ILLINOIS
Physics
GRAINGER COLLEGE OF ENGINEERING

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LAS GLOBAL STUDIES

Module 6: Nuclear Arsenals

ACDIS program in arms control & domestic and international security

Part 1: Overview

Phys 280 Session 17

Module 6 – Nuclear Arsenals

1. Midterm on Thursday, 3-24, 2-3.20pm in class in LL144
2. Midterm review session: Wed, 3-23, 5-6pm, LL144
3. Additional extra credit opportunity:

ACDIS Teach-in

The Military Situation in Ukraine and its Implications of Nuclear Security and Safety

Thursday, 3-31, 2022 at 4pm via zoom

(https://acdis.Illinois.edu/news-events/news/teach-Ukraine)

Phys 280 Session 17

ILLINOIS

The Program in Arms Control & Domestic and International Security (ACDIS)

Thursday March 31, 2022
4:00pm-5:30pm CDT

Teach-in: The Military Situation in Ukraine and its Implications of Nuclear Security and Safety

Professor Nicholas Grossman, Political Science, UIUC
Professor Tomasz Kozlowski, NPRE, UIUC
Professor Frederick Lamb, Physics, UIUC

Dr. Grossman will assess the current military situation in Ukraine, including the history of the conflict, Russian and Ukrainian military objectives, strategic goals and tactics used, the importance of Western military support, possible reasons for Russia's slow progress, and the consequences that this conflict can entail.

Dr. Kozlowski will summarize the nuclear industry in Ukraine, state the risks of conventional warfare to the safe operation of nuclear facilities, describe the impact of a possible nuclear accident caused by the war, and what can be done to uphold nuclear safety during the war.

Dr. Lamb will cover nuclear security in Europe in light of Russia's war on Ukraine, including a summary of the past nuclear disarmament in Ukraine, the history of the Budapest Memorandum, broader implications of the war for non-proliferation efforts, stated Russian concerns of possible nuclear armed missiles in Ukraine, and if a new Intermediate-Range Nuclear Force Treaty could contribute to the resolution of the conflict.

Zoom Information available here:
https://acdis.illinois.edu/news-events/news/teach-ukraine

Zoom Meeting
Meeting ID: 818 0794 2691
Password: acdis

ACDIS
program in arms control & domestic and international security

Impact Technology Has on Evolution of Nuclear Arsenals-3

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

http://thebulletin.org/how-us-nuclear-force-modernization-undermining-strategic-stability-burst-height-compensating-super10578

Bulletin of the Atomic Scientists

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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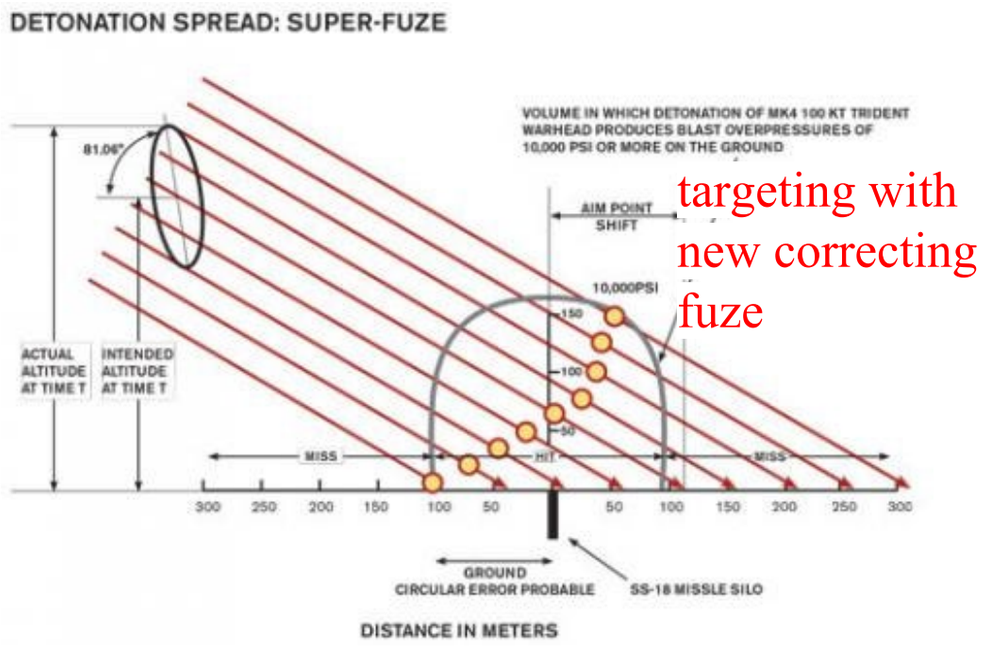
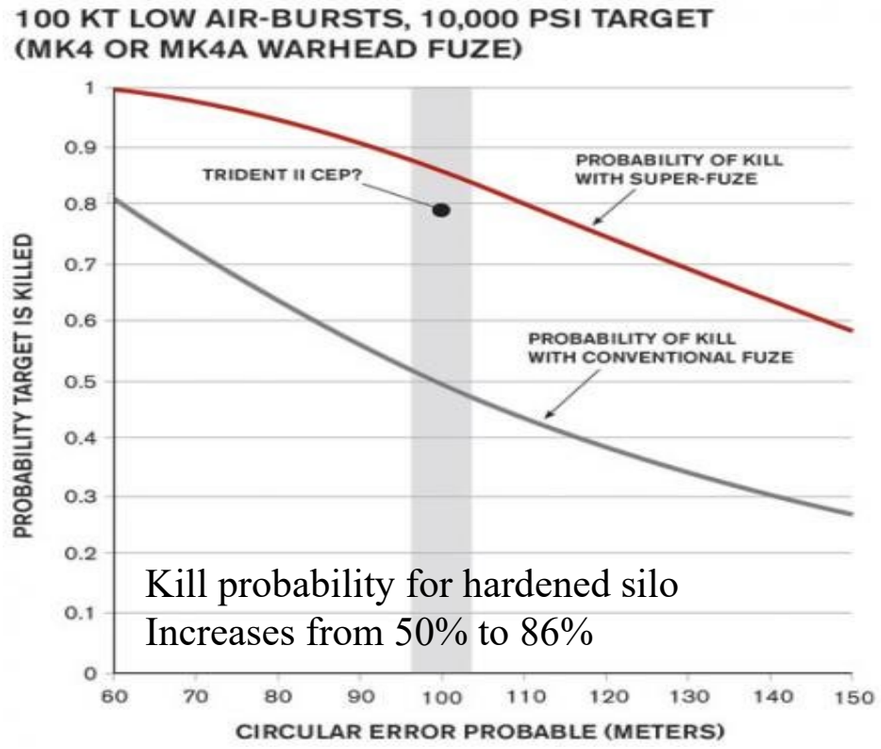
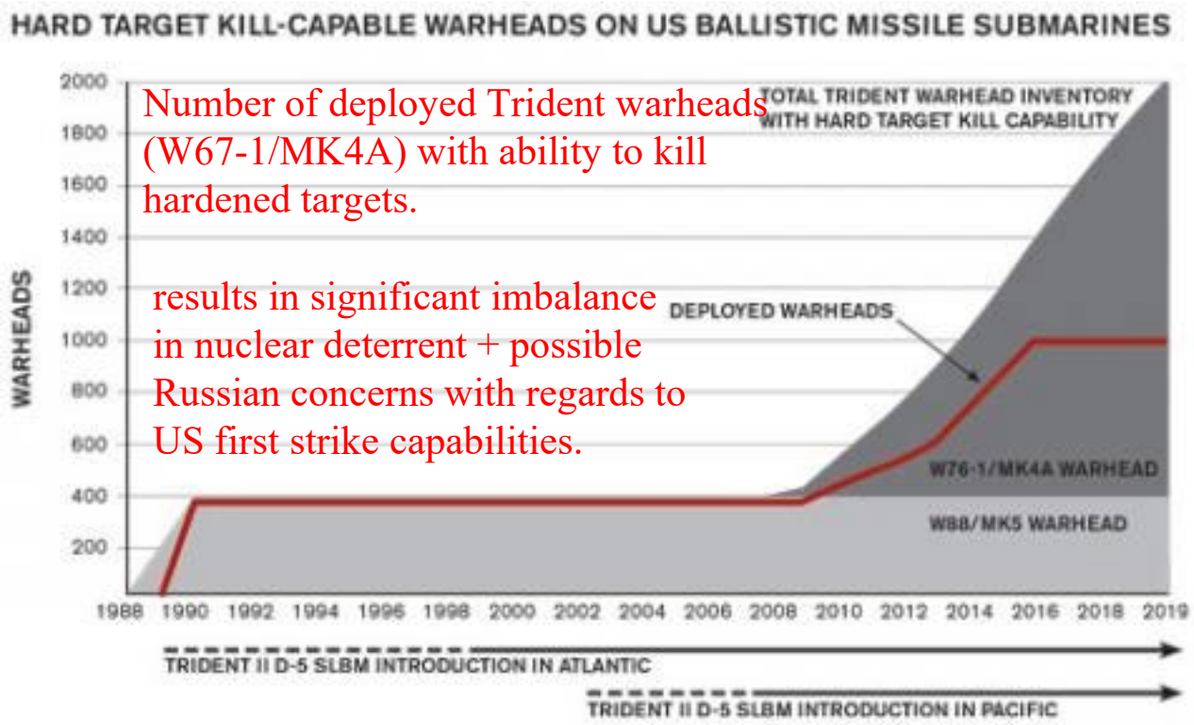
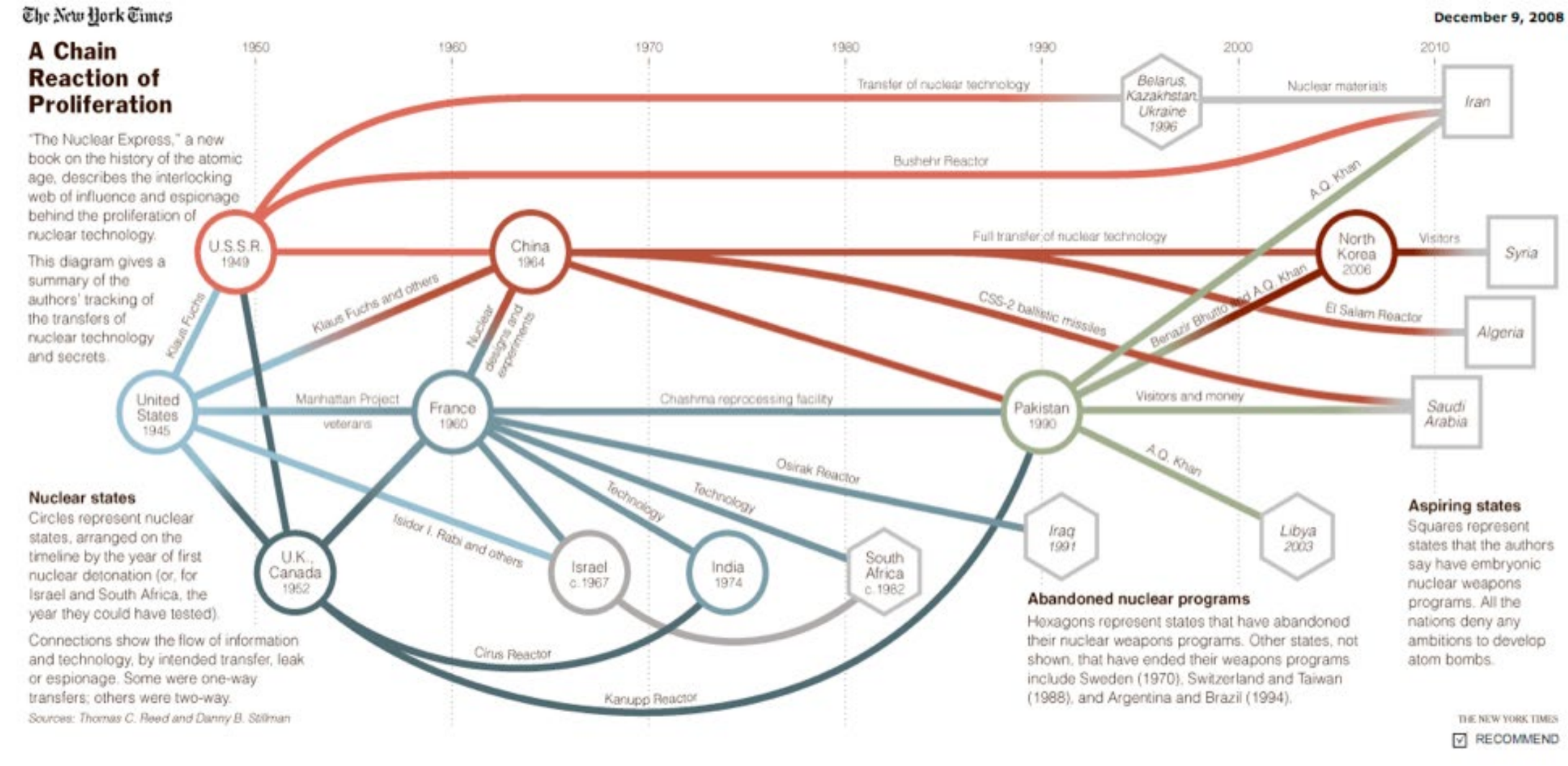
Impact Technology Has on Evolution of Nuclear Arsenals-3







Chain of Proliferation

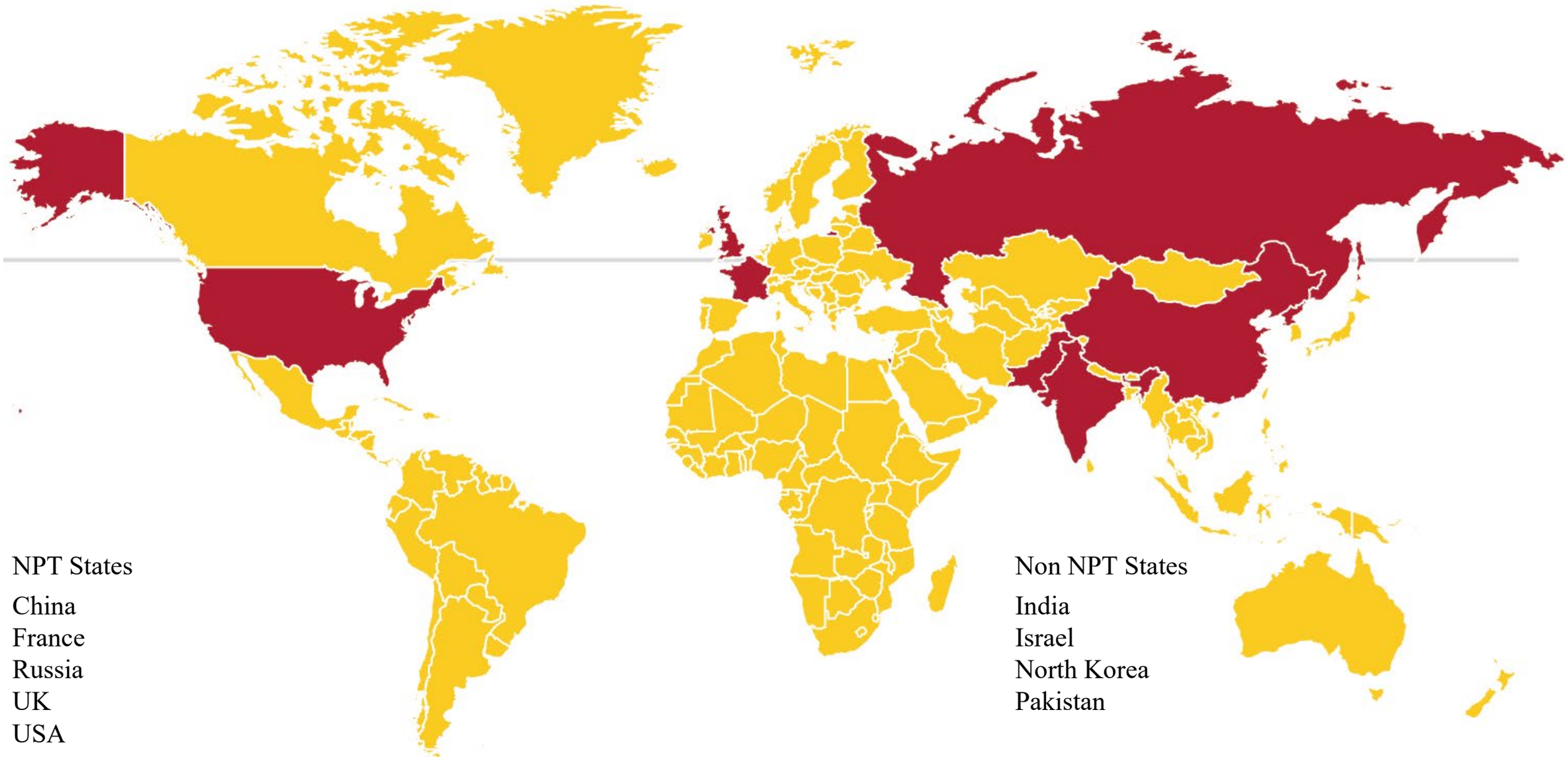


This article has been revised to reflect the following correction:

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.

States With Nuclear Weapons in 2019



NPT States

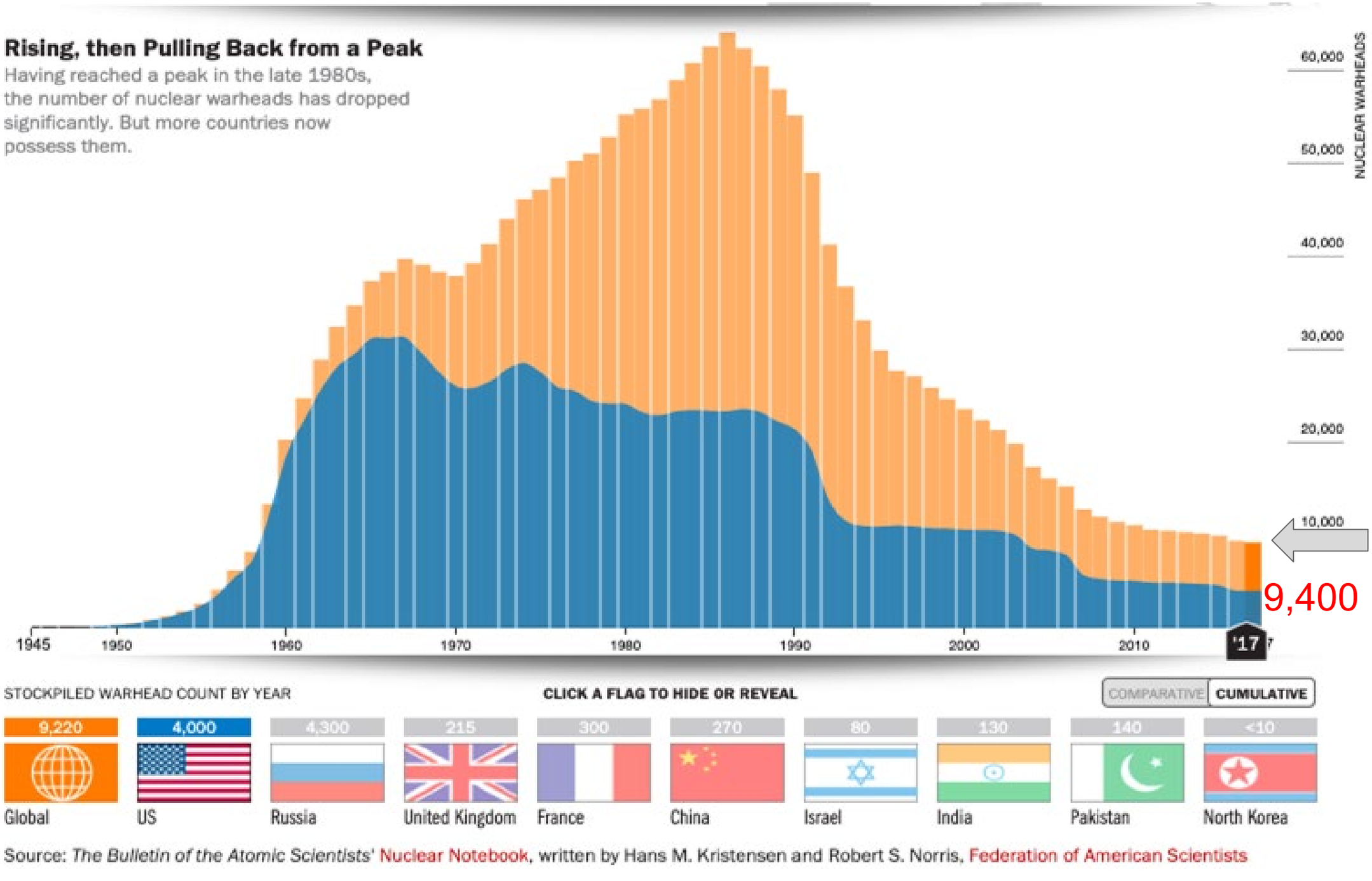
China
France
Russia
UK
USA

Non NPT States

India
Israel
North Korea
Pakistan

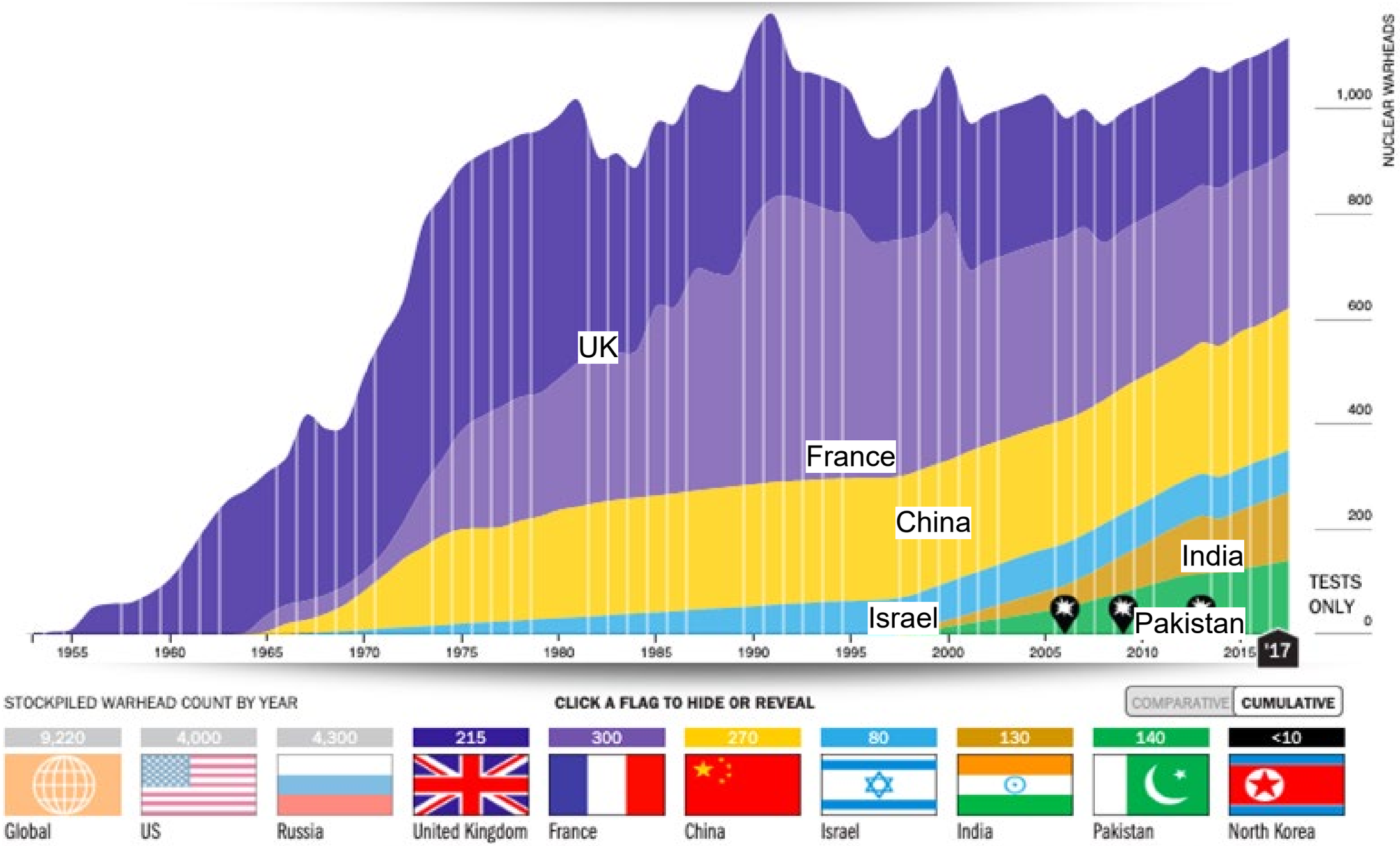
PLOUGHSHARES FUND ploughshares.org

Nuclear Weapons Stockpiles 1945-2017



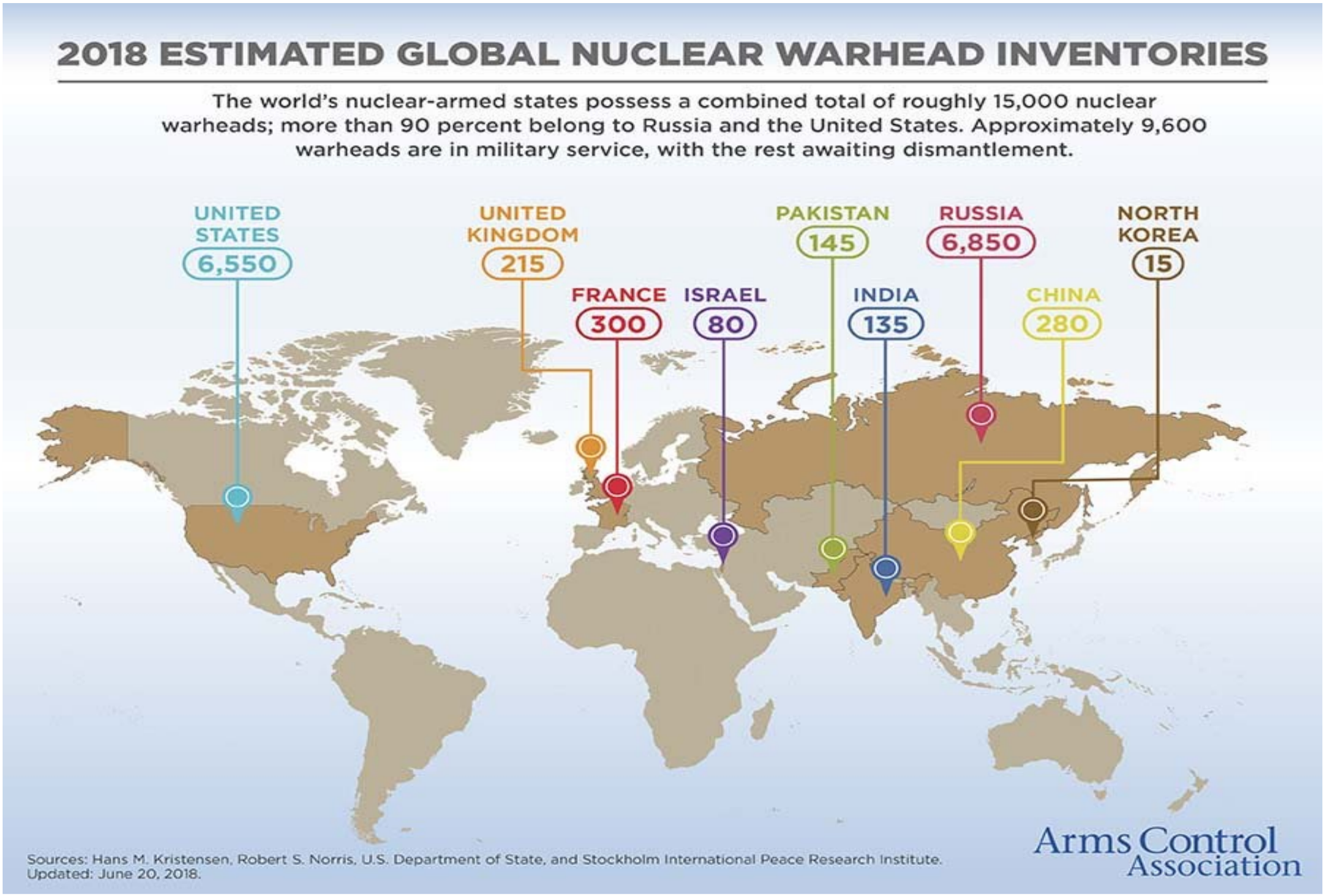
9,330 Nuclear weapons in Military Stockpiles in 2019

World Nuclear Weapons Stockpile 1945-2017



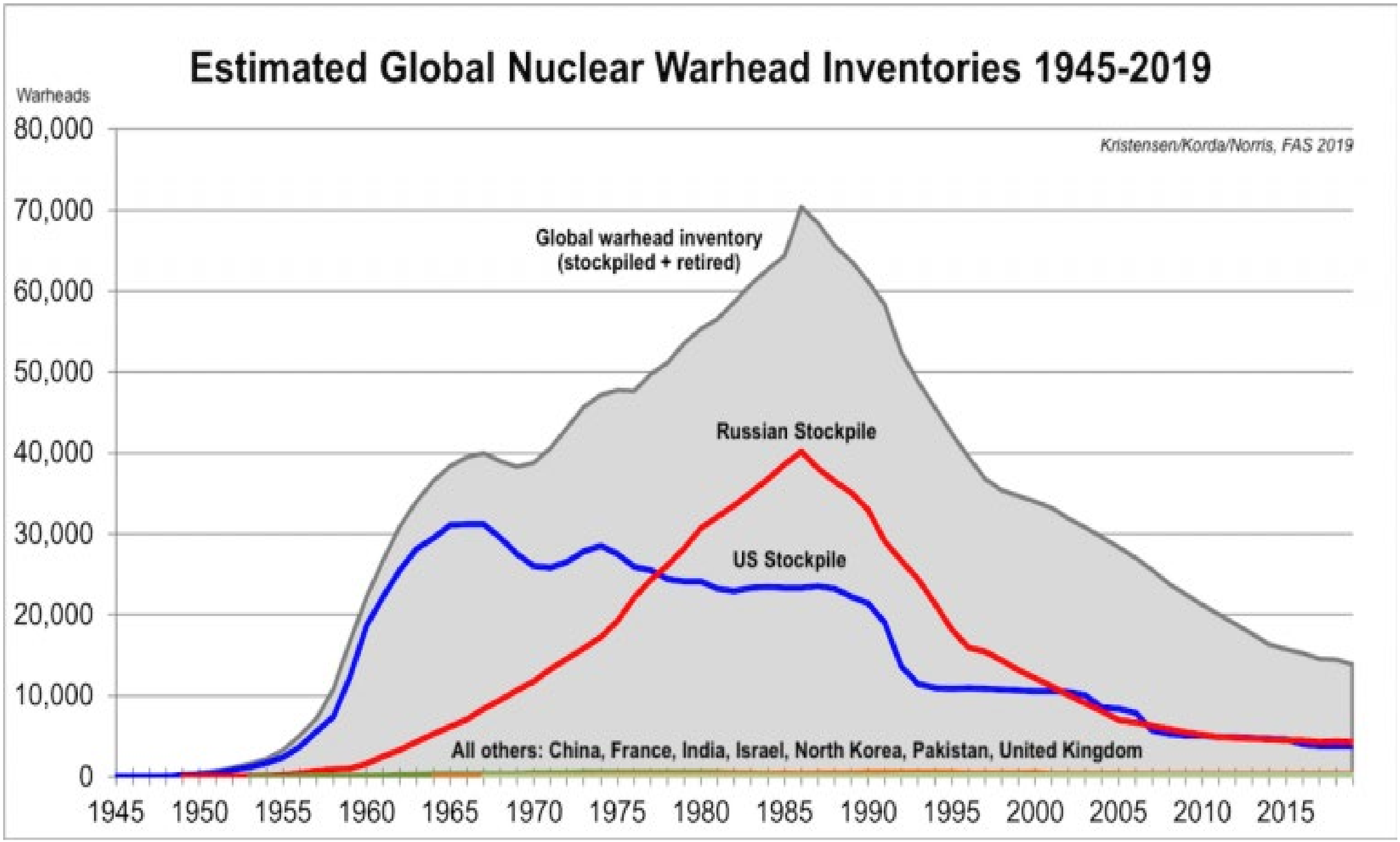
Source: *The Bulletin of the Atomic Scientists'* Nuclear Notebook, written by Hans M. Kristensen and Robert S. Norris, Federation of American Scientists

Arms Control Association 2018 estimate



Breakdown of the Nuclear Weapons Stockpile (2019)

World Nuclear Weapons Stockpile 1945-2019



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

Global Nuclear Weapon Inventory 2019 (Important)

NPT Nuclear Weapon States (Total Weapons)		Non-NPT Nuclear Weapon States (Total Weapons)	
China:	~ 290	Pakistan:	~ 140-150
France:	~ 300	Israel:	~ 80
Russia:	~ 4,330	India:	~ 130-140
UK:	~ 215	North Korea:	~ 20-30
US:	~ 3,800		

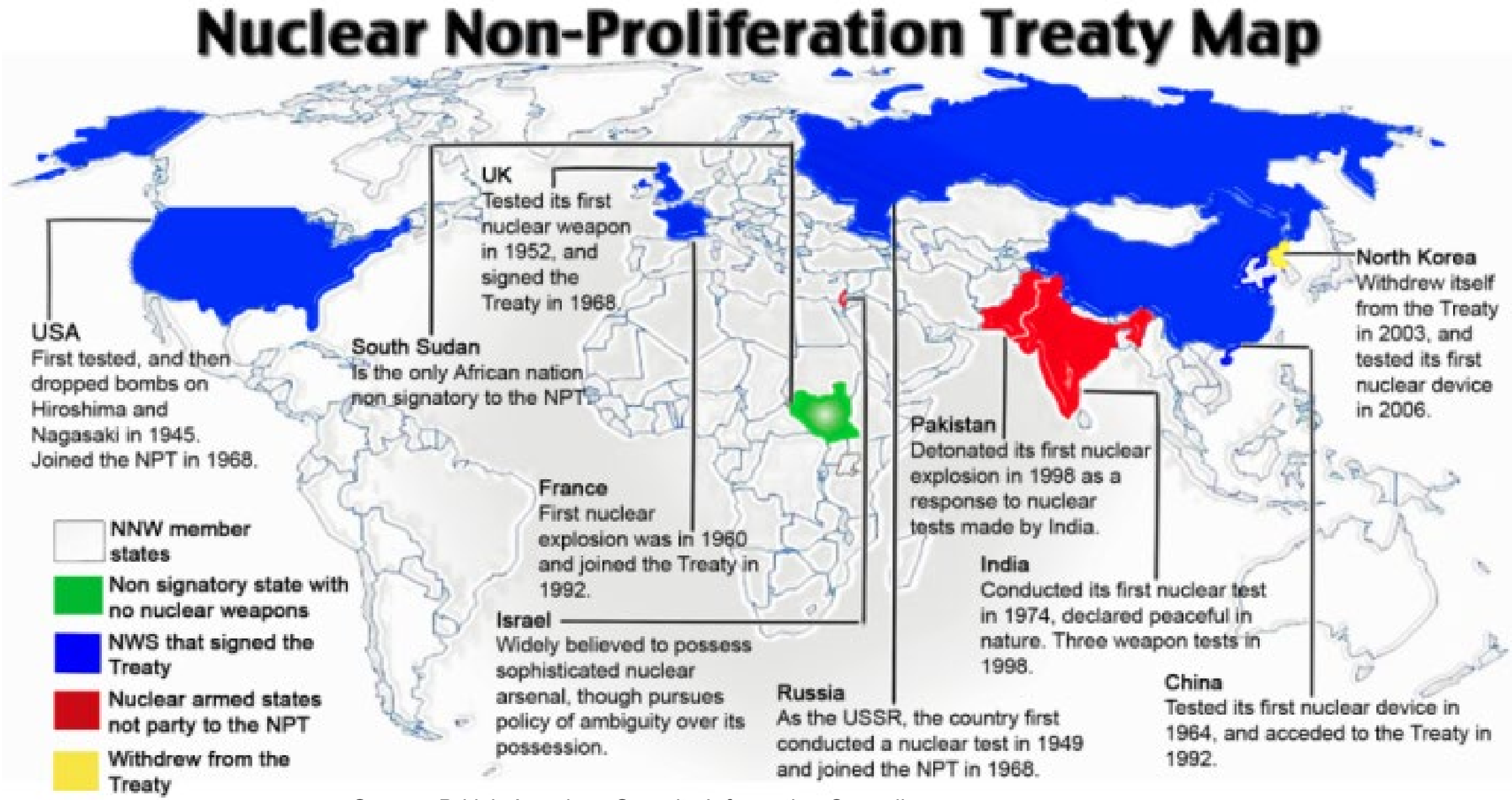
Source: Status of World Nuclear Forces, Written by Hans M. Kristensen and Matt Korda, Federation of American Scientists

2019 Breakdown of Nuclear Forces

Status of World Nuclear Forces 2019*					
Country	**Deployed Strategic**	**Deployed Nonstrategic**	**Reserve/ Nondeployed**	**Military Stockpile**	**Total Inventory**
Russia	1,600*c*	0*d*	2,730*e*	4,330	6,500*f*
United States	1,600*g*	150*h*	2,050*i*	3,800*j*	6,185*k*
France	280*l*	n.a.	20*l*	300	300
China	0*m*	?	290	290	290*m*
United Kingdom	120*n*	n.a.	95	215	215*n*
Israel	0	n.a.	80	80	80*o*
Pakistan	0	n.a.	140-150	140-150	140-150*p*
India	0	n.a.	130-140	130-140	130-140*q*
North Korea	0	n.a.	?	20-30	20-30*r*
Total:	**~3,600**	**~150**	**~5,555**	**~9,330**	**~13,890**

Source: Federation of American Scientists “Status of World Nuclear Forces”

Non-Proliferation Treaty Map



Source: British American Security Information Council

Nuclear Warheads on Alert (2017)

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[a]	27% of Stockpile on Alert SSBNs: 80
Britain	215	40[a]	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 sysyems
Total	**9,425[b]**	**1,869**	

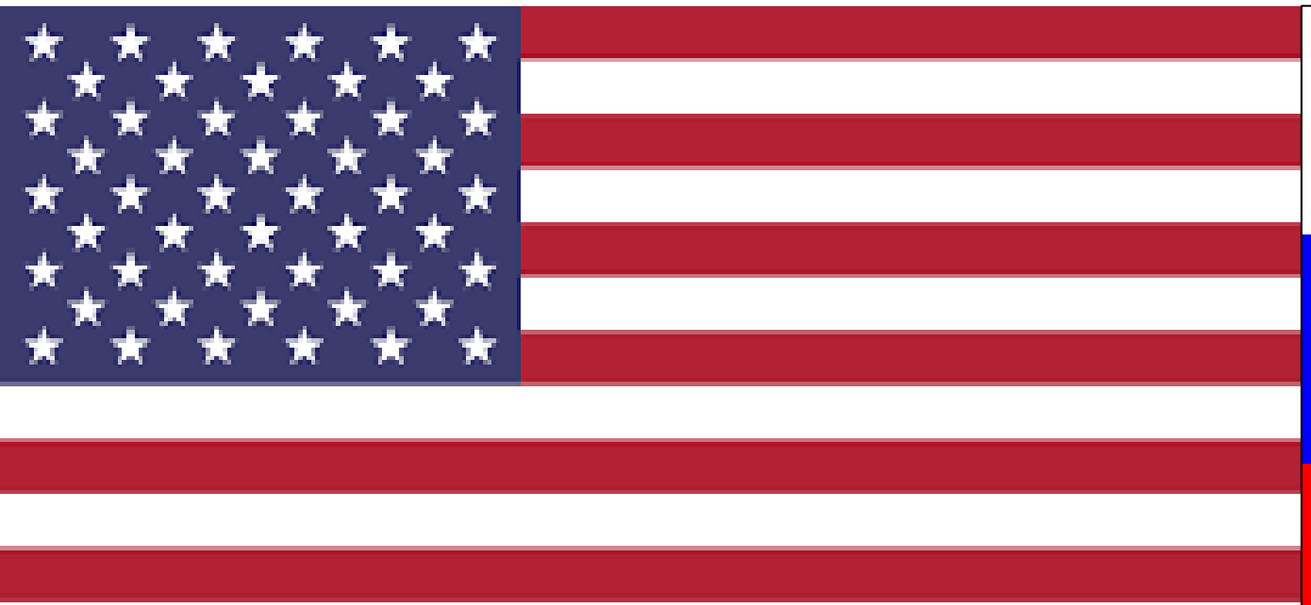
Source:Hans Kristensen, FAS, Alert Status of Nuclear Weapons

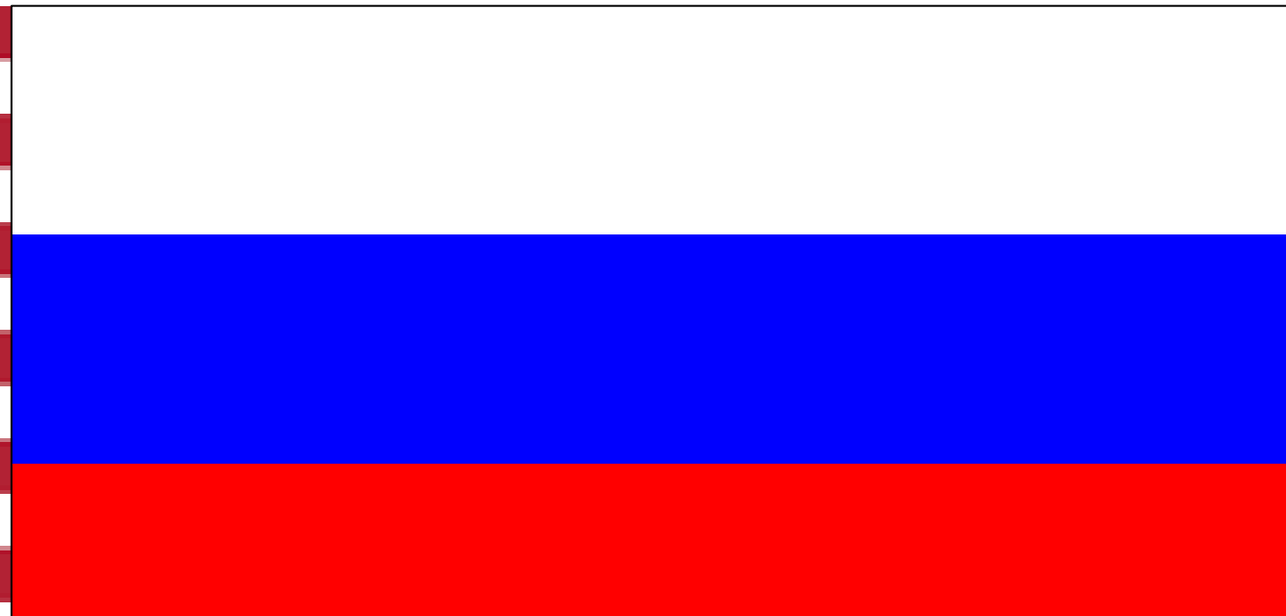
Arms Control Agreements

Strategic N… Abandoned by the US andRussia in Feb 1st, 2019								
	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	In Force
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 Ratifed, 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, 2021**

Source: Arms Control Association “Strategic Nuclear Arms Control Agreements”

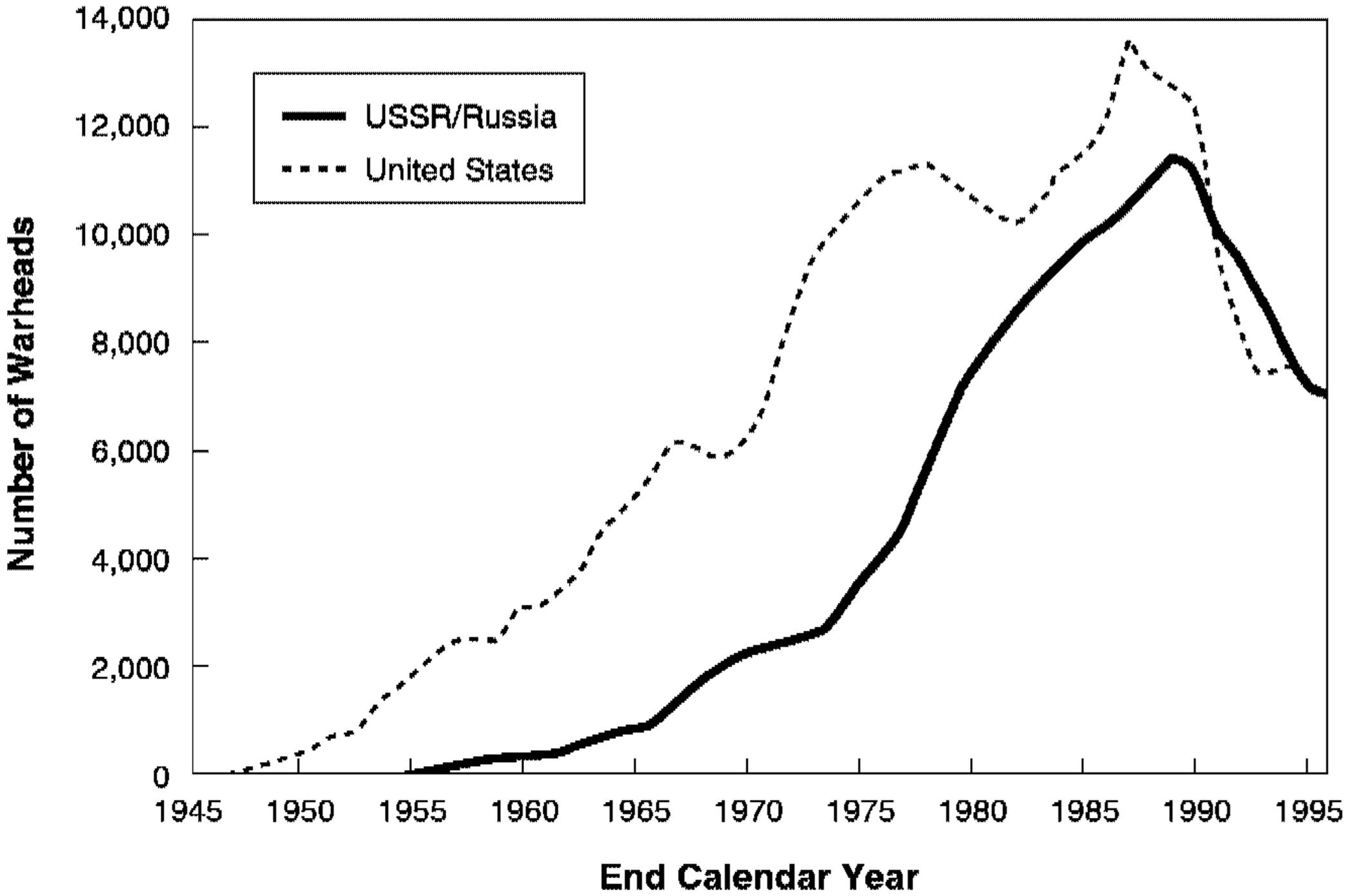
Module 6: Arsenals





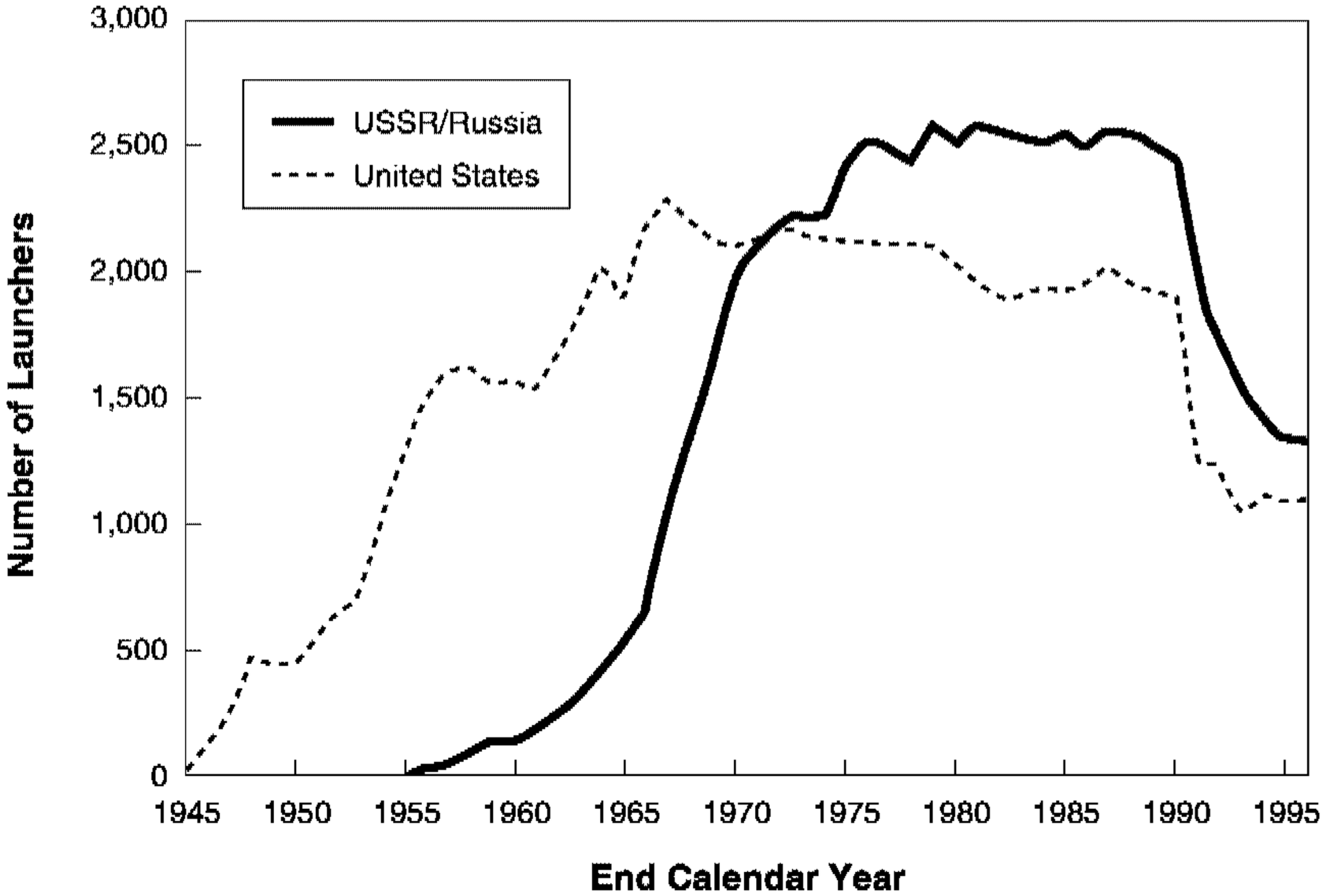
Part 2: Sec 1 Arsenals of the US and SU/Russia

Evolution of US and SU-Russian Strategic Nuclear Warhead Numbers



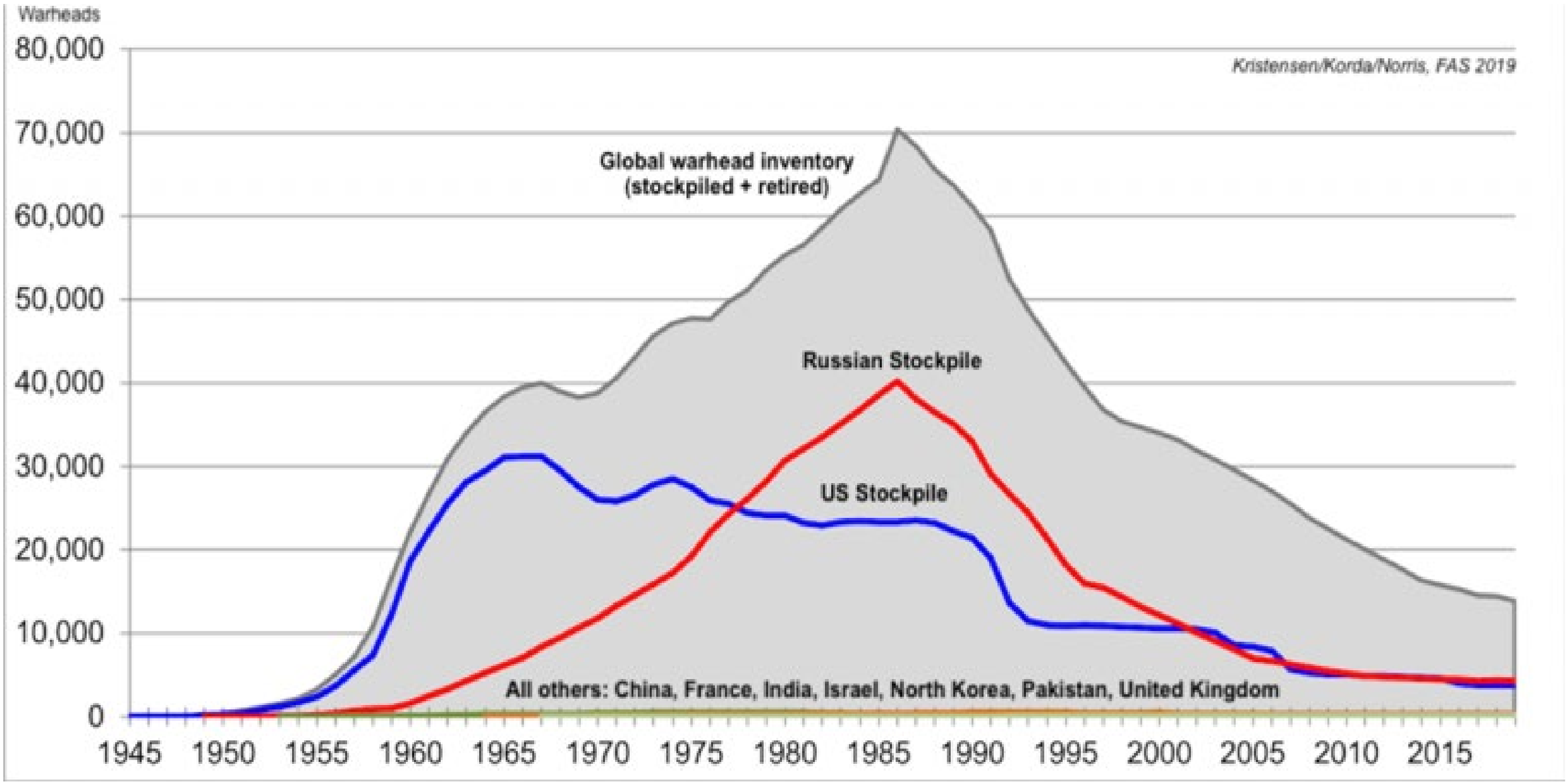
Source: NRDC (Nov. 2002)

Evolution of US and SU-Russian Strategic Nuclear Launcher Numbers

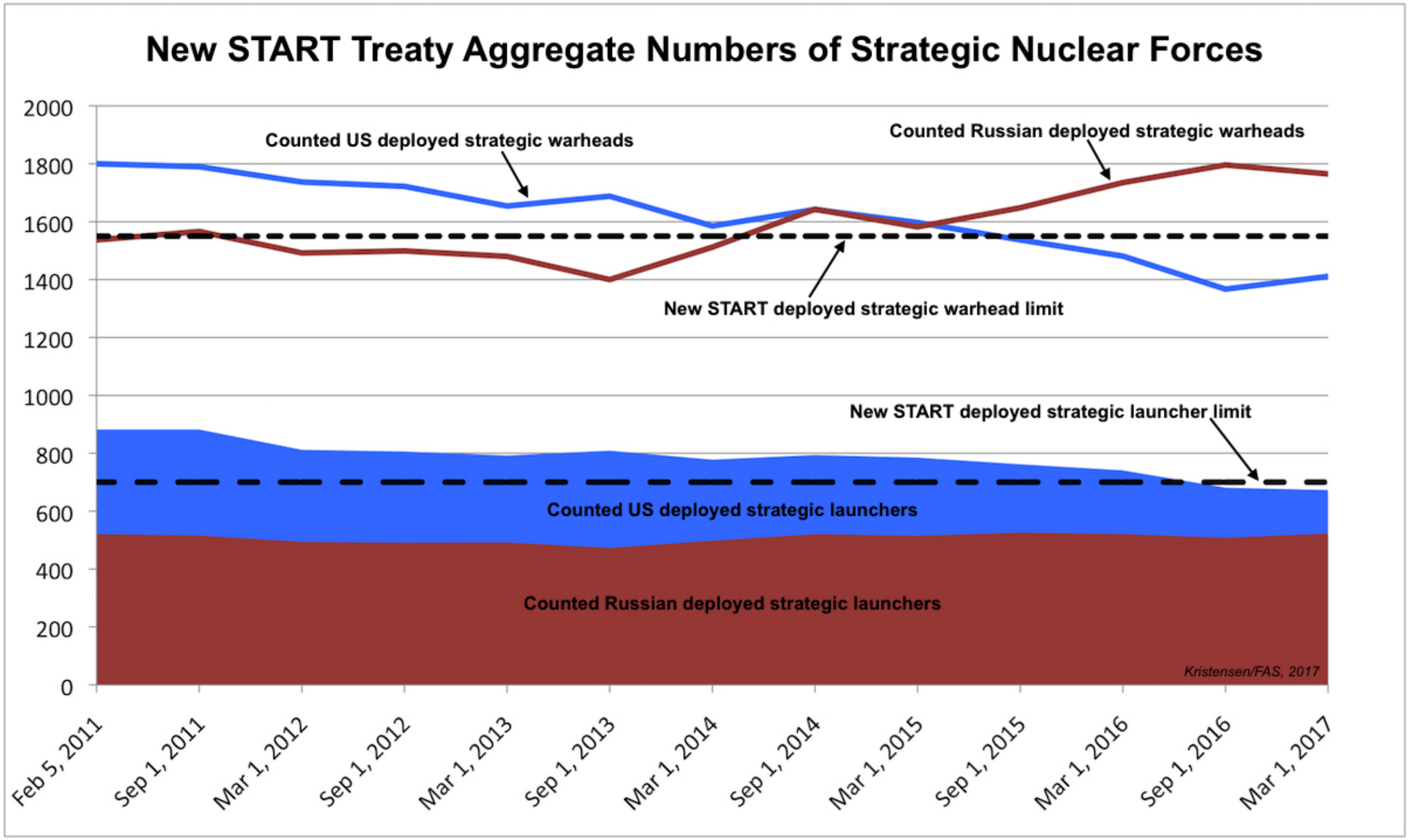


Source: NRDC (Nov. 2002)

Evolution of US and SU-Russian Nuclear Stockpiles (2019)



US and Russian Warheads after New START



Source: Federation of American Scientists

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.

Evolution of US SSBN Nuclear Forces

SSBN Forces	2000	2001	2002	2007*	2012**
SSBNs					
Trident [3]	18	18	18	14	14
Total SSBNs	**18**	**18**	**18**	**14**	**14**
SLBM Launchers					
Trident with C4 [9]	192	168	168		
Trident with D5 [10]	240	264	264	336	336
Total Launchers	**432**	**432**	**432**	**336**	**336**
SLBM Warheads					
W76 (C-4) [14]	1536	1008	1008		
W76 (D-5)	1536	1728	1728	1560	1300
W88 (D-5) [15]	384	384	384	384	380
Total Warheads	**3456**	**3120**	**3120**	**1944**	**1680**

Source: NRDC

Evolution of US ICBM Nuclear Forces

ICBM Forces	2000	2001	2002	2007*	2012**
Launchers					
MINUTEMAN III [8]	500	500	500	500	500
MX (PEACEKEEPER) [9]	50	50	50	50	50
Total Launchers	**550**	**550**	**550**	**550**	**550**
ICBM Deployed Warheads					
W62 (MM III) [16]	600	300	300	0	0
W78 (MM III) [17]	900	900	900	300	300
W87 (MX) [18]	500	500	500	200	200
Total (Deployed)	**2000**	**1700**	**1700**	**500**	**500**

Source: NRDC

2018 Estimate of US Forces Under New START

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

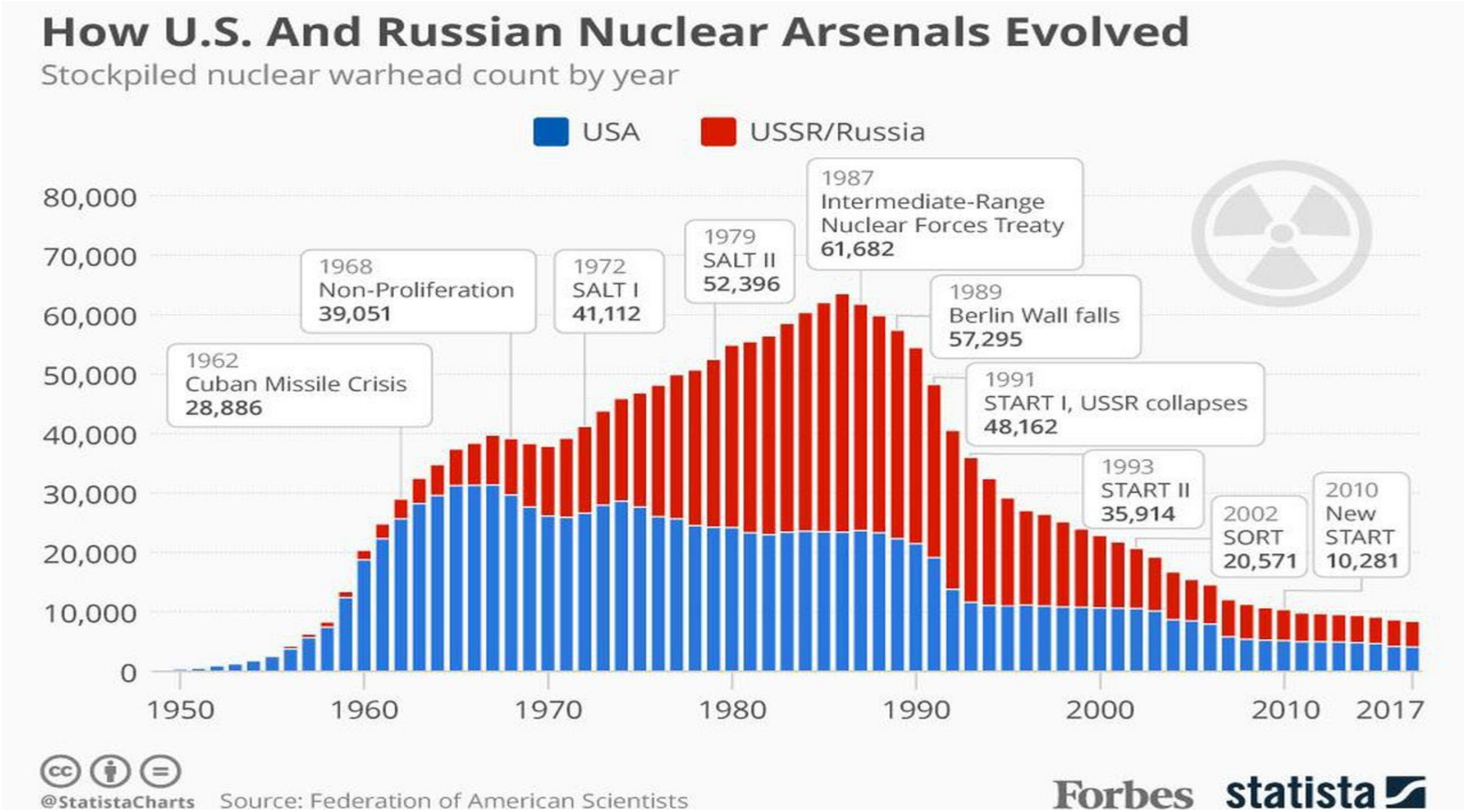
(Estimated Current Forces and Potential New START Forces)

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

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

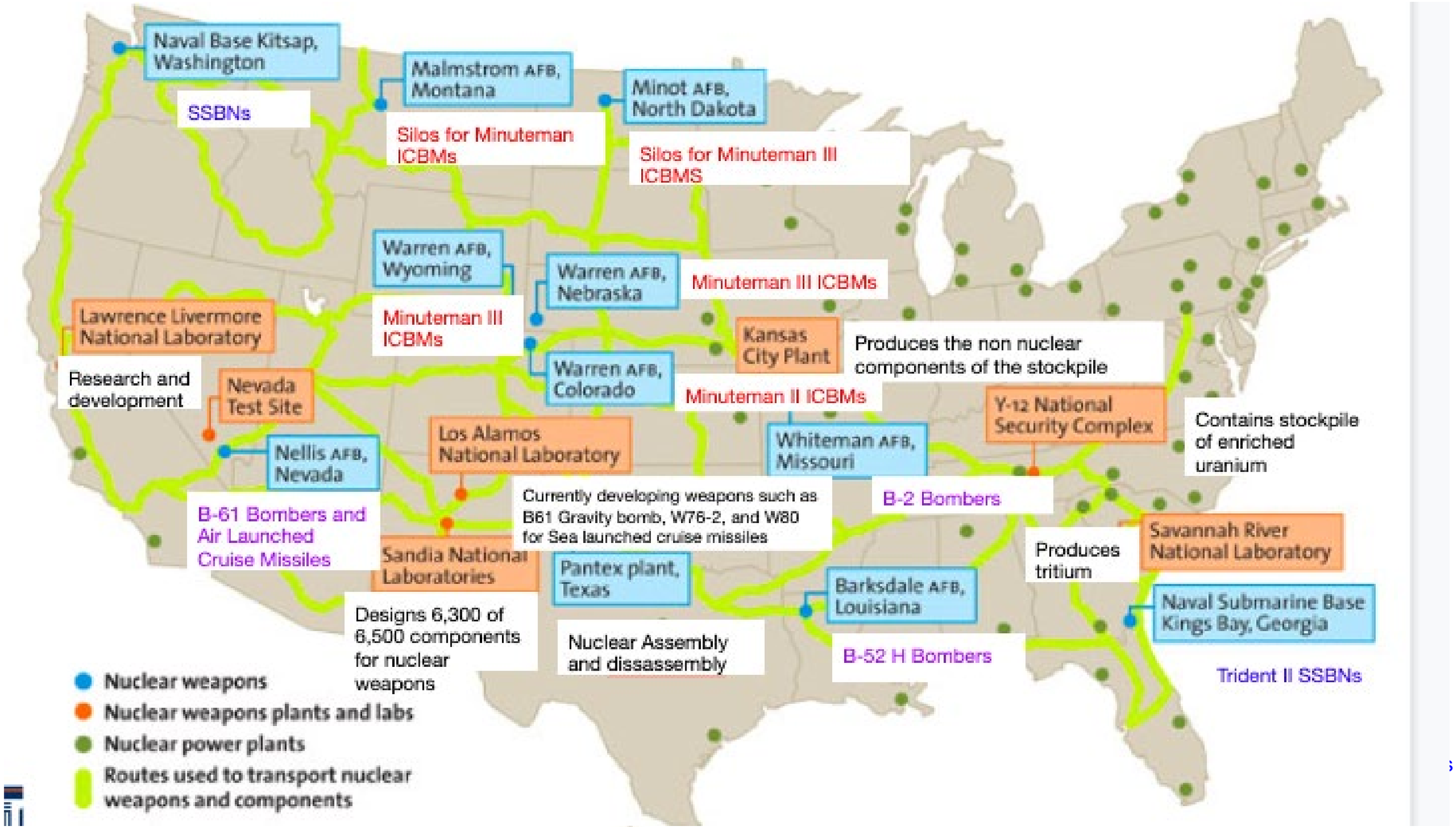
Nuclear Triad	Type
Land	ICBM
Air	Bomber
Sea	SLBM

US and Russian Nuclear Evolution



Source: Information: Federation of American Scientists Chart: Statista

Nuclear Labs, Plants, and Weapons locations (2017)



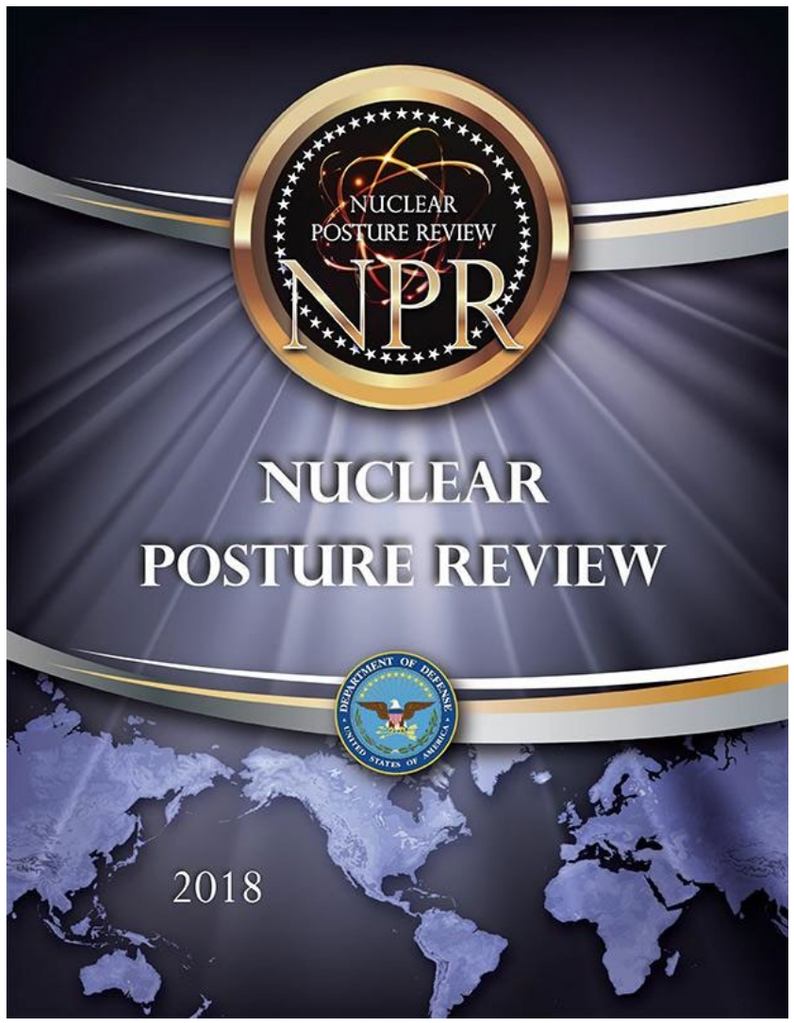
Specific Warheads at Each Nuclear Weapons Facility (2019)

Rank	State/Country	Warheads	Remarks
United States			
1	New Mexico	2,485[a]	Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC) Occasionally at Los Alamos National Laboratory Occasionally at Sandia National Laboratories
2	Washington	1,620[b]	Strategic Weapons Facility Pacific (SWFPAC) Naval Submarine Base Kitsap (SSBNs)
3	Georgia	1,100[c]	Strategic Weapons Facility Atlantic (SWFLANT) Naval Submarine Base Kings Bay (SSBNs)
4	North Dakota	350	91st Missile Wing silos for Minuteman III ICBMs Minot AFB weapons storage area (ICBMs/B-52s)
5	Montana	150	341st 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)[d]
8	Nebraska	72	90th Missile Wing silos for Minuteman III ICBMs
9	Colorado	44	90th Missile Wing silos for Minuteman III ICBMs
10	Wyoming	34	90th Missile Wing silos for Minuteman III ICBMs F.E. Warren AFB weapons storage area
11	California	few	Occasionally at Lawrence Livermore National Laboratory
Europe			
1	Turkey	50	Incirlik AB weapons storage vaults[e]
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

2018 U.S. Nuclear Posture Review

https://media.defense.gov/2018/Feb/02/2001872877/-1/-1/1/EXECUTIVE-SUMMARY.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.

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.

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

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.

Source: 2019 Nuclear Posture Review

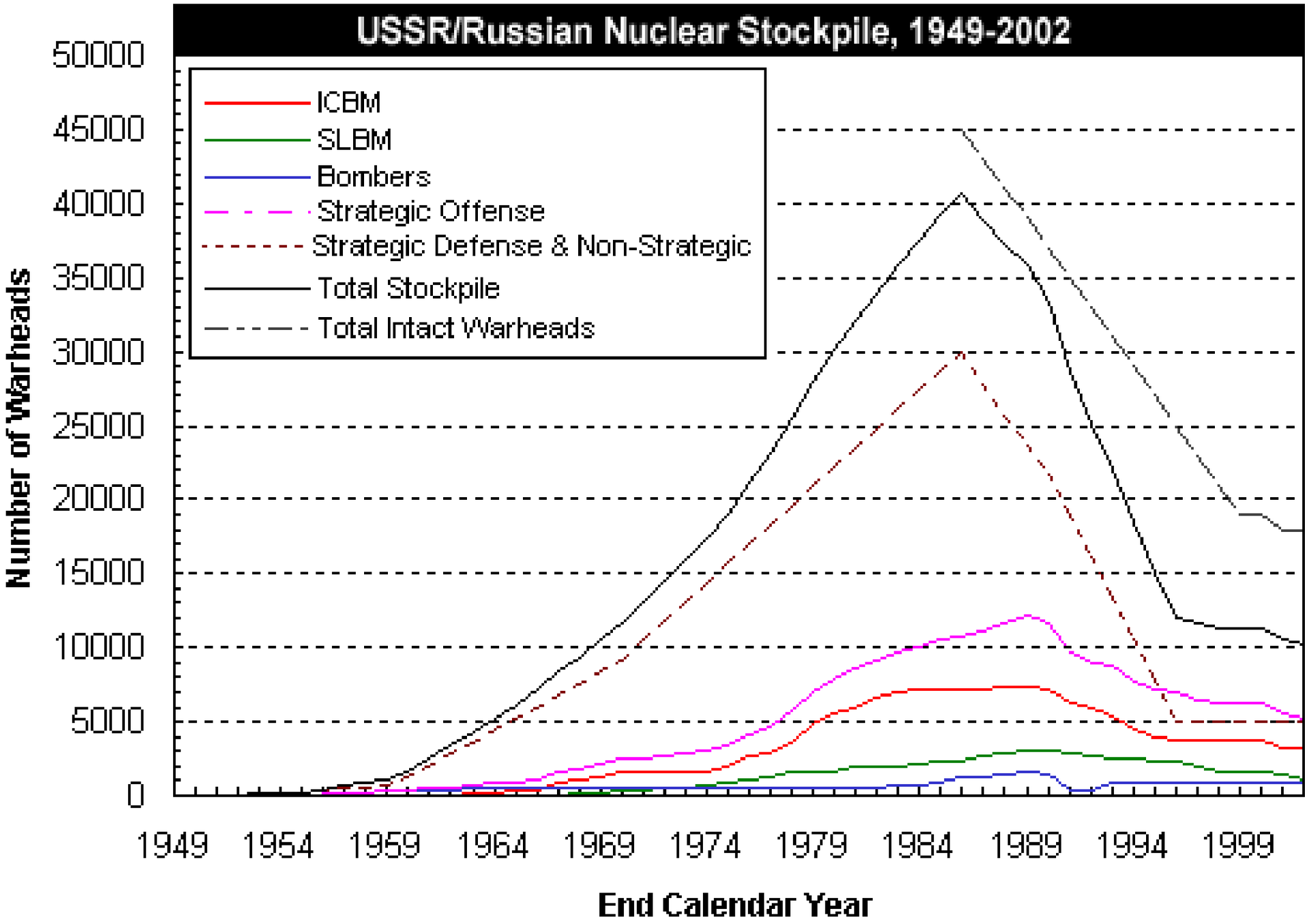
Russian Nuclear Laboratory and Stockpile Locations

Carnegie Endowment for International Peace, *Deadly Arsenals* (2002), **www.ceip.org**

Russian ICBM locations

Source: FAS, Steven Aftergood

SU-Russian Nuclear Warheads



Source: NRDC (Nov. 2002)

Russian Nuclear Forces ICBMs (2019)

	Russian		Year	Warheads	Total
Type/name	**Designation**	**Launchers**	**Deployed**	**x yield (kilotons)**	**Warheads**
Strategic offensive weapons					
ICBMs					
SS-18 M6 Satan	RS-20V	46	1988	10 × 500/800 (MIRV)	460[a]
SS-19 M3 Stiletto	RS-18 (UR-100NUTTH)	20[b]	1980	6 × 400 (MIRV)	120[c]
SS-19 M4	? (Avangard)	-	(2019)	1 × HGV	-
SS-25 Sickle	RS-12M (Topol)	63	1988	1 × 800	63[d]
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[e]
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)	-
Subtotal		**318**			**1165**[f]

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

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
Nonstrategic and defensive weapons						
ABM/Air/Coastal defense						
S-300/S-400 (SA-20/SA-21)			~1000	1992/2007	1 × low	~290
53T6 Gazelle			68	1986	1 × 10	68[q]
SSC-1B Sepal (Redut)			8[r]	1973	1 × 350	4
SSC-5 Stooge (SS-N-26) (K-300P/3M-55)			48	2015	(1 × 10)[s]	24
Land-based air						
Bombers/fighters (Tu-22M3/Su-24M/Su-34/ MiG-31K)			300	1974/2006/1983	ASMs, bombs	~530
Ground-based						
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)[t]						
SSC-8 GLCM (9M729)[u]			16[v]	2017	1 × 10–100	16
Naval						
Submarines/surface ships/air					LACM, SLCM, ASW, SAM, DB, torpedoes	820
Subtotal nonstrategic and defensive forces						**~1,820**[w]
Total						**~4,490**[x]
Deployed						1,600
Reserve						2,890
Retired warheads awaiting dismantlement						**2,000**
Total inventory						**6,490**

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

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