu-95 MS6	25	1984	6 × AS-15A ALCMs, bombs	150
Bear-H16	Tu-95 MS16	30	1984	16 × AS-15A ALCMs, bombs	480
Blackjack	Tu-160	13	1987	12 × AS-15B ALCMs	156
<b>Subtotal</b>		<b>68<sup>m</sup></b>			<b>786<sup>n</sup></b>
<b>Subtotal strategic offensive forces</b>		<b>546<sup>o</sup></b>			<b>~2,670<sup>p</sup></b>

Source: Bulletin of Atomic Scientists, Russian Nuclear Forces (2019), Hans Kristensen and Robert Norris



# Russian Nuclear Forces Cont. (2019)

Type/Name	Designation	Launchers	Year Deployed	Warhead Yield	total
<i>Nonstrategic and defensive weapons</i>					
<b>ABM/Air/Coastal defense</b>					
S-300/S-400 (SA-20/SA-21)		~1000	1992/2007	1 × low	~290
53T6 Gazelle		68	1986	1 × 10	68 <sup>a</sup>
SSC-1B Sepal (Redut)		8 <sup>r</sup>	1973	1 × 350	4
SSC-5 Stoooge (SS-N-26) (K-300P/3M-55)		48	2015	(1 × 10) <sup>a</sup>	24
<b>Land-based air</b>					
Bombers/fighters (Tu-22M3/Su-24M/Su-34/MiG-31K)		300	1974/2006/1983	ASMs, bombs	~530
<b>Ground-based</b>					
SS-21 Scarab SSM (9K79, Tochka)		12	1981	1 × 10–100	5
SS-26 Stone SSM (9K720, Iskander-M)		132	2005	1 × 10–100	66
SSC-7 GLCM (9M728) <sup>t</sup>					
SSC-8 GLCM (9M729) <sup>u</sup>		16 <sup>v</sup>	2017	1 × 10–100	16
<b>Naval</b>					
Submarines/surface ships/air				LACM, SLCM, ASW, SAM, DB, torpedoes	820
<b>Subtotal nonstrategic and defensive forces</b>					<b>~1,820<sup>w</sup></b>
<b>Total</b>					<b>~4,490<sup>x</sup></b>
Deployed					1,600
Reserve					2,890
<b>Retired warheads awaiting dismantlement</b>					<b>2,000</b>
<b>Total inventory</b>					<b>6,490</b>

Source: Bulletin of Atomic Scientists, Russian Nuclear Forces (2019), Hans Kristensen and Robert Norris



# Module 6: Arsenals

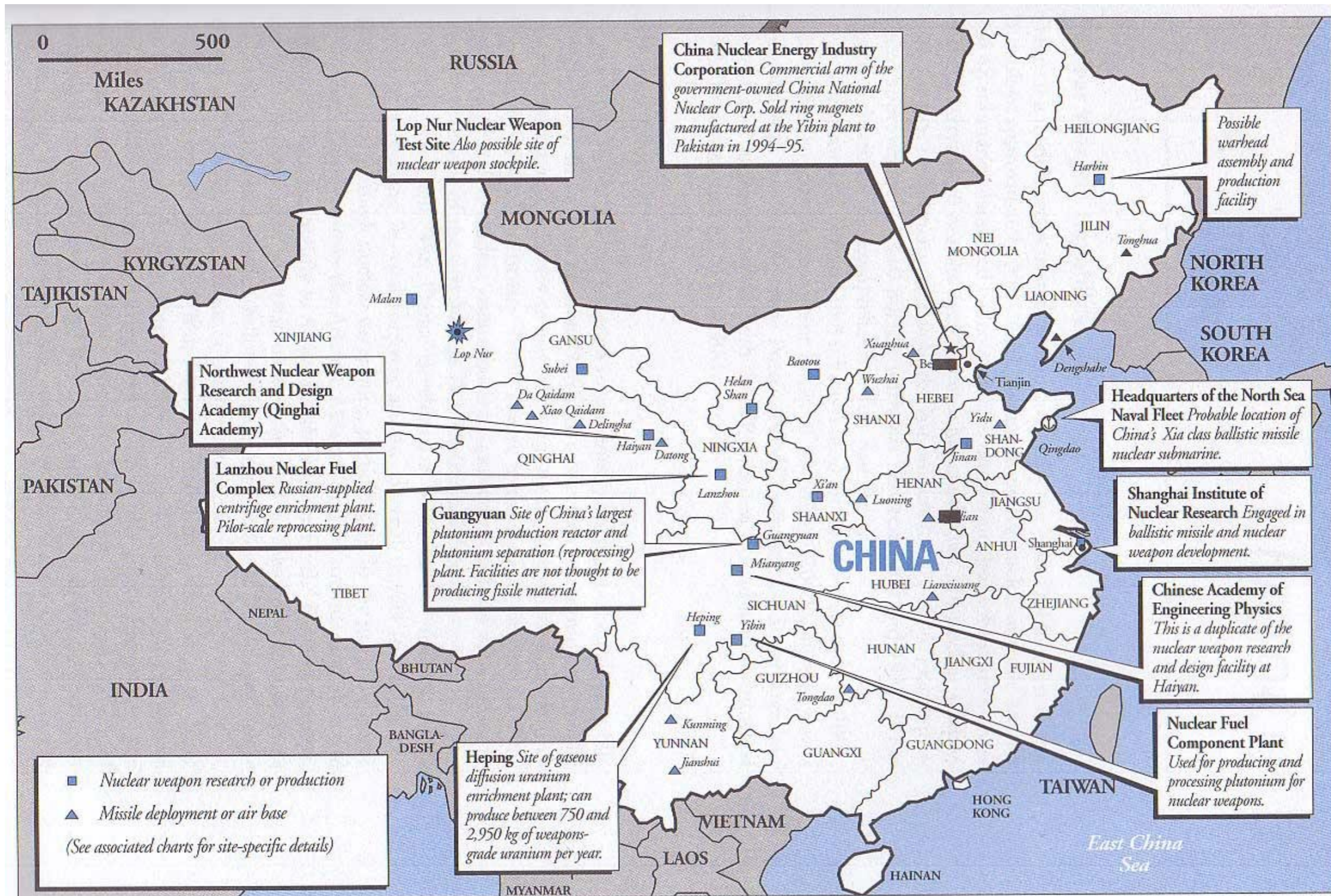
**ACDIS** program in arms control & domestic and international security



## Part 2 sec 2: Arsenals of the U.K, France, and China



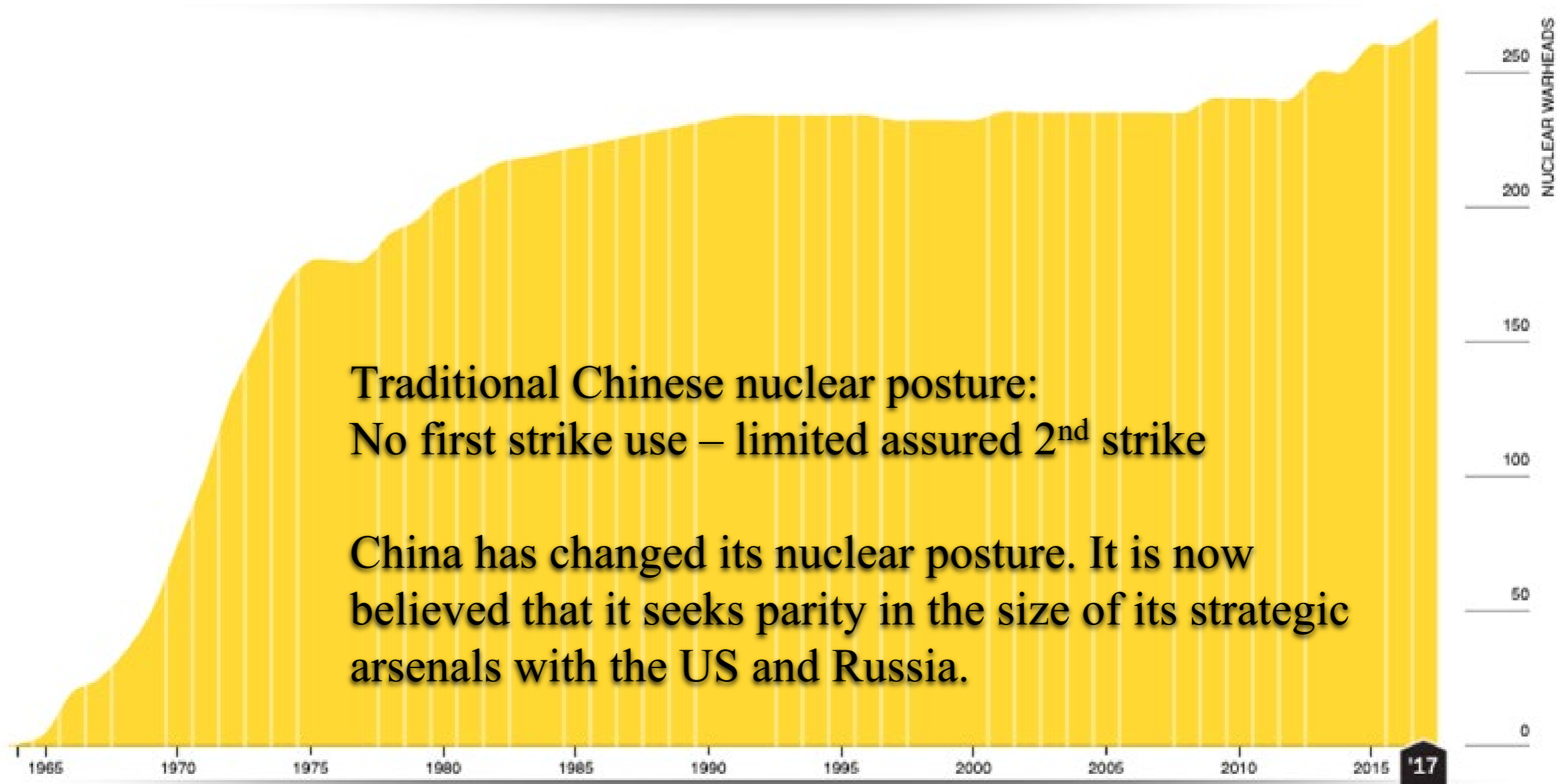
# China's Nuclear Infrastructure



Carnegie Endowment for International Peace, *Deadly Arsenals* (2002), [www.ceip.org](http://www.ceip.org)



# Total Chinese Nuclear Warheads 1945-2017



Source: The Bulletin of the Atomic Scientist Nuclear Notebook, written by Hans M Kristensen and Robert S. Norris, Federation of American Scientists

# Chinese Nuclear Forces (2018)

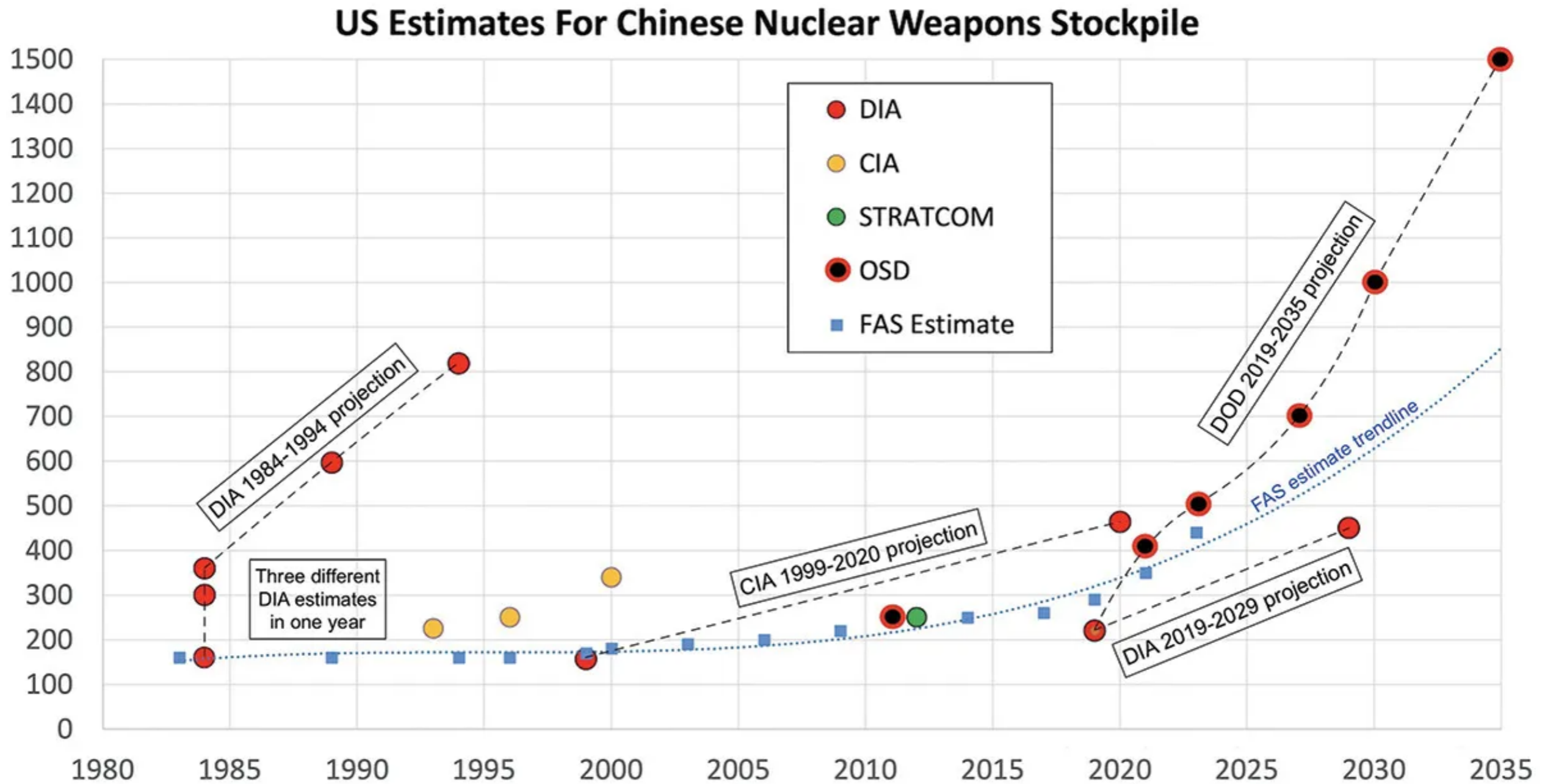
Type	NATO designation	Number of launchers	Year deployed	Range (kilometers)	Warhead x yield <sup>a</sup> (kilotons)	Number of warheads
<b>Land-based ballistic missiles</b>						
sDF-4	CSS-3	~5	1980	5,500+	1 x 3,300	~10
DF-5A	CSS-4 Mod 2	~10	1981	13,000+	1 x 4,000–5,000	~10
DF-5B	CSS-4 Mod 3	~10	2015	~13,000	3 x 200–300	~30
DF-15	CSS-6	?	1990	600	1 x ?	? <sup>b</sup>
DF-21	CSS-5 Mods 2, 6	~40	1991, 2000, 2016	2,150	1 x 200–300	~80 <sup>c</sup>
DF-26	?	16	(2017)	4,000+	1 x 200–300	16
DF-31	CSS-10 Mod 1	~8	2006	7,000+	1 x 200–300	~8
DF-31A	CSS-10 Mod 2	~32	2007	11,000+	1 x 200–300	~32
DF-31AG <sup>d</sup>	(CSS-10 Mod 3?)	(16)	(2017)	?	(1 x ?)	?
DF-41	CSS-X-20	n.a.	?	?	n.a.	n.a.
<i>Subtotal:</i>			~121			~186 <sup>e</sup>
<b>Submarine-launched ballistic missiles<sup>f</sup></b>						
JL-2	CSS-N-14	48	(2016)	7,000+	1 x 200–300	48
<b>Aircraft</b>						
H-6 <sup>g</sup>	B-6	(~20)	1965	3,100+	1 x bomb	(~20)
					(1 x ALBM)	0
Fighters <sup>h</sup>	?	?	?	n.a.	1 x bomb	?
<b>Cruise Missiles<sup>i</sup></b>						
<b>Total</b>						~254 (280) <sup>j</sup>

Currently: Modernizing nuclear forces to strengthen assured 2<sup>nd</sup> strike capability

- road mobile ICBM launchers
- new DF-41
- submarine based missiles



# Projected Chinese Nuclear Stockpile Growth

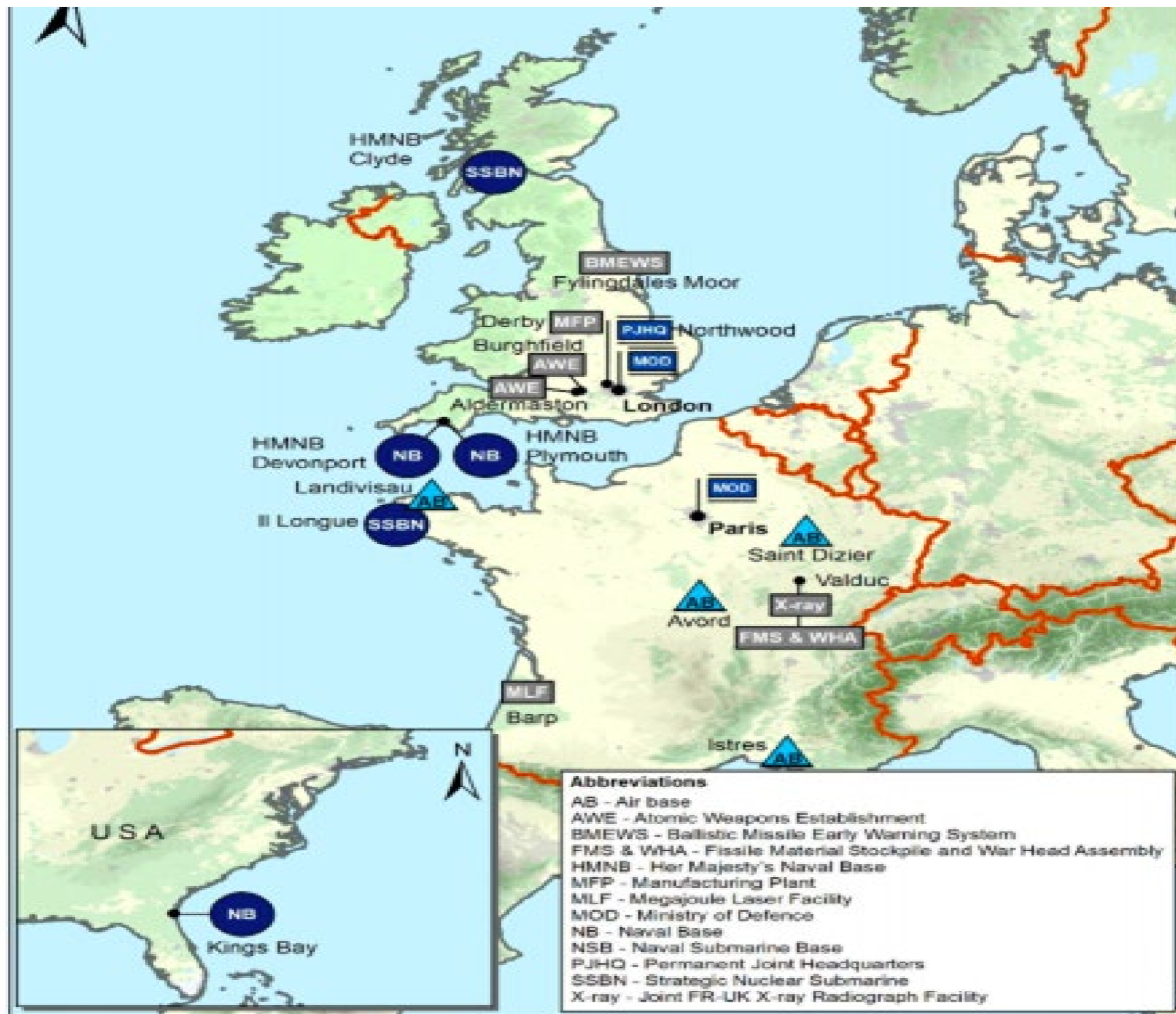


Past Chinese Nuclear Policy: no first use, limited secure second-strike capability.



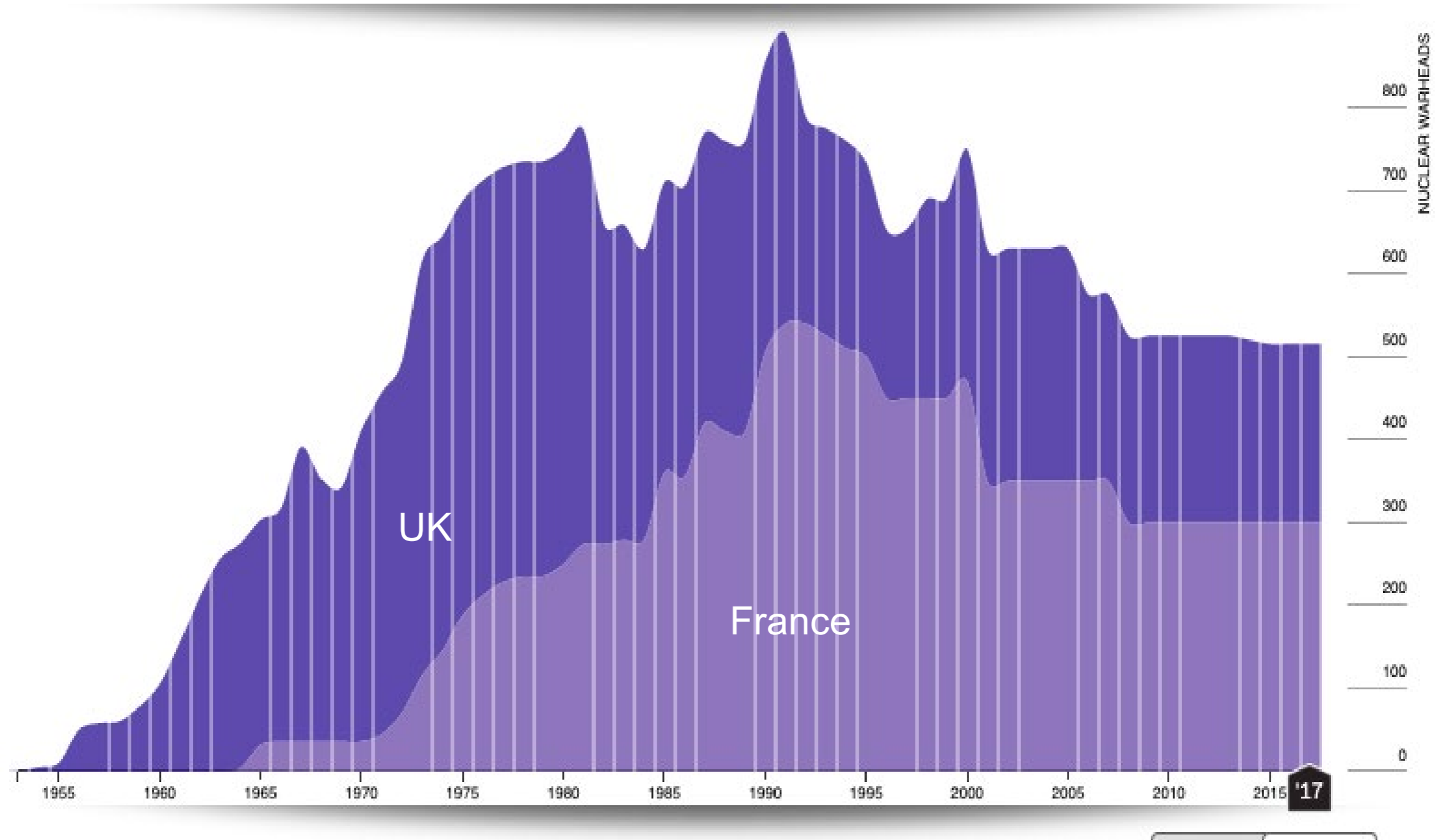
Source: Federation of American Scientists

# French and British Nuclear Structure



*British and French nuclear-related sites. Map by Dan Wilton/ECF*  
 Source: Nuclear weapons in Europe: British and French deterrence forces, Niklas Granholm and John Ryvidqist

# French and British Nuclear Forces(2017)



Source: The Bulletin of the Atomic Scientist Nuclear Notebook, written by Hans M Kristensen and Robert S. Norris, Federation of American Scientists



# French Arsenals (2019)

Weapon System	No.	Year operational	Range(km) <sup>a</sup>	Warheads x yield	Warhead Type	Warheads
<b>Land-based aircraft<sup>b</sup></b>						
Rafale F3/ASMPA	40	2010 <sup>c</sup>	2,000	1 x up to 300 kt	TNA	40
<b>Carrier-based aircraft</b>						
Rafale MF3/ASMPA	10	2011	2,000	1 x up to 300 kt	TNA	10
<b>Submarine-launched ballistic missiles</b>						
M51.1	32	2010	6,000+	4-6 x 100 kt MIRV	TN75	160
M51.2	16	2017	6,000+	4-6 x 150 kt MIRV	TNO	80
<b>Total</b>	<b>98</b>					<b>300<sup>d</sup></b>

## FRENCH SSBNs

NAME/SLBM*	YEAR OPERATIONAL	MISSILE RANGE (KILOMETERS)	WARHEADS x YIELD (KILOTONS)	TOTAL WARHEADS
<i>Le Triomphant</i> /M45	1997	4,000+	4-6 TN75 x 100	80
<i>Le Téméraire</i> /M45	1999	4,000+	4-6 TN75 x 100	80
<i>Le Vigilant</i> /M45	2005	4,000+	4-6 TN75 x 100	80
<i>Le Terrible</i> /M51.1**	(2010)	6,000	4-6 TN75 x 100	0

\* Three sets of 16 M45 missiles are deployed on three of four SSBNs in the operational cycle.  
 \*\* Its first deployment is scheduled for 2010.

SSBN: Nuclear-power ballistic missile submarine  
 SLBM: Submarine-launched ballistic missile

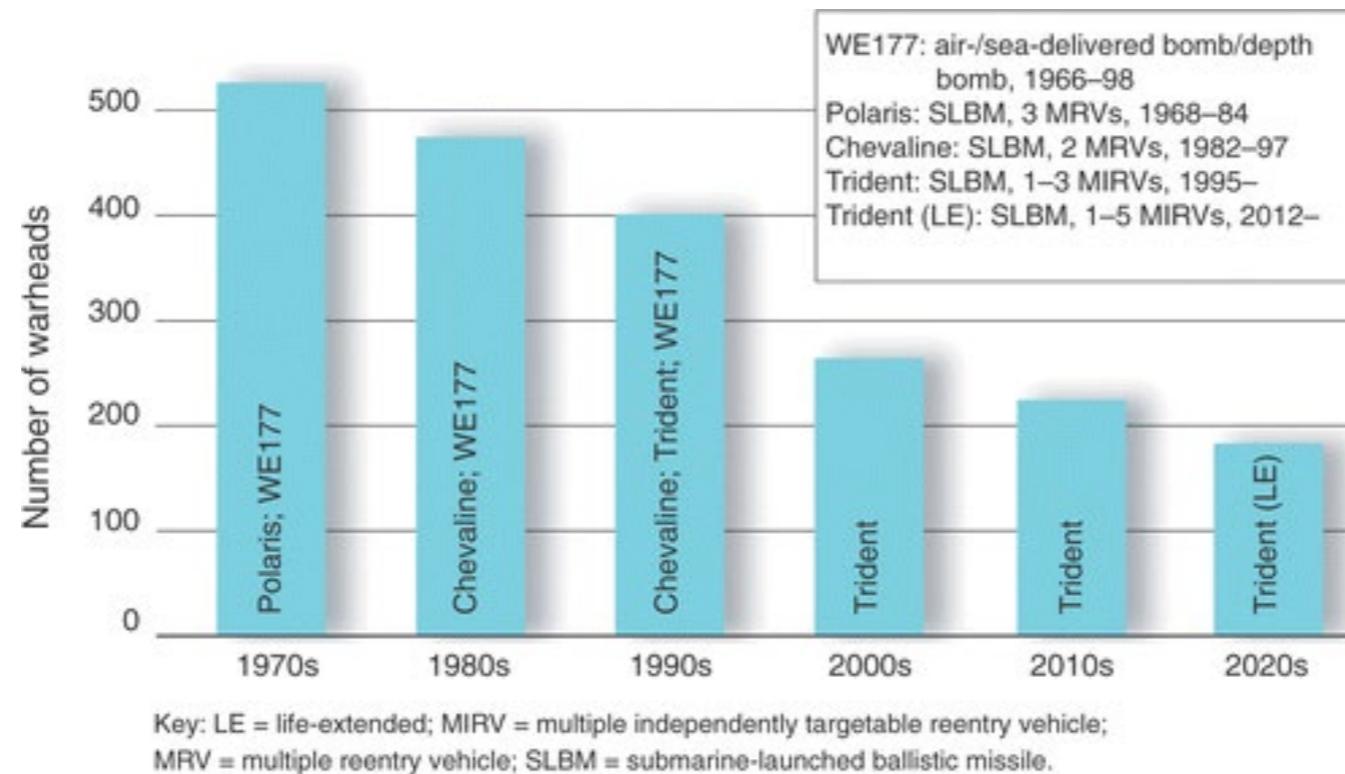
Source: Hans M. Kristensen & Matt Korda (2019) French nuclear forces, 2019, Bulletin of the Atomic Scientists



# U.K. Strategic Nuclear Forces

Weapon System	Warheads					
	No. deployed	Year deployed	Range (km)	Warhead x yield	Type	No. in stockpile
<b>SLBMs</b>						
Trident II D-5	64	1994	7,400	1-3 x 100 Kt	MIRV	200
# average loading five warheads per missile, some missiles carry one warhead , various yield options						

Source: NRDC (Nov. 2002)



Source: Hans Kristensen and Robert S Norris, British Nuclear forces 2011, Bulletin of the Atomic Scientists

The United Kingdom and France (largely) rely on a nuclear deterrent in form of a naval submarine based nuclear arsenal



# Phys 280 Session 18

## Module 6 – Nuclear Arsenals

RPV1 due next week, 4-8 !!

Extra credit assignment – ACDIS Seminar 4-14, 5pm, Coble Hall

### Golden Dome - A Scientific and Technical Assessment

Fred Lamb, Physics UIUC, Chair of the APS missile defense study

Abstract:

In May 2025, President Trump approved the Defense Department's architecture and implementation plan for "Golden Dome"—a multilayered defense system with ground-, sea-, and space-based components intended to protect the United States and its allies and their armed forces against attack by aircraft, ballistic missiles, hypersonic glide vehicles, cruise missiles, and drones fired at anytime from anywhere by any adversary, including peer and near-peer adversaries. This goal is clearly beyond reach anytime soon. Even attempting to create such a system would cost hundreds of billions of dollars or more and have other serious consequences.

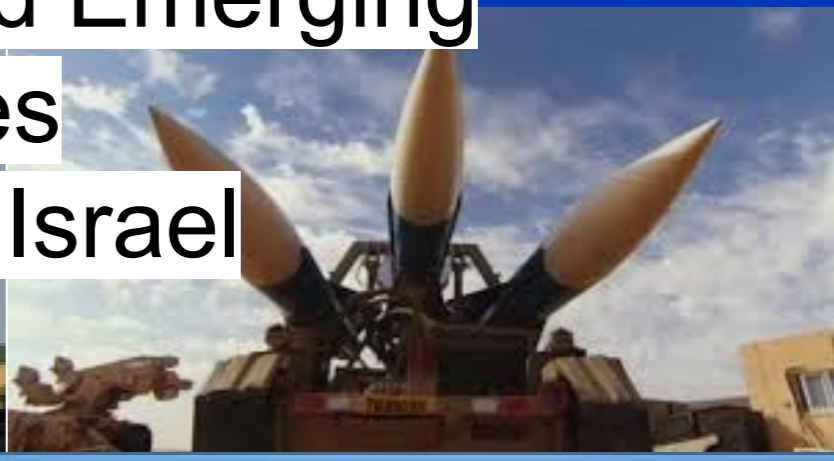
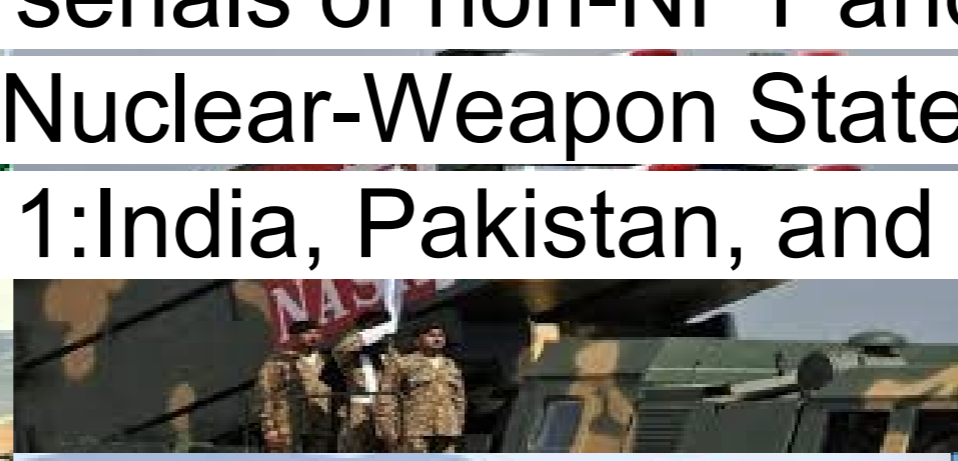


# Module 6: Programs and Arsenals

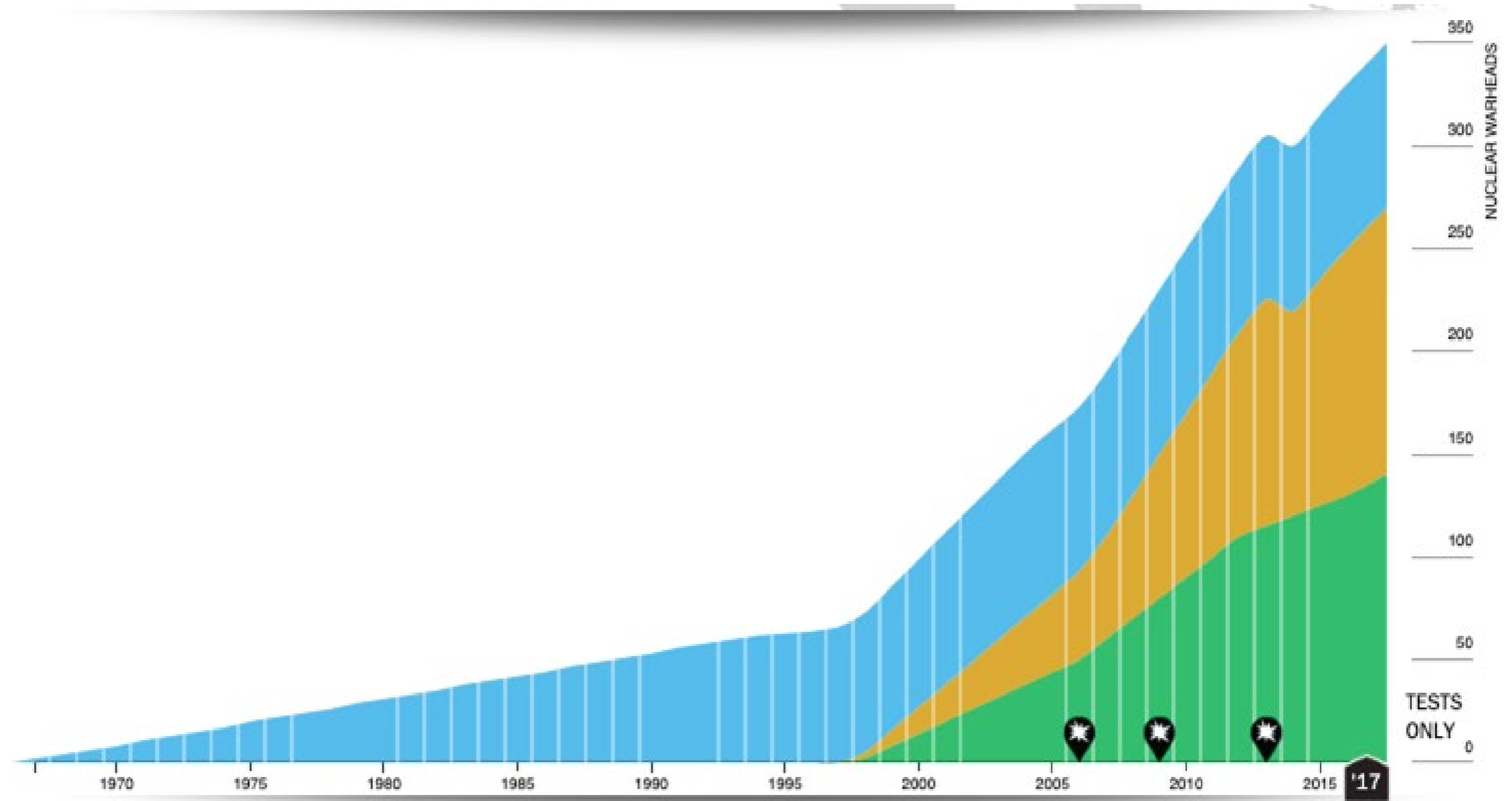
**ACDIS** program in arms control & domestic and international security



## Part 3 : Arsenals of non-NPT and Emerging Nuclear-Weapon States Sec 1: India, Pakistan, and Israel



# Estimates for Arsenals in India, Israel, North Korea and Pakistan (2017)



Source: The Bulletin of the Atomic Scientist Nuclear Notebook, written by Hans M Kristensen and Robert S. Norris, Federation of American Scientists

Israel ~ 80

India ~ 130

Pakistan ~ 140

North Korea < 10



# Indian locations of Nuclear Power and Weapons



## NUCLEAR FACILITIES & DELIVERY SYSTEMS

### ● Nuclear Facilities

- Karachi : Nuclear Power Reactor (Kanupp) - 125-megawatt power reactor
- Kahuta : Nuclear weapon research and development; uranium enrichment
- Chashma : Nuclear Power Reactor - 300-megawatt power reactor
- Khushab : Research reactor and heavy water production plant
- Rawalpindi : New Labs plutonium processing plant
- Lahore : Atomic Energy Minerals Center
- Multan : Heavy water production plant
- Dera Gazi Khan : Uranium Mining
- Chagai Hills : Nuclear test site

### ★ Possible Delivery System Sites:-

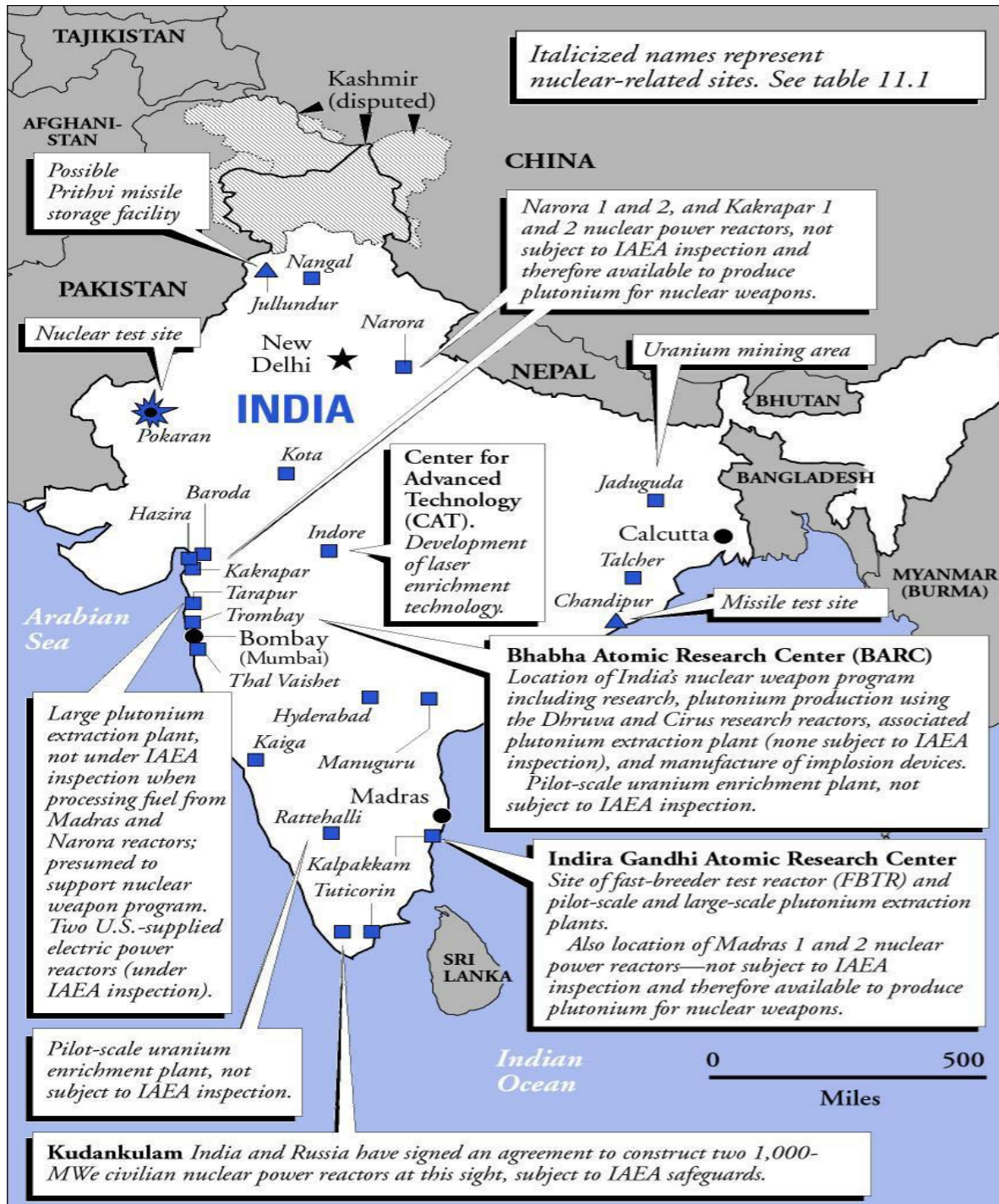
- Sonmiani, Quetta, Sargodha, Malute, Fatehjung.



Map not to scale



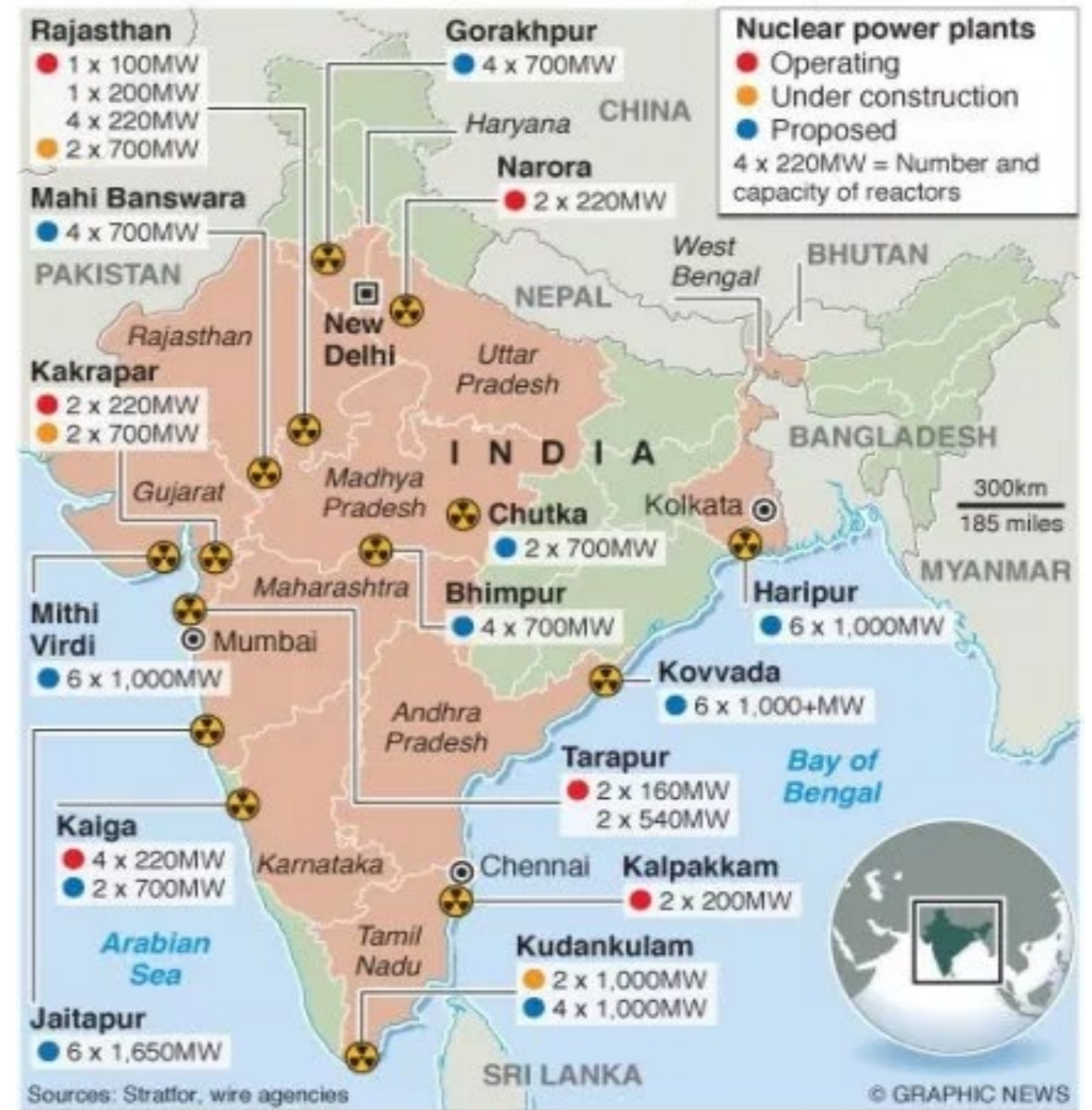
# Indian locations of Nuclear Power and Weapons



Carnegie Endowment for International Peace, *Deadly Arsenals* (2002), [www.ceip.org](http://www.ceip.org)

## India planning huge increase in nuclear power

India is making nuclear power one of its key policy initiatives, with plans to build 48 new reactors and boost output to 63,000 megawatts by 2032 – an almost 14-fold increase on current levels. The country's existing 20 nuclear reactors generate about 4,700 megawatts



Source: Indian Defense Review, RSN Singh



# India's Nuclear and Missile Programs – 1

## India's nuclear weapons use plutonium

- India's first nuclear explosive device used explosive material diverted illegally from a civilian nuclear reactor provided by Canada
- Estimated to have produced 600 kg of weapons-grade plutonium
- Estimated to have produced a smaller, but publicly unknown, quantity of weapons-grade uranium
- This quantity of plutonium is thought to be enough for India to produce ~150-200 nuclear weapons
- The FAS estimates that India has about 130-140 warheads
- India is thought to have the components to deploy a small number of nuclear weapons within days
- No nuclear weapons are known to be deployed among active military units or deployed on missiles

# India's Nuclear and Missile Programs – 2

## India's nuclear weapon tests

India			
Date			
May 18, 1974	02:34:55	27.095 N 71.752 E	2-5 kt
May 11, 1998	10:13:42	27.102 N 71.857 E	12 kt*
May 11, 1998	10:13	?	? *
May 13, 1998	06:51	?	? **

Local time is 5 and one-half hours later than GMT

\* The Indian government announced that three nuclear devices were detonated simultaneously in two shafts, about one kilometer apart. We count this as two tests.

\*\* Seismic records do not discriminate the explosions of two devices (announced by Indian scientists as being 0.2 kt and 0.6 kt), one or both of which may not have detonated.

Source: NRDC



# India's Nuclear and Missile Programs – 3

- India has developed several types of ballistic missiles capable of carrying and delivering a nuclear payload
- Three versions of the short-range, liquid-propellant, road-mobile Prithvi have been developed —
  - Army (range = 150 km, payload = 500 kg)
  - Air Force (range = 250 km, payload = 500–750 kg)
  - Navy (range = 350 km, payload = 500 kg)
- India has developed and successfully tested 7 medium range missiles Agni I-III, with a declared range of up to 3,000 km. The payload for the Agni III missile is assumed to be 1.5 tons.
- India has developed and successfully tested Agni-IV with a range of 4,000 km and Agni V with a range of 5,000 and a payload of 1.5 tons.
- In 2018 India became one of three nations to possess a nuclear triad after the<sup>5</sup><sub>8</sub> successful deterrent patrol of Arihant, India's first SSBN

# Indian Nuclear Forces (2018)

Type	NATO designation	Number of launchers	Year deployed	Range (kilometers)	Warhead x yield (kilotons)	Number of warheads
<b>Aircraft</b>						
Vajra	Mirage 2000H	~16	1985	1,850	1 × bomb	~16
Shamsher	Jaguar IS/IB	~32	1981	1,600	1 × bomb	~32
Subtotal:		~48				~48
<b>Land-based ballistic missiles</b>						
Prithvi-II	n.a.	~24	2003	350b	1 × 12	~24
Agni-I	n.a.	~20	2007c	700+	1 × 40	~20
Agni-II	n.a.	~8	2011d	2,000+	1 × 40	~8
Agni-III	n.a.	~8	2014?	3,200+	1 × 40	~8
Agni-IV	n.a.	n.a.	(2018)	3,500+	1 × 40	n.a.
Agni-V	n.a.	n.a.	(2020)	5,200+	1 × 40	n.a.
Subtotal:		~60				~60e
<b>Sea-based ballistic missiles</b>						
Dhanush	n.a.	2	2013	400	1 × 12	4
K-15	(Sagarika)	(12)	(2018)	700	1 × 12	(12)
K-4	n.a.	(4)	?	3,500	1 × ?	0
Subtotal:		(18)				(16)
<b>Total</b>						<b>130–140f</b>

Source: Bulletin of the Atomic Scientist "Indian Nuclear Forces, Hans Kristensen and Matt Korda



# India's Ballistic Missiles (2019)

Name	Type	Range	Stages/Fuel	Payload Capacity	Last Reported Test	Inducted?	Nuclear Capable?
Prithvi-I	Ballistic	150 km	Single/Liquid	800 kg*	May 2007	Y(a)	Y
Prithvi-II	Ballistic	350 km	Single/Liquid	500-1,000 kg	October 2018*	Y	Y
Dhanush	Ballistic	350 km	Single/Liquid	500 kg	February 2018*	Y*	Y
Agni-I	Ballistic	700 – 900 km	Single/Solid*	1,000 kg*	October 2018*	Y	Y*
Agni-II	Ballistic	2,000 km	Two/Solid	1 ton	February 2018*	Y	Y
Agni-III	Ballistic	3,500 km	Two/Solid	1.5 tons	April 2017*	Y	Y*
Agni-IV	Ballistic	4,000 km	Two/Solid	1,000 kg*	December 2018*	Y*	Y
Agni-V	Ballistic	+5,000 km	Three/Solid	1,000 kg*	December 2018	N	Y
Prahaar	Ballistic	150 km	Single/Solid	200 kg	September 2018*	N*	N*
Pragati	Ballistic*	60 km – 170 km*	Single/Solid*	200 kg	Not Tested	N*	N*

Source: Wisconsin Project on Nuclear Arms Control



# India's SLBM and Cruise Missiles (2019)

Name	Type	Range	Stages/Fuel	Payload Capacity	Last Reported Test	Inducted?	Nuclear Capable?
K-15 (aka B0-5)	SLBM(b)	750 km*	Two/Solid*	1,000 kg*	August 2018*	Y*	Y*
K-4	SLBM*	3,500 km*	Two/Solid*	Unknown	December 2017(c)*	N*	Y*
BrahMos	Cruise	290 – 400 km	Two/Solid and Liquid(d)	200-300 kg	May 2019	(e)N-I: Y B-I: Y B-II: Y B-III: Y* ALCM: Y SLCM: N*	N
Nirbhay	Cruise	1,000 km	Two/solid and liquid(f)	450 kg*	April 2019	N*	Y*

Source: Wisconsin Project on Nuclear Arms Control



# Pakistan's Nuclear and Missile Programs – 1

## Pakistan's current nuclear weapons mainly use HEU

- Pakistan stole uranium enrichment technology from Urenco; has since supplied it to many other countries of concern
- Is estimated to have produced 585–800 kg of highly enriched uranium
- FAS estimates that it could have 120 HEU nuclear weapons
- May possess enough weapon-grade plutonium to produce 3–5 nuclear weapons
- Nuclear weapons are thought to be stored in component form, with the fissile core stored separately from the non-nuclear explosives
- Thought to possess enough components and material to assemble a small number of nuclear weapons in a matter of hours or days

# Pakistan's Nuclear and Missile Programs – 2

## Pakistan's nuclear weapon tests

<b>Pakistan</b>			
<b>Date</b>			
May 28, 1998	10:16:15	28.862 N 64.818 E	9-12 kt#
May 30, 1998	06:54:55	28.487 N 63:787 E	5 kt

Local time is 5 hours later than GMT

# Pakistani officials announced that five nuclear devices were tested. Seismic records do not discriminate these and possibly only one device was detonated.

last revised 11.25.02

Source: NRDC



# Pakistan's Nuclear and Missile Programs – 3

## Pakistan's nuclear delivery capability

- Thought to have about 30 nuclear-capable short-range Chinese M-11 surface-to-surface missiles, which have a range of 280–300 km
- Announced deployment of the Shaheen I in 2001
- Tested Ghauri I (range > 1,300 km, payload = 700 kg)
- Tested Ghauri II (range = 2,000 km, payload = 850 kg)
- Tested Shaheen II, (range 1,500-2000 km, payload 700kg)
- Primary nuclear capable aircraft is the F-16, which can deliver a 1,000-kg bomb to a distance of 1,400 km

# Pakistani Nuclear Forces, 2018

Type	NATO designation	Number of launchers	Year deployed	Range (kilometers) <sup>1</sup>	Warhead x yield (kilotons) <sup>3</sup>	Number of warheads <sup>2</sup>
<b>Aircraft</b>						
F-16A/B		~24	1998	1,600	1 x bomb	~24
Mirage III/V		~12	1998	2,100	1 x bomb (or Ra-ad)	~12
<b>Subtotal:</b>		<b>~36</b>				<b>~36</b>
<b>Land-based ballistic missiles</b>						
Abdali (Hatf-2)		10	(2015)	200	1 x 5-12 kt	10
Ghaznavi (Hatf-3)		~16	2004	300	1 x 5-12 kt	~16
Shaheen-1(Hatf-4)		~16	2003	750	1 x 5-12 kt	~16
Shaheen-1A (Hatf-4)		-	(2018)	900	1 x 5-12 kt	-
Shaheen-2(Hatf-6)		~12	2014	1,500	1 x 10-40 kt	~12
Shaheen-3 (Hatf-6)		-	(2018)	2,750	1 x 10-40 kt	-
Ghauri (Hatf-5)		~24	2003	1,250	1 x 10-40 kt	~24
NASR (Hatf-9)		~24	(2013)	60-70	1 x 5-12 kt	~244
Ababeel (Hatf-?)		-	-	2,200	MIRV or MRV	-
<b>Subtotal:</b>		<b>~102</b>				<b>~102</b>

Source: Bulletin of the Atomic Scientist "Pakistani Nuclear Forces, Hans Kristensen and Matt Korda

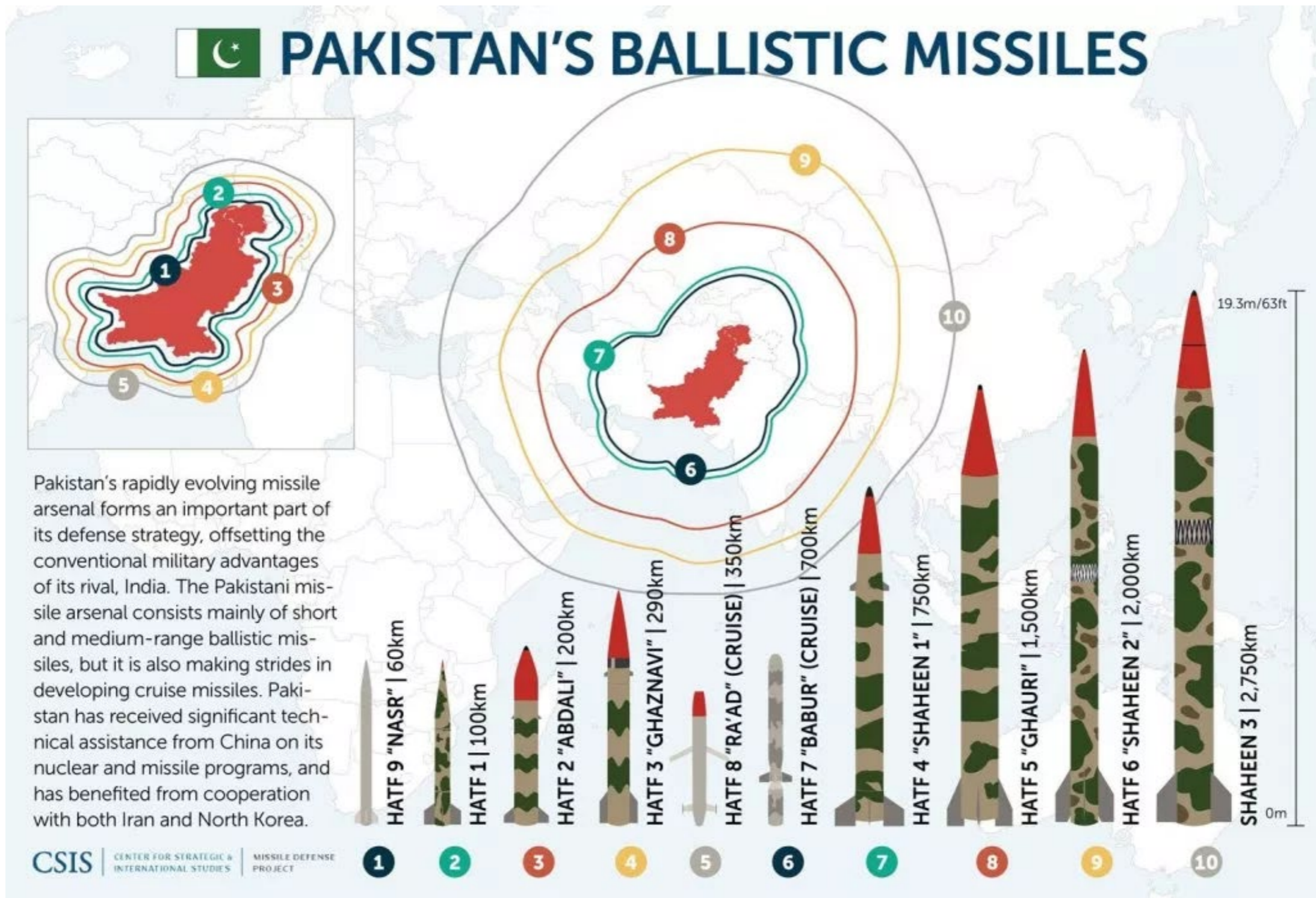


# Pakistani Ra'ad Air-Launched Cruise Missile



**Pakistani Ra'ad Air Launched Cruise Missile**

# Pakistan's Ballistic Missiles Lineup

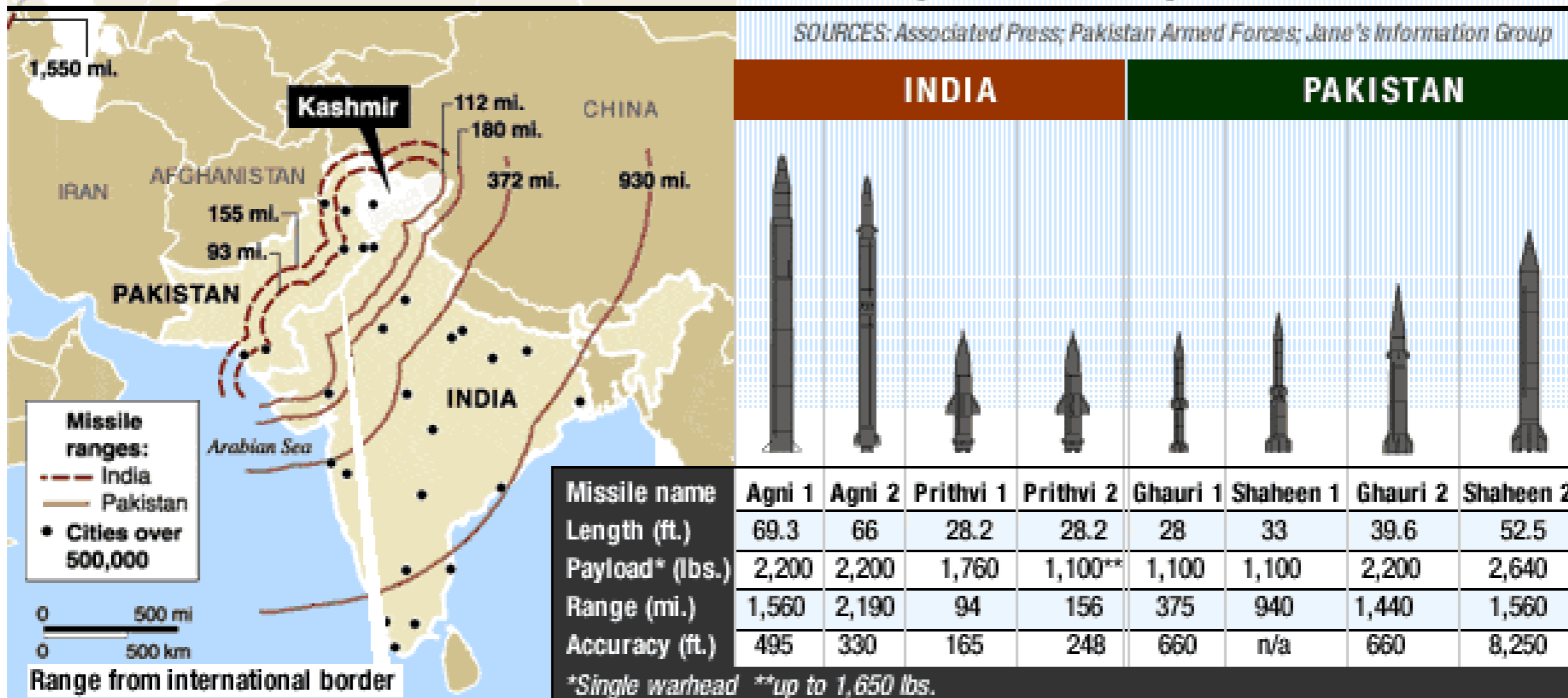


Source: Missile Defense Project, "Missiles of Pakistan," *Missile Threat*, Center for Strategic and International Studies, June 14, 2018, last modified June 15, 2018, <https://missilethreat.csis.org/country/pakistan/>.



# Security Concerns of India's and Pakistan Define the Parameters of Ballistic Missile Arsenals

With India and Pakistan both possessing nuclear weapons and the means to deliver them great distances, a possible war could result in millions of deaths in both countries. The following illustrates the range of missiles:



Source: CNN (May 2003)

# Israel's Nuclear Weapons Complex



Carnegie Endowment for International Peace, *Deadly Arsenals* (2002), [www.ceip.org](http://www.ceip.org)



# Israel's Nuclear and Missile Programs – 1

## Israel's nuclear weapons primarily use Pu

- Is thought to have completed its first nuclear device by late 1966 or early 1967, probably using HEU stolen from the United States
- Is reported to have hurriedly assembled deliverable devices just before the 1967 six-day war.
- Is estimated to have produced ~ 860 kg of weapons-grade plutonium as of January 2017
- Is thought to have enough plutonium to fabricate ~ 100–200 nuclear weapons
- Is thought to have ~ 75–200 fission weapons, FAS estimate: 80. (Some sources disagree, claiming much more capability, including modern thermonuclear weapons)

# Israel's Nuclear and Missile Programs – 2

## Israel's nuclear delivery capability

- Jericho I: short-range, solid-propellant (range = 500 km, payload = 500 kg). Developed with the French. Deployed in 1973. Land- and rail-mobile.
- Jericho II: medium-range, solid-propellant (range = 1,500 km, payload = 1,000 kg). Developed with the French. Deployed in 1990; currently has ~ 100. Land- and rail-mobile.
- Jericho III: intermediate-range, solid-propellant (range approx. 4,000 km, payload = 1,000 kg). Indigenous. Tested.
- Israel could also deliver nuclear weapons using its U.S.-supplied F-4E and F-16 aircraft.
- Israel could also deliver nuclear weapons using its cruise missiles (the U.S.-supplied Harpoon, range = 120 km, payload = 220 kg, or a new 1,200-km cruise missile).



# Summary of Israel's Nuclear Delivery Systems

**Table 1.** Israeli nuclear forces, 2014

TYPE	YEAR FIRST DEPLOYED	RANGE (KM)	COMMENT
<b>AIRCRAFT</b>			
F-16A/B/C/D/I Fighting Falcon	1980	1,600	Nuclear bombs possibly stored at underground facility near Tel Nof Air Base
F-15I Ra'am (Thunder)	1998	3,500	Potential nuclear strike role
<b>LAND-BASED MISSILES</b>			
Jericho II	1984–1985	1,500+	Possibly 25–50 at Zekharia for TELs in caves
Jericho III	?	4,000 ?	In development
<b>SEA-BASED MISSILES</b>			
Dolphin-class submarines	2002 ?	?	Possibly modified cruise missile for land-attack

Dolphin class submarines, if nuclear armed, provide secure nuclear 2<sup>nd</sup> strike capability.



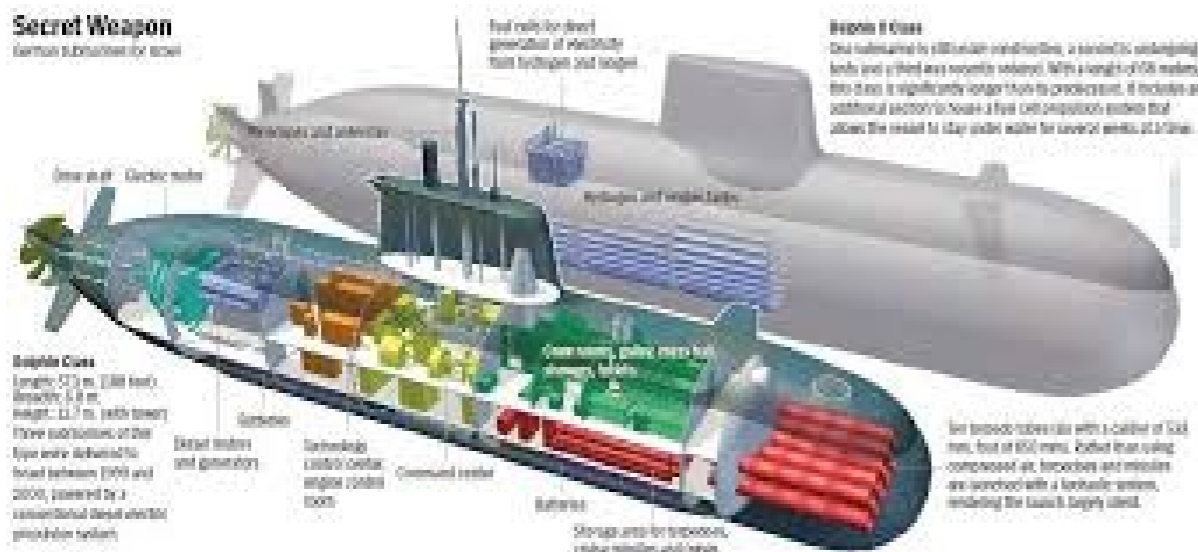
# Israeli Dolphin Class Submarines



Source: Secret Shores



Source: National Interest



Source: Hi Sutton



Source: Spiegel Online



# Module 6: Arsenals


**ACDIS** program in arms control & domestic and international security



## Part 3 Sec 2: Arsenals of North Korea



# The History between Trump and Kim

 **Donald J. Trump**   
@realDonaldTrump 

Why would Kim Jong-un insult me by calling me "old," when I would NEVER call him "short and fat?" Oh well, I try so hard to be his friend - and maybe someday that will happen!

 **Donald J. Trump**   
@realDonaldTrump

North Korean Leader Kim Jong Un just stated that the "Nuclear Button is on his desk at all times." Will someone from his depleted and food starved regime please inform him that I too have a Nuclear Button, but it is a much bigger & more powerful one than his, and my Button works!

 **Donald J. Trump**   
@realDonaldTrump 

Just heard Foreign Minister of North Korea speak at U.N. If he echoes thoughts of Little Rocket Man, they won't be around much longer!

11:08 PM - 25 Sep 2017




 **Donald J. Trump**   
@realDonaldTrump 

A message from Kim Jong Un: "North Korea will stop nuclear tests and launches of intercontinental ballistic missiles."  
Also will "Shut down a nuclear test site in the country's Northern Side to prove the vow to suspend nuclear tests." Progress being made for all!

8:22 PM - 20 Apr 2018


31,009 Retweets 134,354 Likes 



 **Donald J. Trump**   
@realDonaldTrump 

Vietnam is thriving like few places on earth. North Korea would be the same, and very quickly, if it would denuclearize. The potential is AWESOME, a great opportunity, like almost none other in history, for my friend Kim Jong Un. We will know fairly soon - Very Interesting!

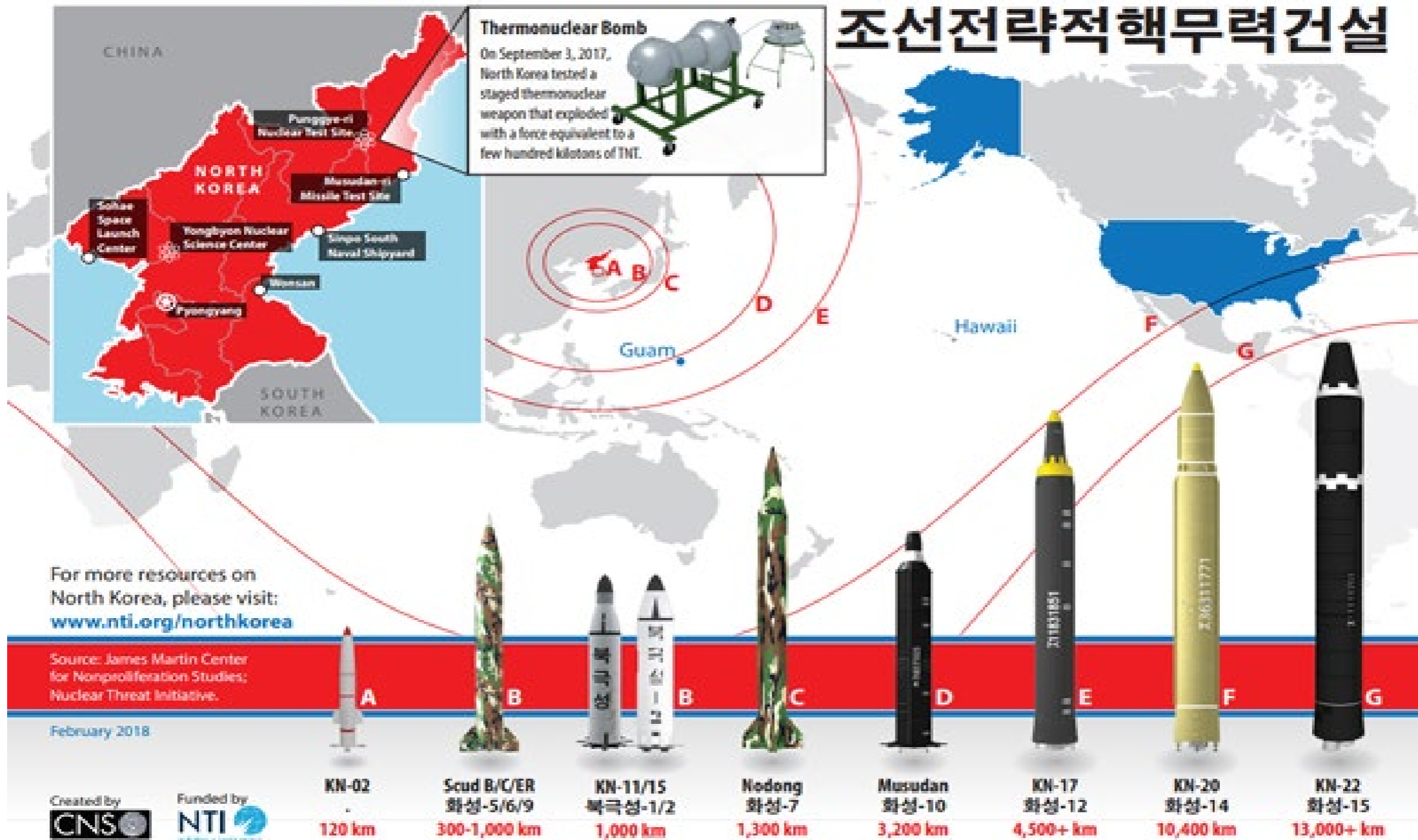
9:31 PM - 26 Feb 2019



# North Korea's Nuclear Capabilities (2018)

## NORTH KOREAN STRATEGIC NUCLEAR THREAT

## 조선전략적핵무력건설



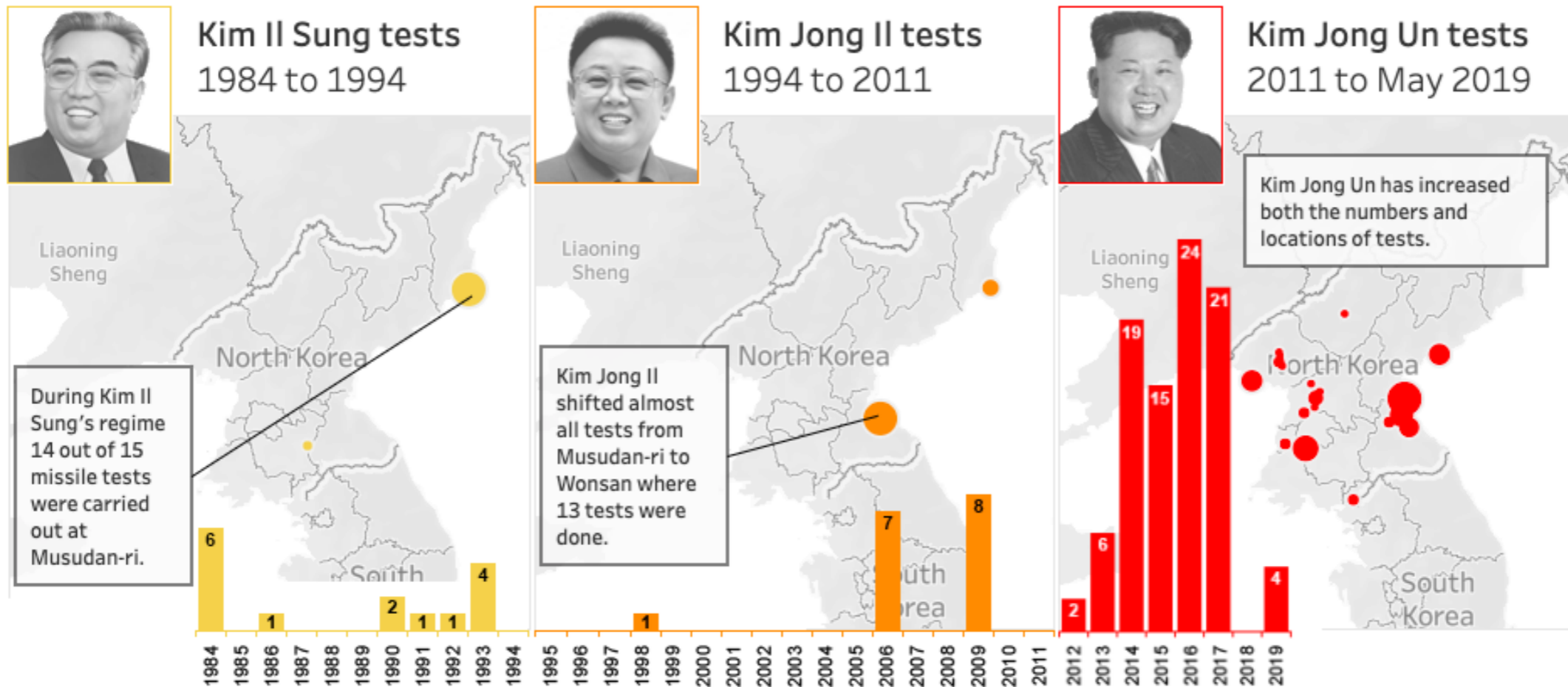
Source: Nuclear Threat Initiative



# History of North Korean Missile Tests

Created by **CNS** Funded by **NTI**  
NTI BUILDING A SAFER WORLD

## Kim Family Missile Tests



+ a b | e a u

← → ↶ ↷

Source: Understanding North Korea's Missile Tests, NTI



# North Korean Missile Test Successes and Failures

Created by  
**CNS**

Funded by  
**NTI**  
BUILDING A SAFER WORLD

### Reliability of Old vs New Missiles



Test Result  
■ Failure  
■ Success

Comparison of missile tests since Kim Jong Un took power in 2011. North Korea's older missiles are very reliable compared to its missiles still under development.

Source: Understanding North Korea's Missile Tests, NTI



# North Korean Missiles with Nuclear Capability (2018)

Type/Name <sup>a</sup>	US/Other Designations	Year Deployed	Range (km) <sup>b</sup>	Stages (Fuel)	Payload x Capacity (kg)	Launchers <sup>c</sup>
Land-based ballistic missiles <sup>d</sup>						
ICBMs (5,500+ km range)						
(Bukkeukseong-3)	?	Dev.	?	? (solid)	1 x ?	TEL (C) <sup>e</sup>
Hwasong-15	KN-22\	Dev.	13,000	2 x liquid	1 x 1,000?	TEL
Hwasong-14	KN-20	Dev.	10,400	2 (liquid)	1 x ?	TEL
Hwasong-?	KN-14	Dev.	(9,000)	3 (liquid)	1 x ?	TEL
Hwasong-13	KN-08 <sup>f</sup>	Dev.	5,500+	3 (liquid)	1 x ?	TEL
Taepo Dong-2	Taepo Dong-2 <sup>g</sup>	(2012)	12,000+	3 (liquid)	1 x 800+	Fixed
IRBMs (3,000–5,500 km range)						
Hwasong-12	KN-17	Dev.	3,300–4,500	1 (liquid)	1 x 1,000	TEL
Hwasong-10 <sup>h</sup>	Musudan, BM-25	(2017)	3,000+	1 (liquid)	1 x 1,000	<50 TEL
MRBMs (1,000–3,000 km range)						
Bukkeukseong-2 <sup>i</sup>	KN-15	Dev.	1,000+	1 (solid)	1 x ?	TEL (C)
Hwasong-7	Nodong <sup>j</sup>	(1993)	1,200+	1 (liquid)	1 x 1,000	<100 TEL
Hwasong-9	Scud ER, KN-4	(2016)	1,000 <sup>k</sup>	1 (liquid)	1 x 500	TEL
Submarine-launched ballistic missiles (SLBMs)						
Bukkeukseong-1 <sup>l</sup>	KN-11	Dev.	(1,000+)	1 (solid)	n.a.	(1) SSB

Source: Bulletin of the Atomic Scientist "North Korean Nuclear Capabilities (2018)", Hans Kristensen and Matt Korda



# North Korean Nuclear Tests and Resource Capabilities (2018)

Date	Seismic Signal	Estimated Yield	Remarks
October 9, 2006	Magnitude 4.1	0.5 kilotons	The Director of National Intelligence (DNI) said the test produced a yield of "less than one kiloton - well below the yield of other states' first nuclear test." <sup>a</sup>
May 25, 2009	Magnitude 4.5	1-3 kilotons	DNI said the yield of the test was "a few" kilotons, <sup>b</sup> which "suggests the North has the capability to produce nuclear weapons with a yield of roughly a couple kilotons TNT equivalent." <sup>c</sup>
February 12, 2013	Magnitude 5	10 kilotons	DNI said "several kilotons." <sup>d</sup>
January 6, 2016	Magnitude 4.8	5 kilotons	North Korea said test was a successful "hydrogen bomb," but the US intelligence community said "the low yield of the test is not consistent with a successful test of a thermonuclear device." <sup>e</sup>
September 9, 2016	Magnitude 5.1	10-15 kilotons	
September 3, 2017	Magnitude 6.1	140-250 kilotons	
Total: 6			

Source: Bulletin of the Atomic Scientist "North Korean Nuclear Capabilities (2018), Hans Kristensen and Matt Korda



# North Korean Missile Displays



# North Korea's Nuclear Program

- 1950s: NK nuclear research reportedly begins.
- mid-1980s: Concerns over NK's nuclear weapons program grow when US intelligence satellites reportedly photograph construction of a research reactor and the beginnings of a reprocessing facility at Yongbyon.
  - 1985 April: NK accedes to the NPT after a concerted sales effort by the USSR, which hopes to sell light-water reactors (LWRs) to NK for electrical power generation. These are never built, in part due to the collapse of the Soviet Union.

1991: US signals it will withdraw its nuclear weapons from SK as part of its global return of tactical nuclear weapons to United States territory.



# North Korea's Nuclear Program

## History (cont'd) —

- IAEA chemical analysis indicates NK had separated plutonium in four campaigns over a 3-year period beginning in 1989 and that NK possesses more Pu than it had declared to the IAEA or to the international community.
- 1993: NK announces it is withdrawing from the NPT.
- 1994: US threatens war with NK. President Carter flies to NK and negotiates a nuclear agreement to avoid war.

# Key Elements of the 1994 Agreed Framework

North Korea	United States
<p data-bbox="642 404 1292 533">North Korea freezes its operation and construction of nuclear facilities under IAEA supervision.</p> <p data-bbox="642 598 1270 860">North Korea allows the canning and nonreprocessing of spent fuel from its 5-MW reactor under IAEA monitoring. Fuel to be removed from North Korea.</p> <p data-bbox="642 885 1243 1283">North Korea agrees to provide all necessary information and access, "including taking all steps that may be deemed necessary by the IAEA" to determine the accuracy of North Korea's initial declaration on past plutonium production</p> <p data-bbox="642 1308 1243 1616">North Korea agrees to begin dismantling its finished and incomplete nuclear facilities and to begin removal of spent fuel upon delivery of key reactor components for first light-water reactor.</p> <p data-bbox="642 1641 1251 1896">North Korea agrees to complete dismantling of its nuclear facilities and removal of its spent fuel upon delivery of key components for second reactor.</p>	<p data-bbox="1372 404 2079 574">The United States agrees to provide heavy fuel oil to replace the electrical production potential of the shutdown 5-MW reactor.</p> <p data-bbox="1372 598 1983 813">The United States agrees to establish an international consortium to construct two modern, light-water reactors in North Korea.</p> <p data-bbox="1372 885 2060 1058">International consortium agrees to complete a significant portion of the reactor complex, not including key components.</p> <p data-bbox="1372 1308 2074 1432">International consortium to deliver key components for first light-water reactor.</p> <p data-bbox="1372 1641 2060 1766">International consortium to deliver key components for second light-water reactor.</p>



# The Aftermath of the 1994 Agreement

The light-water reactors were [never built](#). The US-led consortium tasked with constructing them was in severe debt; senators [accused Clinton](#) of understating their cost while overstating how much US allies would contribute to funding them. Hawkish Republicans in Congress [derided](#) the framework for supposedly [rewarding aggressive behaviour](#).

Heavy fuel shipments were often delayed. Rust Deming, assistant secretary of state, [told Congress](#) that “to be frank, we have in past years not always met the fuel year deadline”. Meanwhile, Robert Gallucci, a diplomat who had negotiated the framework, [warned that it could fail](#) unless the US did “what it said it would do, which is to take responsibility for the delivery of the heavy fuel oil”.

North Korea was not removed from the State Department’s list of state sponsors of terrorism until 2008, though it had [long met the criteria for removal](#). A [limited number](#) of US sanctions were eased, but not until 2000 – six years later than pledged in the Agreed Framework. According to Gallucci, Congressional [scepticism](#) about the deal led to “the minimum interpretation of sanctions lifting”. As he [told a congressional committee](#): “the North Koreans have always been disappointed that more has not been done by the US.”

This only worsened under Washington’s next regime: in 2002, the Bush administration’s [Nuclear Posture Review](#) listed North Korea as one country the US might have to use nuclear weapons against, while its [2002 National Security Strategy](#) listed the north as a “rogue” regime against which the US should be prepared to use force. To this day, the US has [28,500 troops](#) stationed across 11 US military bases in South Korea, and the two countries continue with their [joint annual military exercises](#) off the coast of the Korean Peninsula.

As abhorrent as the North Korean regime is, it’s not hard to see why the ruling clique might have concluded that Pyongyang remains in Washington’s crosshairs and that the US was never truly committed to the Agreed Framework. Still, as subsequent [negotiations](#) have shown, North Korea remains desperate for fuel, and its regime still exhibits a paranoid, self-serving obsession with security. Its past actions strongly suggest that the nuclear programme is a bargaining chip that Pyongyang is prepared to give up under the right circumstances.

The benefits of a new, more robust peace agreement are obvious: an end to the threat of nuclear war in East Asia, and a boost to the global nuclear non-proliferation regime. The story of the 1994 framework proves this is far from impossible, but also that it will demand both careful, determined diplomacy and a commitment to honouring any promises made. Sadly, the Trump administration so far seems capable of neither.

Source: The Conversation, Why the US’s 1994 deal with North Korea failed – and what Trump can learn from it



# North Korea's Nuclear Program

## History (cont'd) —

- 2002 December: NK announces it is restarting its reactor because US violated the Agreed Framework, ends its cooperation with the IAEA, orders inspectors out.
- 2003 January: NK announces it is withdrawing from the NPT.
- 2004: NK tells visiting US experts it has separated the Pu in the spent reactor fuel at Yongbyon and is making nuclear weapons, shows “Pu” to visiting experts. NK is believed to have extracted 24–42 kg of Pu, enough for 6–12 nuclear bombs.
- 2006 October 9: NK tests a Pu nuclear explosive device: 0.7-2 kT.
- 2007 February 28: New 6-party agreement announced (see separate slide).
- 2009 April 5: NK launches a long-range rocket, is condemned by the UN, announces it will build its own LWR without outside help.
- 2009 May 25: NK tests a second nuclear explosive device: 2-5.4 kT.



# Six-Party Agreement (2007 Feb 28)

An important first step toward complete, verifiable, and irreversible denuclearization of the Korean peninsula and the establishment of a more stable, peaceful, and prosperous Northeast Asia.

## **The D.P.R.K. agreed that it will, within 60 days:**

- Shut down and seal Yongbyon nuclear facility for eventual abandonment
- Invite IAEA to conduct necessary monitoring and verifications
- Discuss with the other parties a list of all its nuclear programs, including plutonium extracted from used fuel rods, that would be abandoned

## **The other Parties agreed that they will:**

- Provide emergency energy assistance to North Korea in the initial phase
- Make an initial shipment of emergency energy assistance equivalent to 50,000 tons of heavy fuel oil (HFO) within the first 60 days of the agreement

Five working groups will be established to carry out initial actions and formulate specific plans to implement the agreement, leading to a denuclearized D.P.R.K. and a permanent peace.



# North Korea's Nuclear Program

Enrichment (see the assigned reading written by Hecker) —

- 2010 November: NK showed visiting U.S. experts (Carlin, Hecker, and Lewis)
  - An openly constructed, recently completed small but industrial-scale centrifuge uranium-enrichment facility
  - An experimental light-water reactor (LWR) under construction
- NK claimed 2,000 P-2 centrifuges in 6 cascades in the modern facility at Yongbyon (build with external help from Khan)
- Publicly displayed facility is sufficient to produce
  - 2 tons of LEU/year, enough to supply the LWR under construction
  - 1 bomb/year of HEU, if slightly reconfigured
- Experts believe NK has undisclosed centrifuge facilities at other sites, probably producing weapon-grade HEU. NK has fundamentally changed its nuclear strategy.
- New leadership under Kim Jong-un appears to continue nuclear weapons program aggressively.



# North Korea's Nuclear Program

History (cont'd) —

- 2011 Dec 17 Kim Jong-un ascends to Supreme Leader of NK
- 2012 Feb 29: NK agrees to freeze nuclear program in exchange for energy and food relieve.
- 2012 Apr. 12: Unsuccessful NK missile test leads to cancellation of food and energy relieve agreement.
- 2012 May 4: Reports that NK has resumed construction of LWR for Pu production at Yongbyon.
- 2012 Dec. 12: Successful test of long range missile launching satellite into orbit
- 2013 Feb. 12: NK tests third nuclear explosive device, 6-16kT.
- 2016 Jan. 6: NK tests fourth nuclear warhead, 7-9kT, claimed thermonuclear device
- 2016 Sep. 9: NK tests fifth nuclear warhead, 15-25 kT.
- 2017 Sep. 3: NK tests sixth nuclear warhead, 70-280 kT.
- 2018 June 12: First US and North Korean Summit held in Singapore
- 2019 Feb 27: The Second US and North Korean Summit held in Hanoi, Vietnam



# North Korea's Nuclear Program

- NK's new nuclear strategy —
  - Appears to have abandoned its Pu program, shutting down its 5 MWe gas-graphite reactor and giving up on external assistance for LWRs
  - Is attempting to construct an experimental 25-30 MWe LWR of indigenous design as part of an electrical power program (probably not for bomb Pu)
- Major concerns about NK's new nuclear strategy —
  - Can NK construct its own LWR safely?
  - Will NK's enrichment program lead to additional weapons or export?

# North Korea's Nuclear Program

- Can NK construct its own LWR safely?
  - NK appears to have no experience with key LWR design and safety issues.
  - Radiation-resistant steels and stringent construction are needed to withstand the intense, long-term radiation produced by LWRs.
  - NK has little experience with uranium oxide fuels and fuel-cladding alloys.
  - The concrete reactor foundation is insufficiently robust.
  - The concrete containment shell is being poured in small sections from a small concrete mixer.
  - These safety concerns will increase dramatically if NK builds larger LWRs, because the risks would extend well beyond NK's borders.

# North Korea's Nuclear Program

- Will NK's enrichment program lead to additional weapons or export?
  - Bomb-grade HEU can be produced by slightly reconfiguring the existing centrifuge cascade
  - NK has indigenous U ore and all the know-how and equipment needed to make feedstock for its centrifuge cascades
- NK can ratchet up the current nuclear threat by
  - Greatly expanding its HEU production at undisclosed sites
  - Increasing substantially the size of its nuclear arsenal
  - Conducting additional nuclear tests to increase the sophistication of its nuclear weapon designs
  - Exporting nuclear weapon materials or technology
- NK's categorical denial of any earlier enrichment activities, when they clearly existed, complicates diplomatic reengagement

# What to Do About NK's Nuclear Program?

- Top priority: prevent NK from expanding its arsenal or exporting its nuclear technologies
- Long-term goal: denuclearize the Korean peninsula
- Few options but to reengage NK diplomatically
- Hecker advocates 3 No's supported by 1 Yes:
  - No more bombs
  - No better bombs (which means no more testing)
  - No export of bombs or bomb technology and materials
  - Yes to meeting NK's fundamental security concerns
- What are NK's fundamental security requirements?
  - Normalization of relations with the United States
  - Energy and economic aid / Regime survival

