Physics/Global Studies 280: Session 17

Plan for This Session

News

Complete Module 5: Delivery Systems

Module 6: Nuclear Arsenals

News

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

Bulletin of the Atomic Scientists

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.

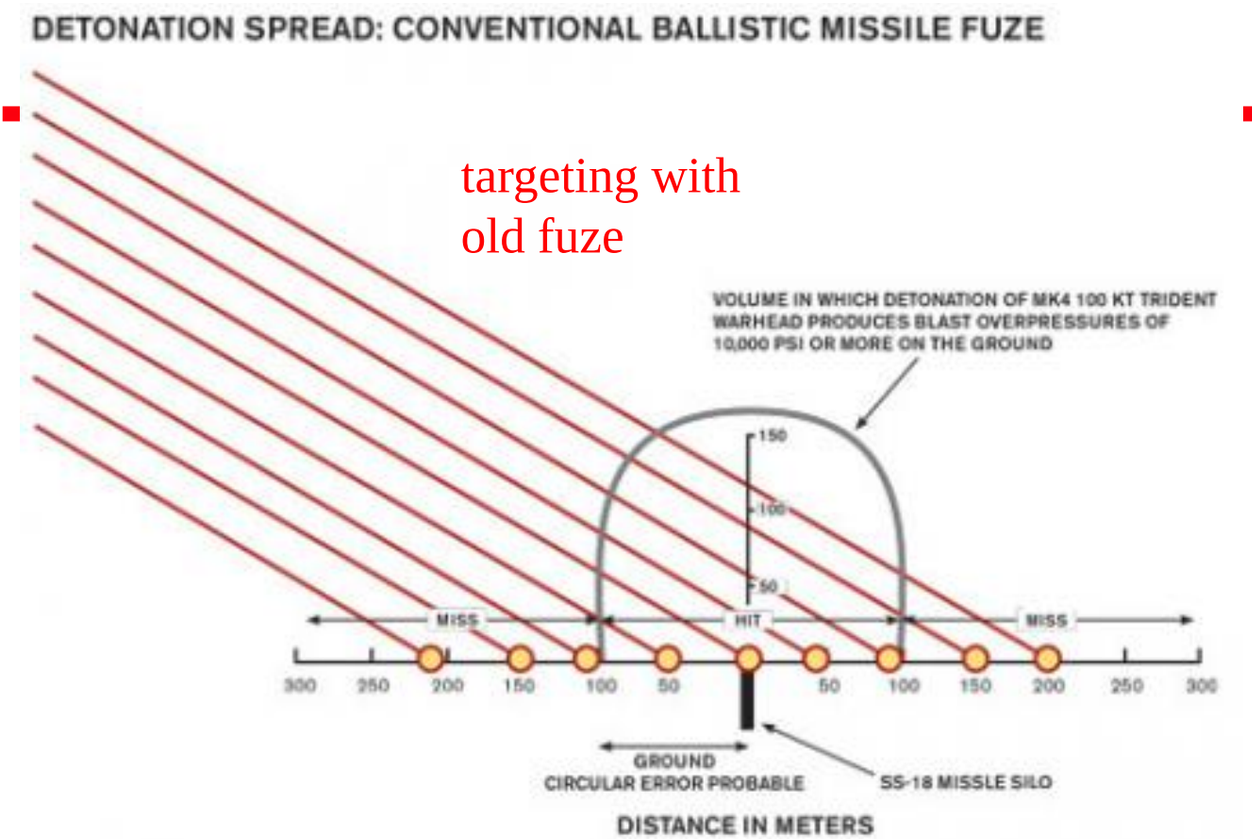
(/bio/hans-m-kristensen)

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

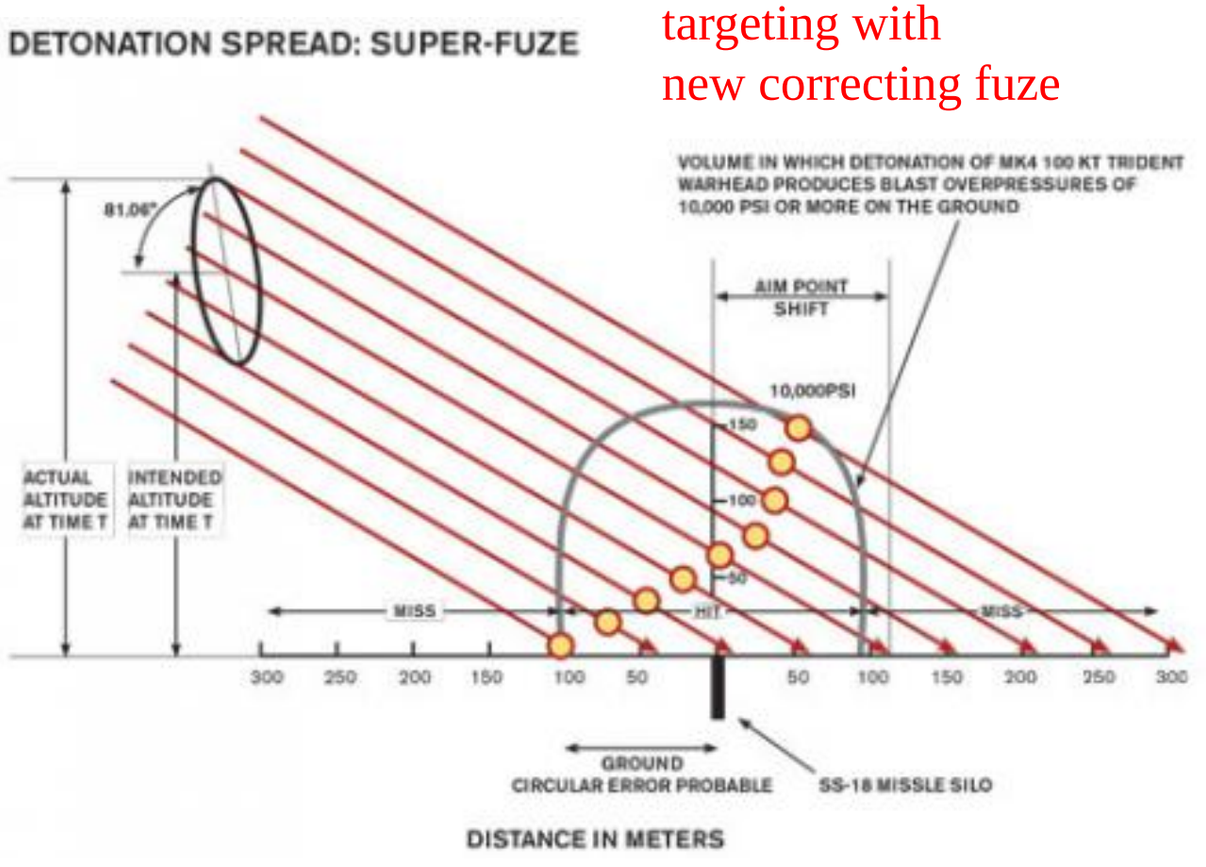
Kristensen is the director of the Nuclear Information Project with the Federation of American Scientists (FAS) in Washington, DC. His work

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

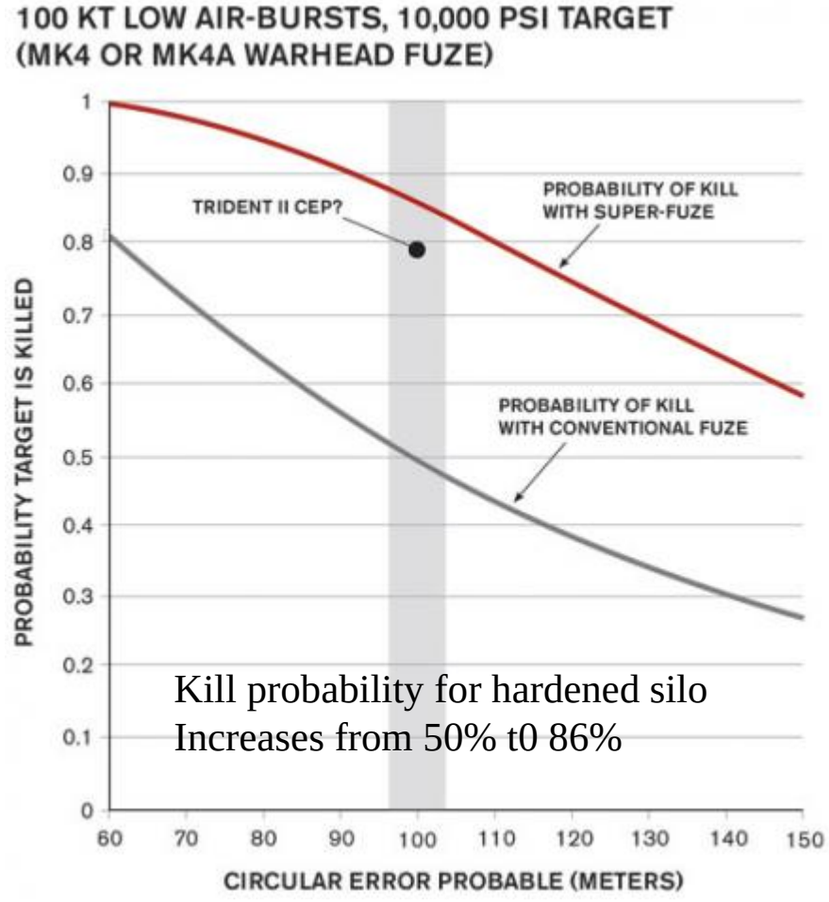
Bulletin of the Atomic Scientist



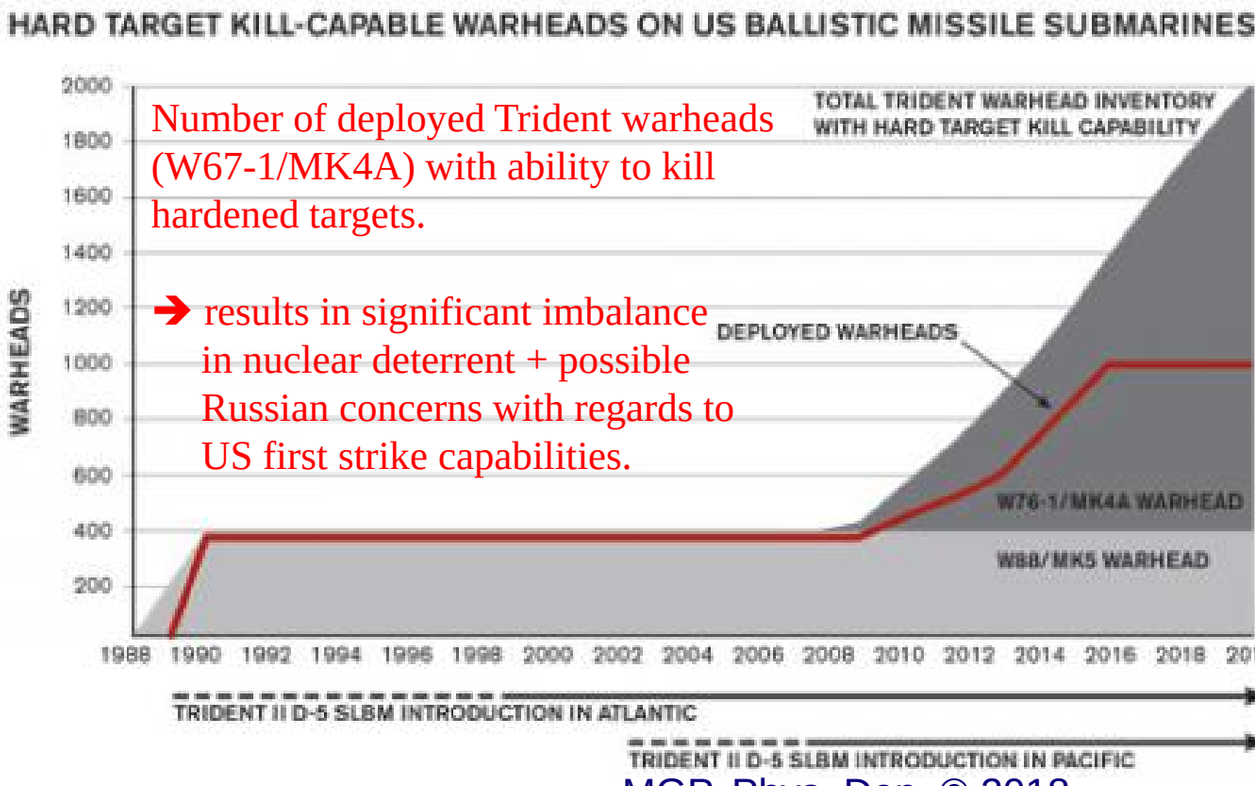
targeting with
old fuze



targeting with
new correcting fuze



Kill probability for hardened silo
Increases from 50% t0 86%

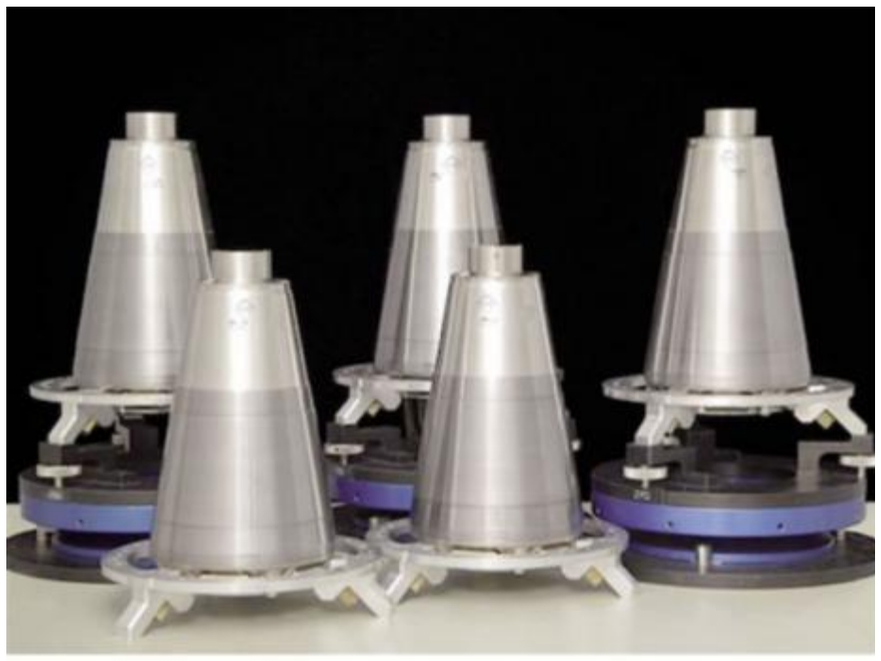


Number of deployed Trident warheads (W67-1/MK4A) with ability to kill hardened targets.

➔ results in significant imbalance in nuclear deterrent + possible Russian concerns with regards to US first strike capabilities.

Bulletin of the Atomic Scientist

AMF&F Firing System
(Arming, Fusing and Firing)
for W67-1Mk4A warhead



Our conclusions. Under the veil of an otherwise-legitimate warhead life-extension program, the US military has quietly engaged in a vast expansion of the killing power of the most numerous warhead in the US nuclear arsenal: the W76, deployed on the Navy's ballistic missile submarines. This improvement in kill power means that all US sea-based warheads now have the capability to destroy hardened targets such as Russian missile silos, a capability previously reserved for only the highest-yield warheads in the US arsenal.

The capability upgrade has happened outside the attention of most government officials, who have been preoccupied with reducing nuclear warhead numbers. The result is a nuclear arsenal that is being transformed into a force that has the unambiguous characteristics of being optimized for surprise attacks against Russia and for fighting and winning nuclear wars. While the lethality and firepower of the US force has been greatly increased, the numbers of weapons in both US and Russian forces have decreased, resulting in a dramatic increase in the vulnerability of Russian nuclear forces to a US first strike. We estimate that the results of arms reductions with the increase in US nuclear capacity means that the US military can now destroy all of Russia's ICBM silos using only about 20 percent of the warheads deployed on US land- and sea-based ballistic missiles.

Physics/Global Studies 280
Module 6: Nuclear Arsenals and Proliferation

Part 1: Overview of Programs and Arsenals

Part 2: Arsenals of the NPT Nuclear-Weapon States:
The United States, Russia, the United Kingdom, France, and China

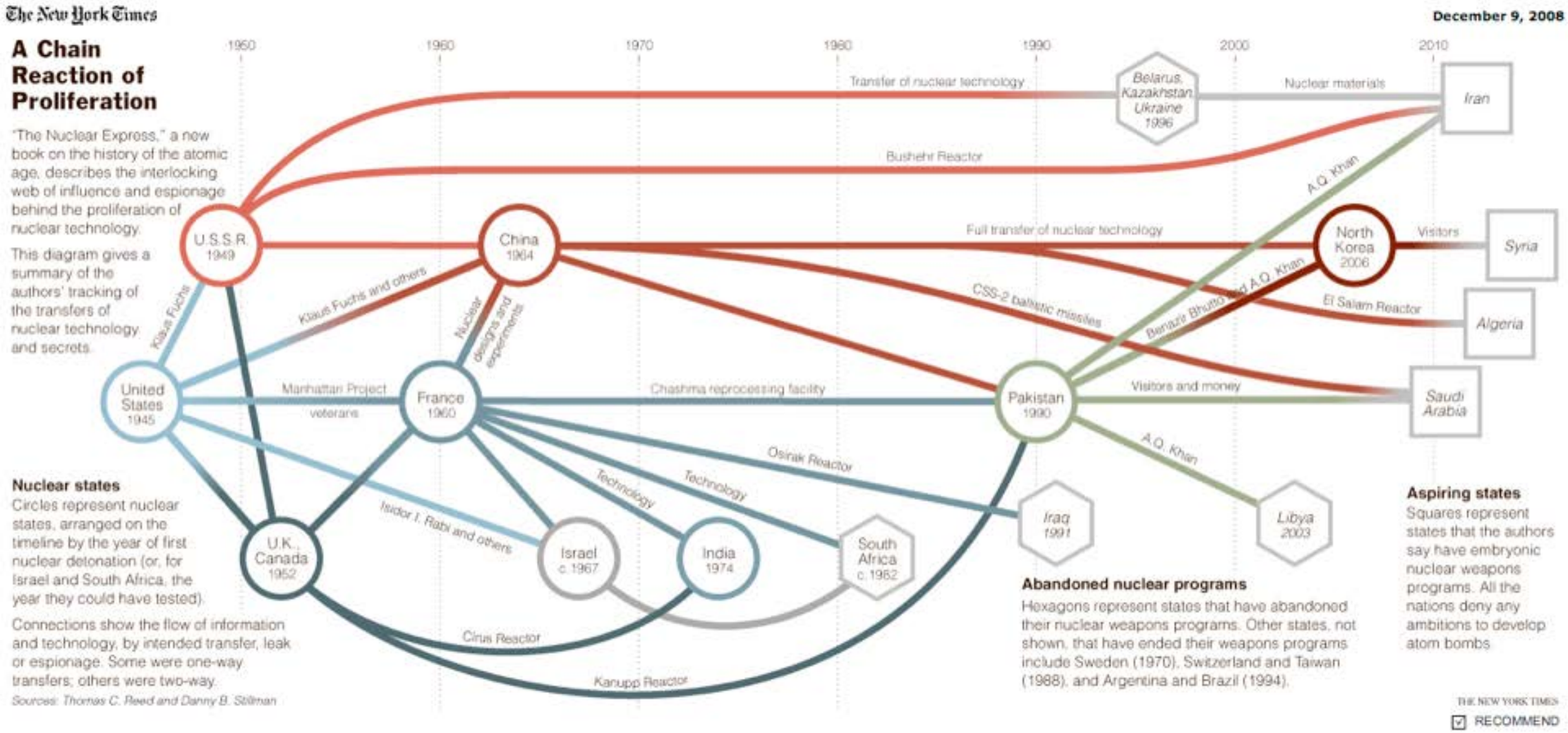
Part 3: Arsenals of non-NPT and Emerging Nuclear-Weapon States:
India, Pakistan, Israel and North Korea

Part 4: Threat Perceptions

Module 6: Programs and Arsenals

Part 1: Overview of Programs and Arsenals

Module 6: Nuclear Arsenals and Proliferation

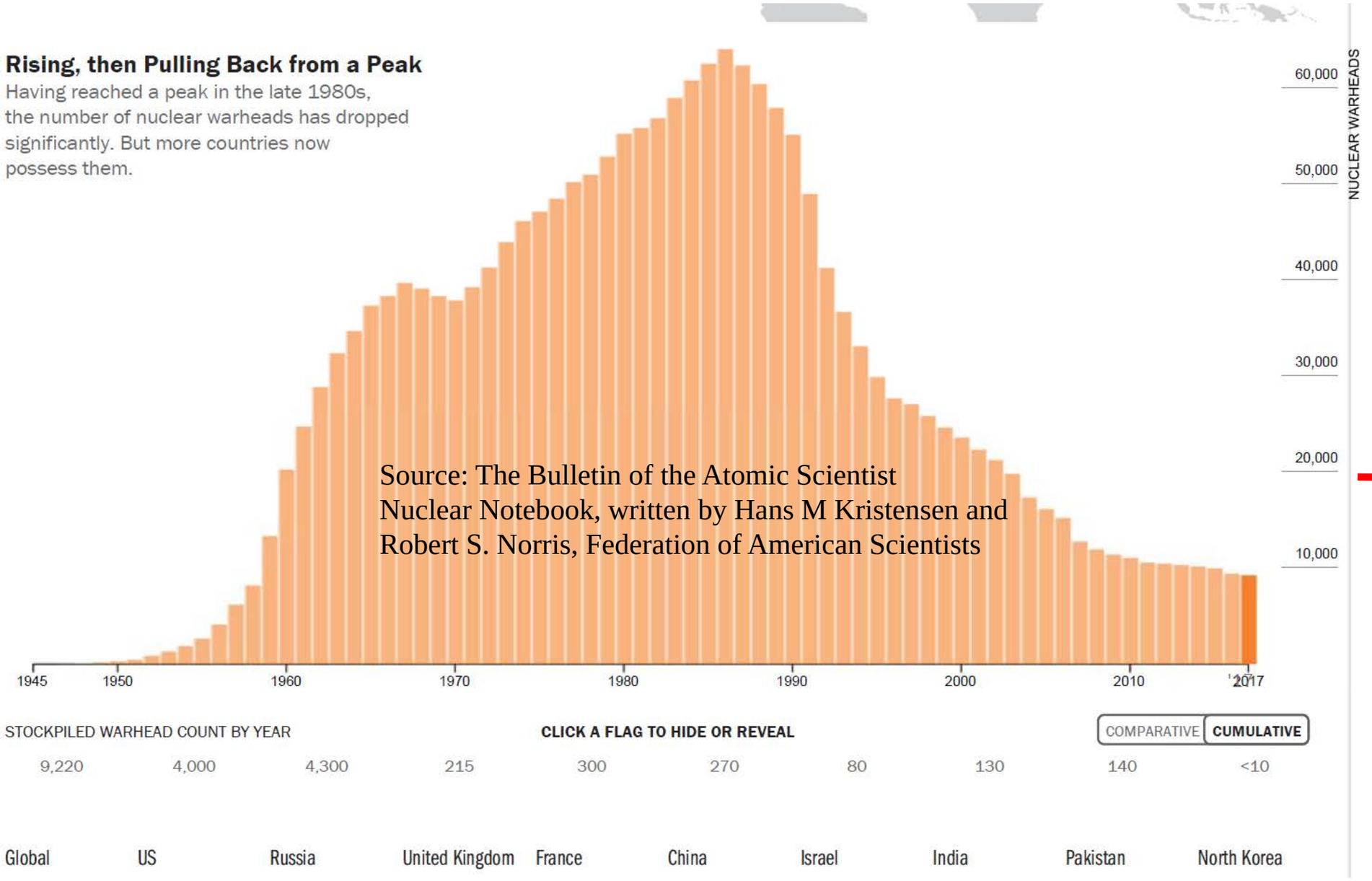


This article has been revised to reflect the following correction:

Correction: December 15, 2008

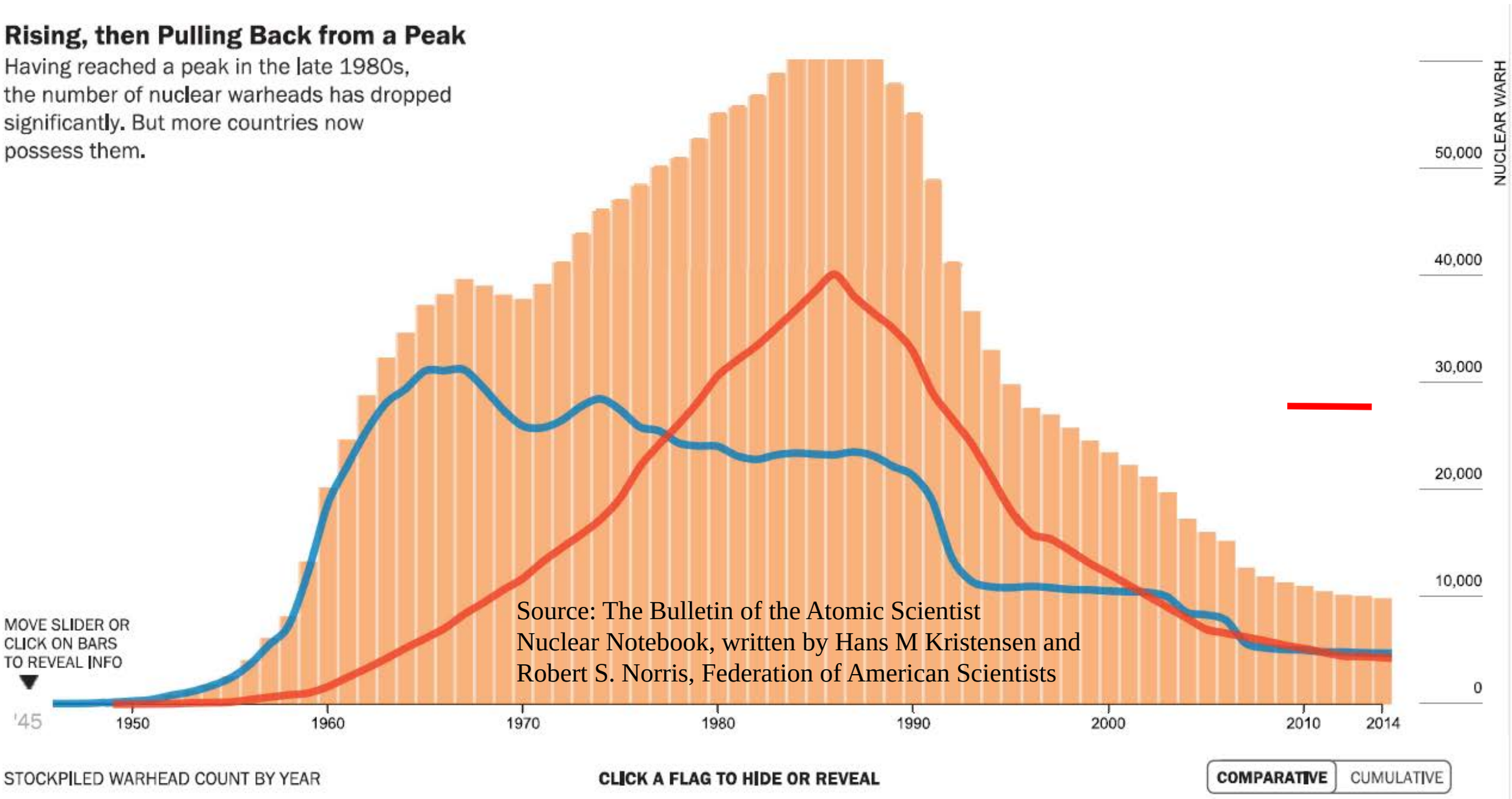
A chart last Tuesday with an article about the proliferation of the atomic bomb, showing the exchange of nuclear information and technology between countries, misidentified the type of reactor that India acquired from Canada, which allowed India to make fuel for its first nuclear test. It was a CIRUS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

World Nuclear Weapon Stockpiles 1945–2014



9,220 total nuclear weapons in 2017

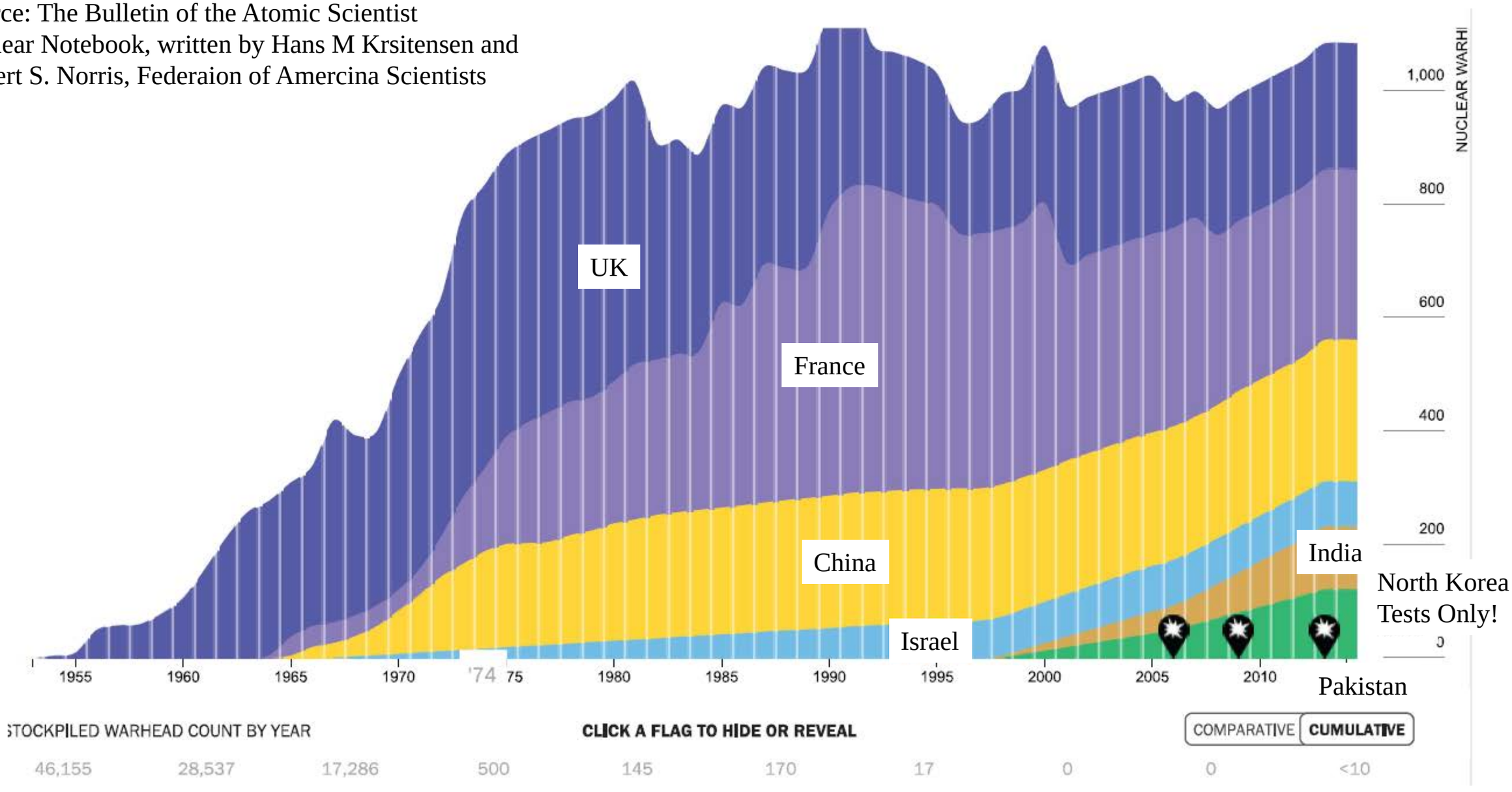
World Nuclear Weapon Stockpiles 1945–2014



USA and Russia

World Nuclear Weapon Stockpiles 1945–2014

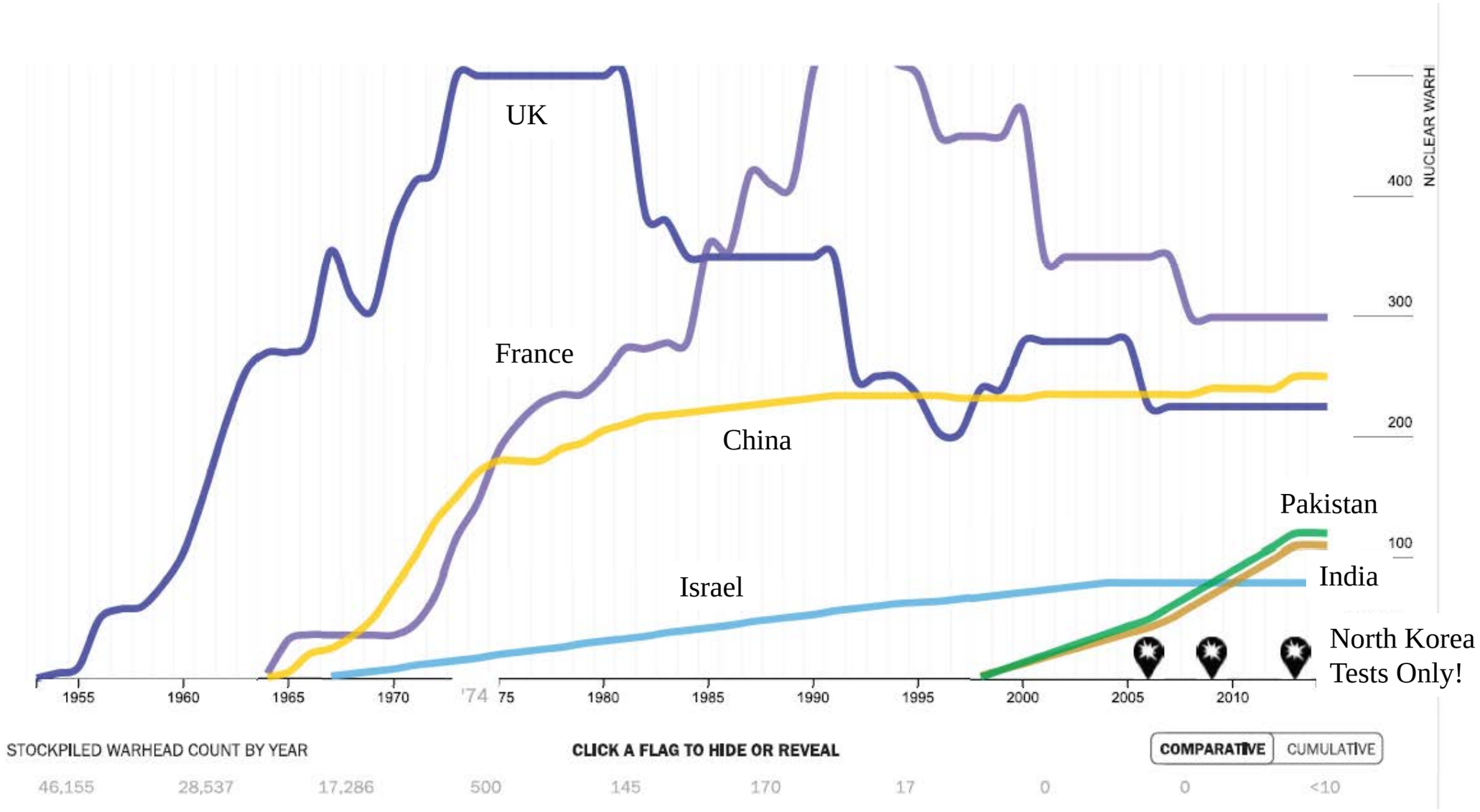
Source: The Bulletin of the Atomic Scientist
Nuclear Notebook, written by Hans M Krsitensen and
Robert S. Norris, Federaion of Amercina Scientists



Other Nuclear Weapon States

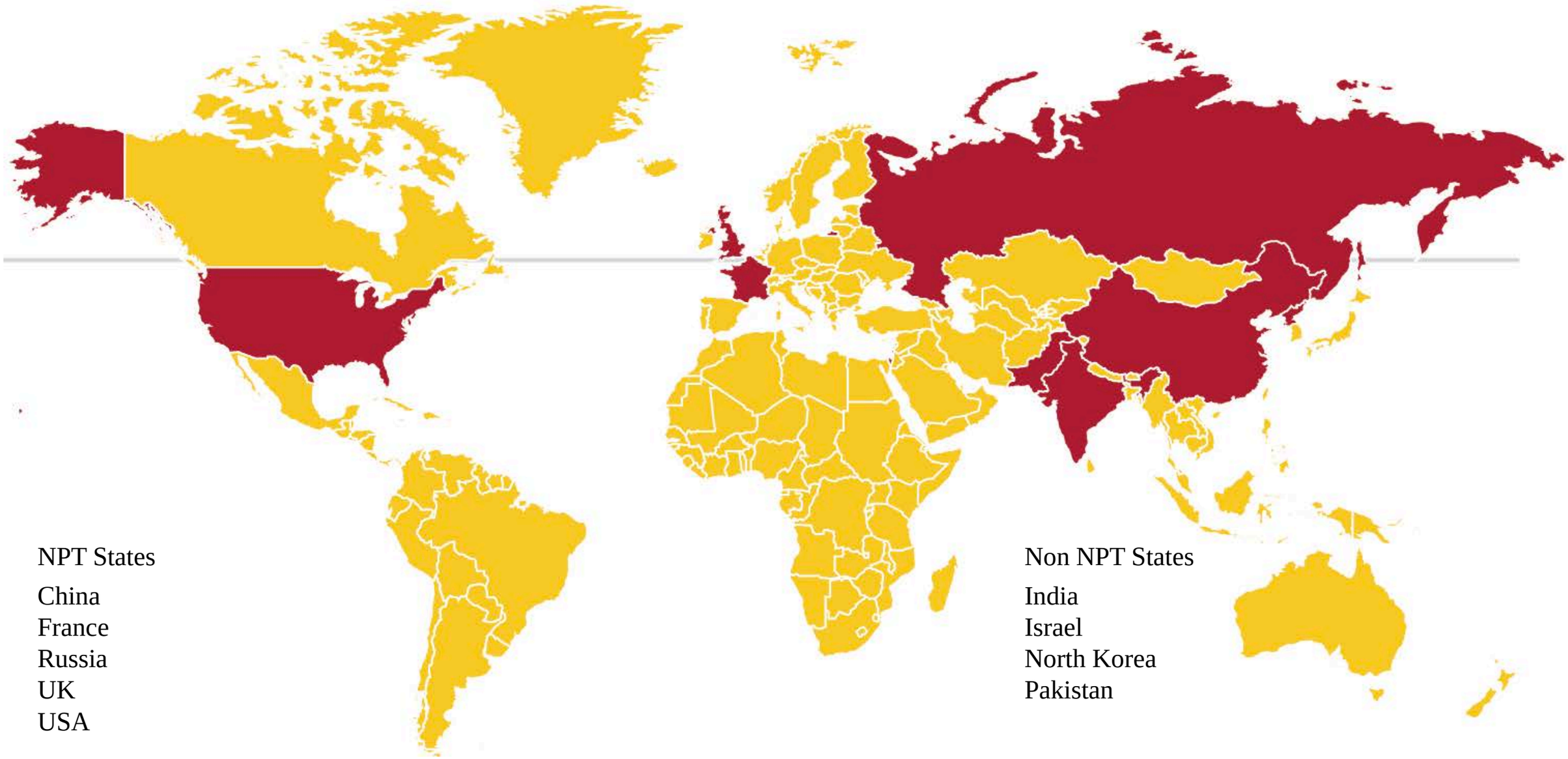
World Nuclear Weapon Stockpiles 1945–2014

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



Other Nuclear Weapon States

States With Nuclear Weapons in 2014



NPT States

China
France
Russia
UK
USA

Non NPT States

India
Israel
North Korea
Pakistan

PLOUGHSHARES FUND ploughshares.org

Global Nuclear Weapon Inventory 2014 (Important)

NPT Nuclear Weapon States (Total Weapons)

China: ~ 250

France: ~ 300

Russia: ~ 4,300

UK: ~ 225

US: ~ 4,760

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

Global Nuclear Weapon Inventory 2014 (Important)

Non-NPT Nuclear Weapon States (Total Weapons)

Pakistan: ~ 120

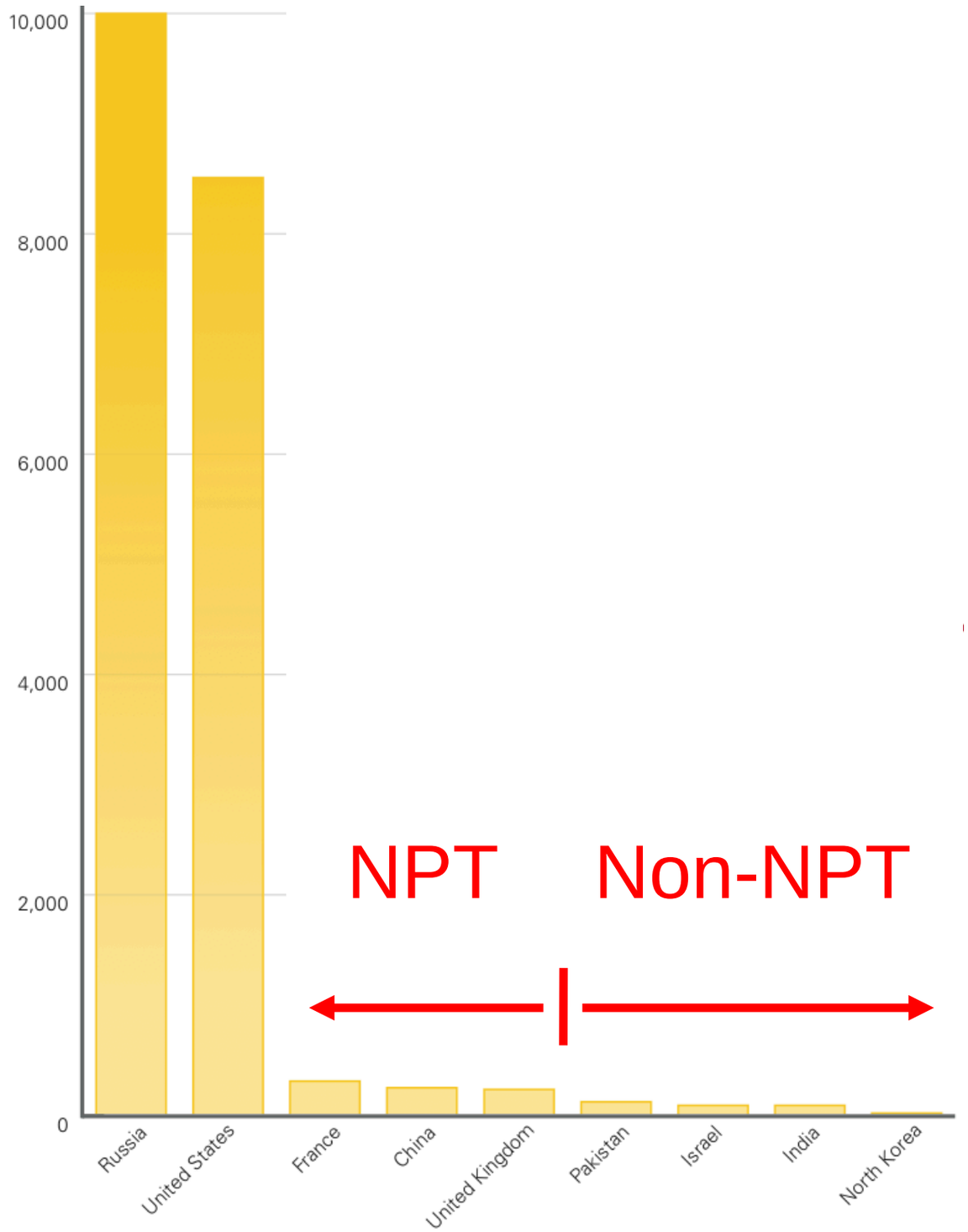
Israel: ~ 80

India: ~ 110

North Korea: < 10

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

States With Nuclear Weapons in 2012



Nuclear Warheads on Alert

United Nations Institute for Disarmament Research
UNIDIR/2012/6 Hans Kristensen, Matthew McKinzie

Table 1. Estimated alert nuclear forces, 2012

Country	Stockpiled warheads[a]	Alert warheads[b]	Remarks
United States	5,000	920	Split more or less evenly between ICBMs and SLBMs
Russian Federation	4,500	890	Mainly warheads on ICBMs; alert levels vary greatly depending on type
France	300	80[c]	One SSBN on patrol
United Kingdom	225	48[c]	One SSBN on patrol
China	240	0	Warheads are not mated with delivery systems or in military custody
Pakistan	100	0	Warheads are not mated with deployed delivery vehicles
India	90	0	Warheads are not mated with deployed delivery vehicles
Israel	80	0	Warheads are not mated with deployed delivery vehicles
Total	~10,540	~1,940	

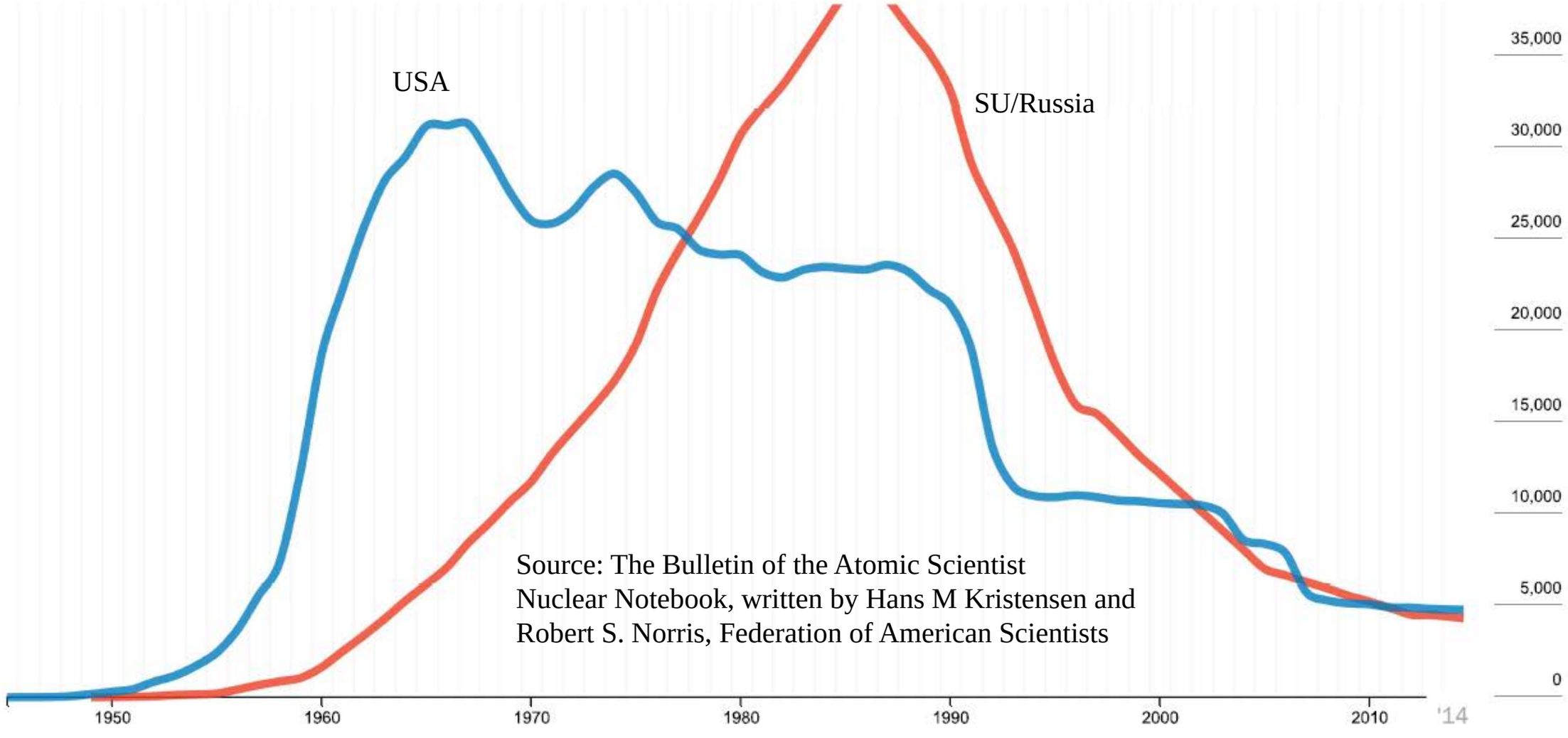
[a] This includes warheads in the military stockpile assigned to nuclear forces. Additional retired, but still intact, warheads may be in storage awaiting dismantlement. The United States and the Russian Federation each have several thousand warheads in this category.
[b] Warheads are considered on alert if they are deployed on a delivery system that is deployed and ready to launch the weapons within minutes or hours.
[c] Although deployed and fully operational, SLBMs on French and British SSBNs are thought to require longer preparation to launch than US and Russian alert weapons.

Part 2: Arsenals of the NPT Nuclear-Weapon States

Will cover impact of New Start in Arms Control Module

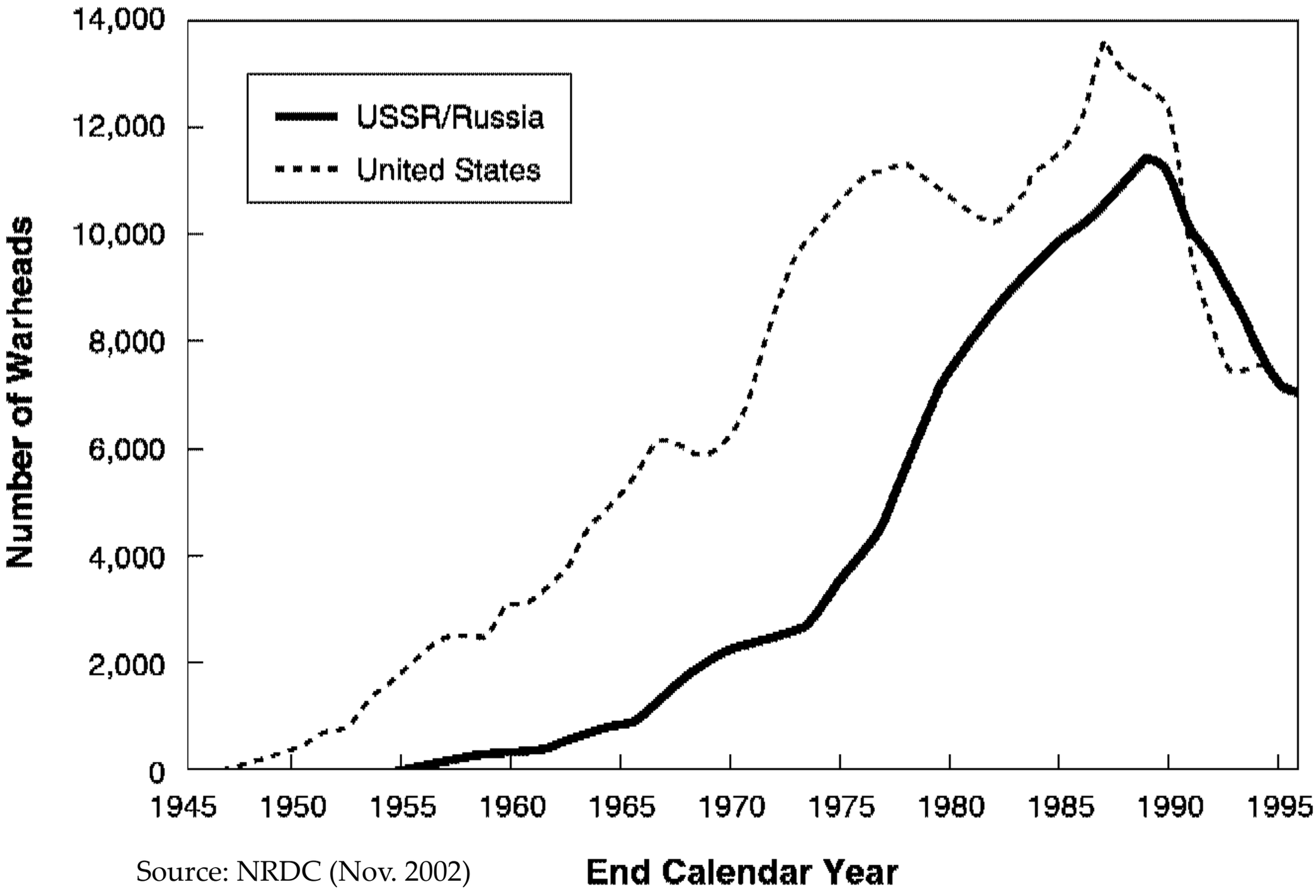
The United States, Russia, the United Kingdom, France, and China

Evolution of US and SU-Russian Nuclear Stockpiles



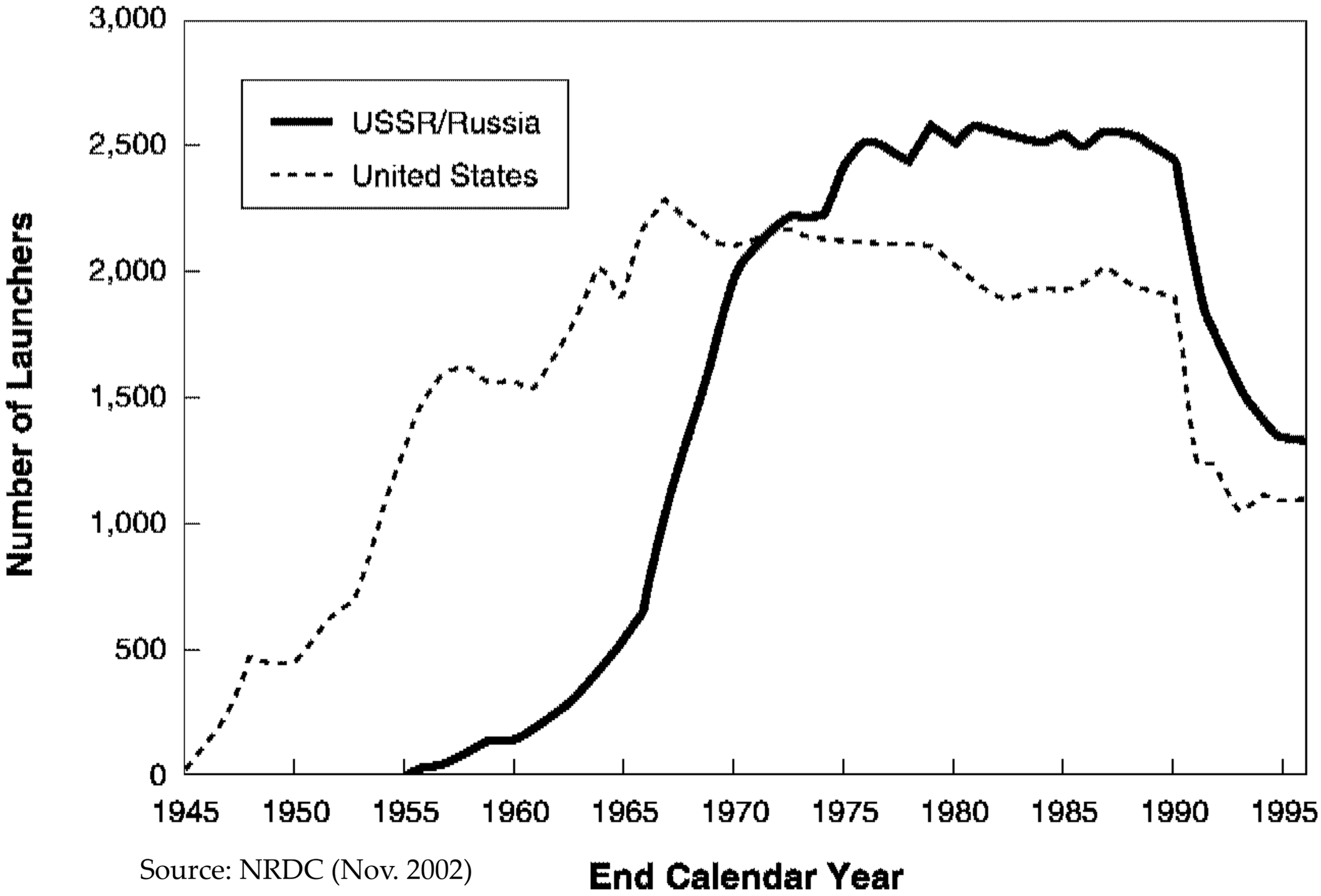
Source: The Bulletin of the Atomic Scientist
Nuclear Notebook, written by Hans M Kristensen and
Robert S. Norris, Federation of American Scientists

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)

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.

Tactical Nuclear Weapons in Europe

The long-standing position of Washington is that its air-to-surface weapons in Europe connect the security of NATO and the United States. Still, the tactical arms are not intended for use against any particular nation and the infrastructure required to employ the weapons no longer stands at combat readiness.

A December 2008 **report** by an advisory panel to the U.S. Defense Department found that the time required to bring the aircraft that would fire the nuclear weapons into battle mode was "now measured in months rather than minutes."

The report detailed different views within the alliance, with some high-level U.S. officials at NATO headquarters in Belgium described as not being supportive of keeping the tactical weapons in Europe. An anonymous U.S. general was quoted to say that the nuclear bombs were no longer required as Washington could extend its nuclear umbrella to cover European allies from outside the continent.

Evolution of US Nuclear Bomber Forces – 1

Bomber Forces	2000	2001	2002	2007	2012
Bombers (Total Inventory) [1]					
B-52 Stratofortress	94	94	94	94	94
B-2 Spirit	21	21	21	21	21
Total (Bombers)	**115**	**115**	**115**	**115**	**115**

Source: NRDC

Evolution of US Nuclear Bomber Forces – 2

Bomber Forces	2000	2001	2002	2007	2012
Bombers Weapons (Force Loadings) [12]					
Bombs [13]	516	516	516	516	1,286
ALCM (AGM-86B) [16]	430	430	430	430	45
ACM (AGM-129A) [17]	430	430	430	430	45
Total (Force Loading Weapons)	**1,376**	**1,376**	**1,376**	**1,376**	**1,376**
* The 2007 figure is a goal of the Bush administration's 2001 Nuclear Posture Review ** The 2012 figure is a limit of the Treaty of Moscow signed on May 24, 2002					

Source: NRDC

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**

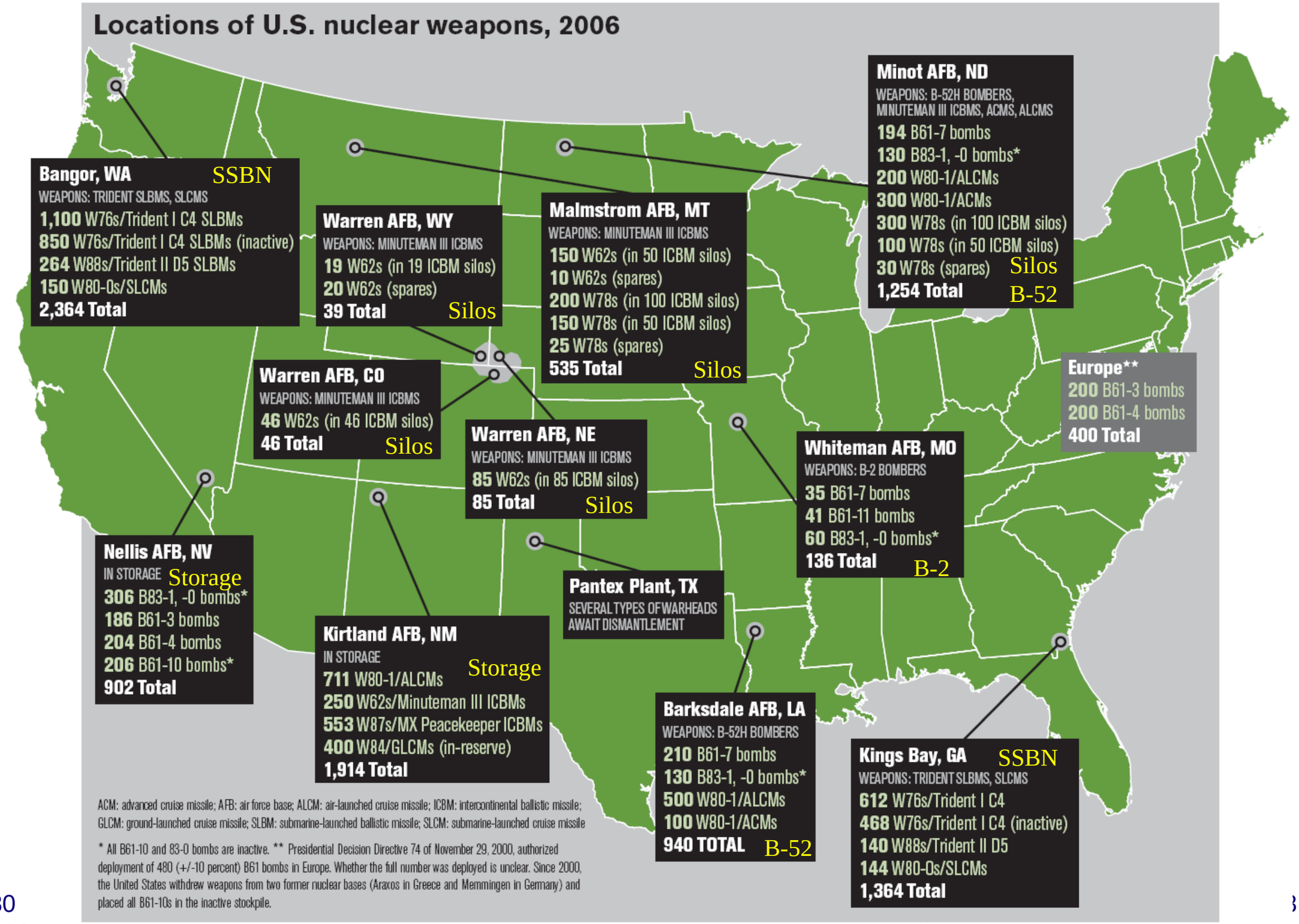
Source: NRDC

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

Locations of U.S. Nuclear Weapons



NRDC, Where the Bombs are, 2006, Bulletin of the Atomic Scientists, Nov-Dec 2006

2010 U.S. Nuclear Posture Review

Obama Limits When U.S. Would Use Nuclear Arms

By DAVID E. SANGER and PETER BAKER

WASHINGTON — President Obama said Monday that he was revamping American nuclear strategy to substantially narrow the conditions under which the United States would use nuclear weapons.

But the president said in an interview that he was carving out an exception for "outliers like Iran and North Korea" that have violated or renounced the main treaty to halt nuclear proliferation.

2010 U.S. Nuclear Posture Review

The document to be released Tuesday after months of study led by the Defense Department will declare that "the fundamental role" of nuclear weapons is to deter nuclear attacks on the United States, allies or partners, a narrower presumption than the past. But Mr. Obama rejected the formulation sought by arms control advocates to declare that the "sole role" of nuclear weapons is to deter a nuclear attack.

"We are going to pursue opportunities for further reductions in our nuclear posture, working in tandem with Russia but also working in tandem with NATO as a whole," he said.

An obvious such issue would be the estimated 200 tactical nuclear weapons the United States still has stationed in Western Europe. Russia has called for their removal, and there is growing interest among European nations in such a move as well. But Mr. Obama said he wanted to consult with NATO allies before making such a commitment.

Physics/Global Studies 280: Session 18

Plan for This Session

RE4 (1) **v0** due today – electronically.
(2) Be prepared to discuss **v0** with your peer review partner in the writing labs on March 26th (immediately after spring break).
(3) **v1** will be due Thursday March 29th

RPv1 will be due Thursday April 5th

News and Discussion

Module 6: Nuclear Arsenals (cont'd)

News Chinese Views on the 2018 Nuclear Posture Review, and Their Implications

Michael S. Chase (https://jamestown.org/analyst/michael-s-chase,*March 12, 2018*

The 2018 U.S. Nuclear Posture Review (NPR), released in February, appears to be focused mainly on the challenges presented by Russian nuclear weapons and strategy. Nonetheless, the document also has some potentially important implications for China, where analysts continue to discuss and debate China's approach to strategic deterrence generally as well as Chinese nuclear policy and strategy and nuclear force modernization in particular.

Unsurprisingly, China's reaction to the latest U.S. NPR has been critical. (The PRC Ministry of National Defense spokesperson stated: "We hope the U.S. side will discard its 'cold-war mentality,' shoulder its own special and primary responsibility for nuclear disarmament, understand correctly China's strategic intentions and take a fair view on China's national defense and military development".

More specifically, Chinese experts assessing the NPR's implications for China appear to be focusing on its proposals to develop new nuclear capabilities and its listing of several types of non-nuclear strategic attacks that could result in nuclear escalation. For example, Professor Li Bin, a well-known Chinese nuclear policy expert at Tsinghua University, states that the United States "could prepare more nuclear tools and could threaten to use nuclear weapons on more occasions." **[1]** Moreover, Li argues that the strategy reflects a renewed attempt to use U.S. advantages in nuclear weapons to pursue "regional and global hegemony."

News Chinese Views on the 2018 Nuclear Posture Review, and Their Implications

Michael S. Chase (https://jamestown.org/analyst/michael-s-chase,*March 12, 2018*

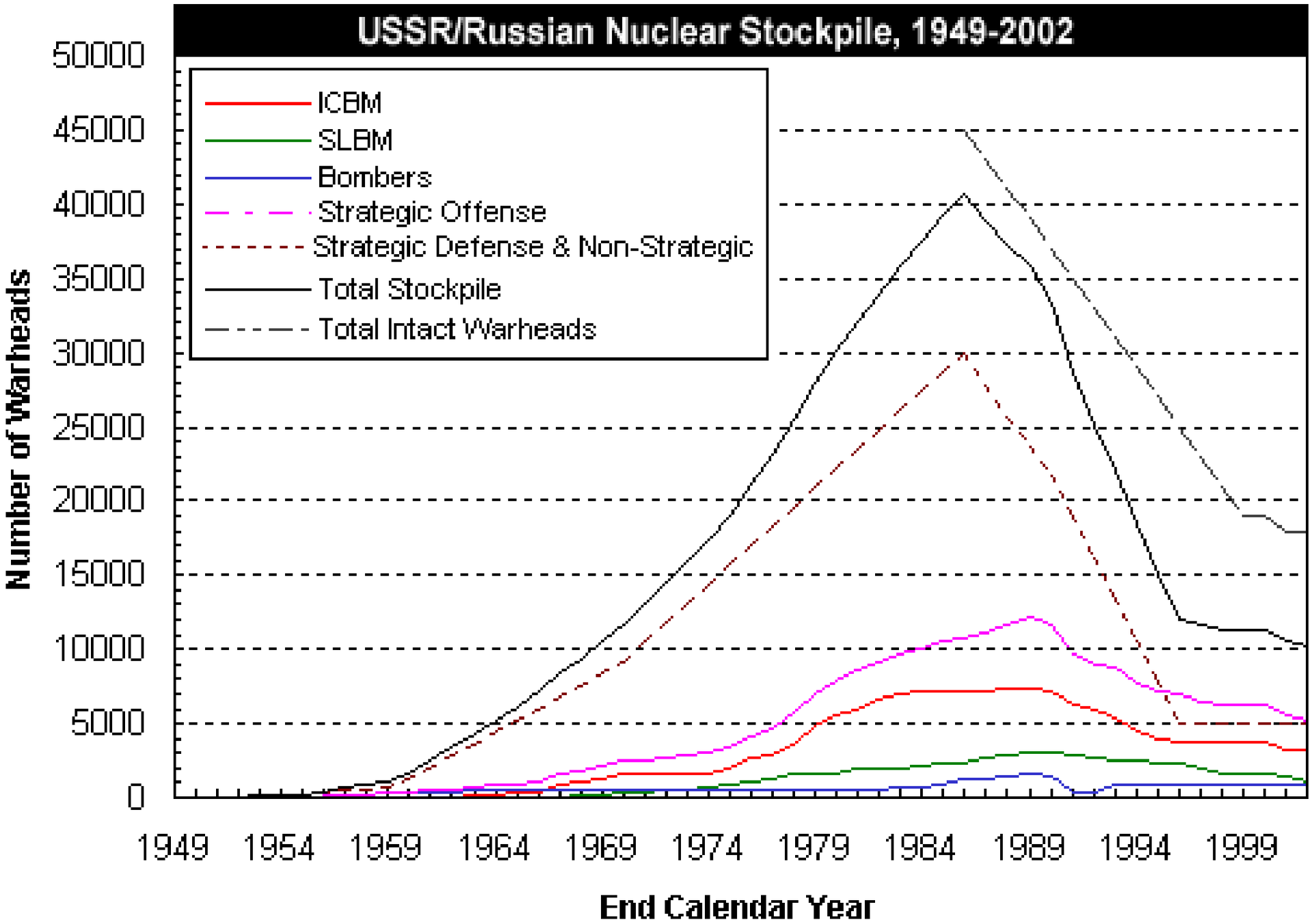
As for how China should respond, a late January *PLA Daily* article called for China to strengthen and expand its nuclear deterrence capabilities (SCMP (http://www.scmp.com/news/china/diplomacydefence/ article/2131261/china-needs-more-nuclear-warheads-deter-us-threat), January 30), but such moves were already well underway in response to Chinese concerns about advances in U.S. intelligence, surveillance, and reconnaissance (ISR), precision strike, and missile defense capabilities. Indeed, the 2013 edition of the *Science of Military Strategy*, an influential volume published by the PLA's Academy of Military Science (AMS), assessed that China's faces an increasingly complex nuclear security environment and underscored the importance of responding by strengthening China's nuclear deterrent capabilities. On the whole, therefore, Chinese strategists are likely to view the NPR as validating China's existing approach to nuclear force modernization, which has been largely congruent with its stated nuclear policy and strategy.

Initial indications are that China will view the NPR as underscoring the need to continue moving ahead with a nuclear force modernization program that is increasing the quality and quantity of Chinese nuclear forces, albeit in ways that appear to be largely consistent with China's longstanding no first use (NFU) policy, and an approach to nuclear strategy that focuses on providing China with a modern and secure nuclear retaliatory capability.

As for China's NFU policy, even if Chinese strategists are concerned about aspects of the NPR, it provides little impetus for China to officially change its longstanding nuclear policy. Indeed, Fu Ying, Chair of the Foreign Affairs Committee of the PRC's National People's Congress (NPC), reaffirmed China's adherence to NFU in her remarks at the Munich Security Conference in February (Xinhua (https://news.cgtn.com/news/7849444d34677a6333566d54/share_p.html), February 18).

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

SU-Russian Nuclear Warheads



Source: NRDC (Nov. 2002)

Russian Nuclear Forces (2011)

Type/name	Russian designation	Launchers	Year deployed	Warheads x yield (kilotons)	Total warheads
Strategic offensive weapons					
ICBMs					
SS-18 M6 Satan	RS-20V	50	1988	10 × 500/800 (MIRV)	500
SS-19 M3 Stiletto	RS-18	50	1980	6 × 400 (MIRV)	300
SS-25 Sickle	RS-12M (Topol)	120	1985	1 × 800	120
SS-27 Mod 1	RS-12M2 (Topol-M)	51	1997	1 × 800	51
SS-27 Mod 1	RS-12M1 (Topol-M)	18	2006	1 × 800?	18
SS-27 Mod 2	RS-24	6	2010	3 × 400? (MIRV)	18
Subtotal		**295**			**1,007**
SLBMs					
SS-N-18 M1 Stingray	RSM-50	4/64	1978	3 × 50 (MIRV)	192
SS-N-23 Skiff	R-29RM	1/16	1986	4 × 100 (MIRV)	64
SS-N-23 M1	RSM-54 (Sineva)	5/80	2007	4 × 100 (MIRV)[1]	320
SS-N-32	RSM-56 (Bulava)	(1/16)	(2011)	6 × 100 (MIRV)	(96)
Subtotal		**10/160**			**576**
Bombers/weapons					
Bear-H6	Tu-95 MS6	32	1984	6 × AS-15A ALCMs, bombs	192
Bear-H16	Tu-95 MS16	31	1984	16 × AS-15A ALCMs, bombs	496
Blackjack	Tu-160	13	1987	12 × AS-15B ALCMs or AS-16 SRAMs, bombs	156
Subtotal		**76**			**844**[2]
Subtotal strategic offensive forces					**~2,430**

Russian Nuclear Forces

Russian SS-25 Road-Mobile Launcher

Russian SS-27 Mod 1 ICBM Launch

Russian Nuclear Forces

Russian SS-27 Road-Mobile Launcher

Russian Nuclear Forces (2010)

NONSTRATEGIC AND DEFENSIVE WEAPONS					
ABM/Air defense					
53T6	Gazelle	68	1986	1 x 1,000/10	68[2]
SA-10	Grumble	1,900	1980	1 x low	630
Land-based air					
Bombers/fighters		~524		ASM, bombs	650
Naval					
Submarines/surface ships/air				SLCM, ASW, SAM, ASM, DB, torpedoes	700
SUBTOTAL NONSTRATEGIC AND DEFENSIVE FORCES					**~2,000[3]**
TOTAL					**~4,600[4]**

1. The Sineva probably carries at least four MIRVed warheads. U.S. intelligence in 2006 estimated that the missile can carry "up to 10" warheads.

2. All Gorgon missiles apparently have been removed from the ABM system.

3. We estimate that an additional 3,300 nonstrategic warheads are in reserve or awaiting dismantlement, leaving a total inventory of approximately 5,300 nonstrategic warheads.

4. We estimate that an additional 7,300 intact warheads are in reserve or awaiting dismantlement, for a total inventory of approximately 12,000 warheads.

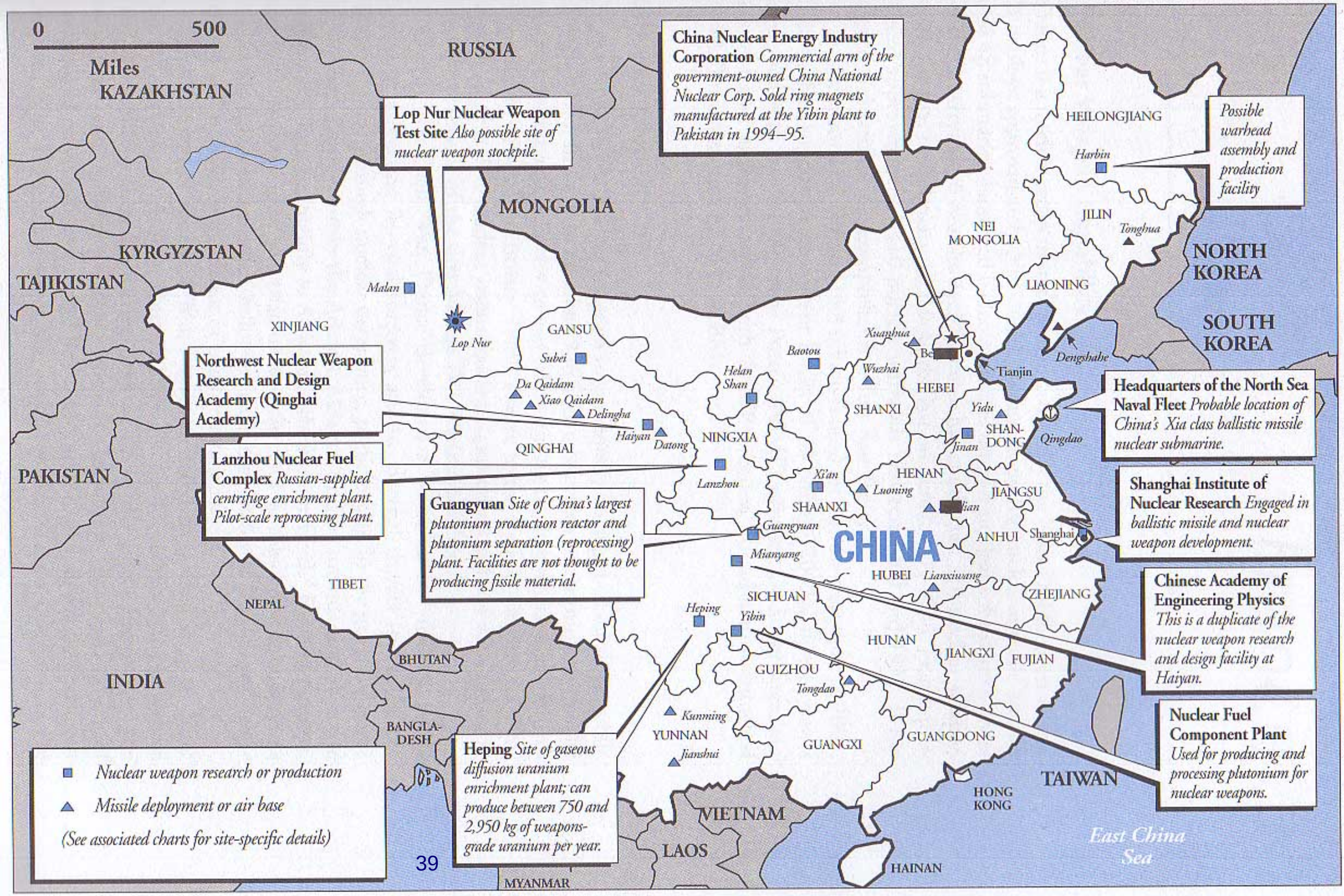
ABM: Antiballistic missile
ALCM: Air-launched cruise missile
ASM: Air-to-surface missile
ASW: Antisubmarine weapon
DB: Depth bomb
ICBM: Intercontinental ballistic missile
MIRV: Multiple independently targetable reentry vehicle
SAM: Surface-to-air missile
SLBM: Submarine-launched ballistic missile
SLCM: Sea-launched cruise missile
SRAM: Short-range attack missile

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).

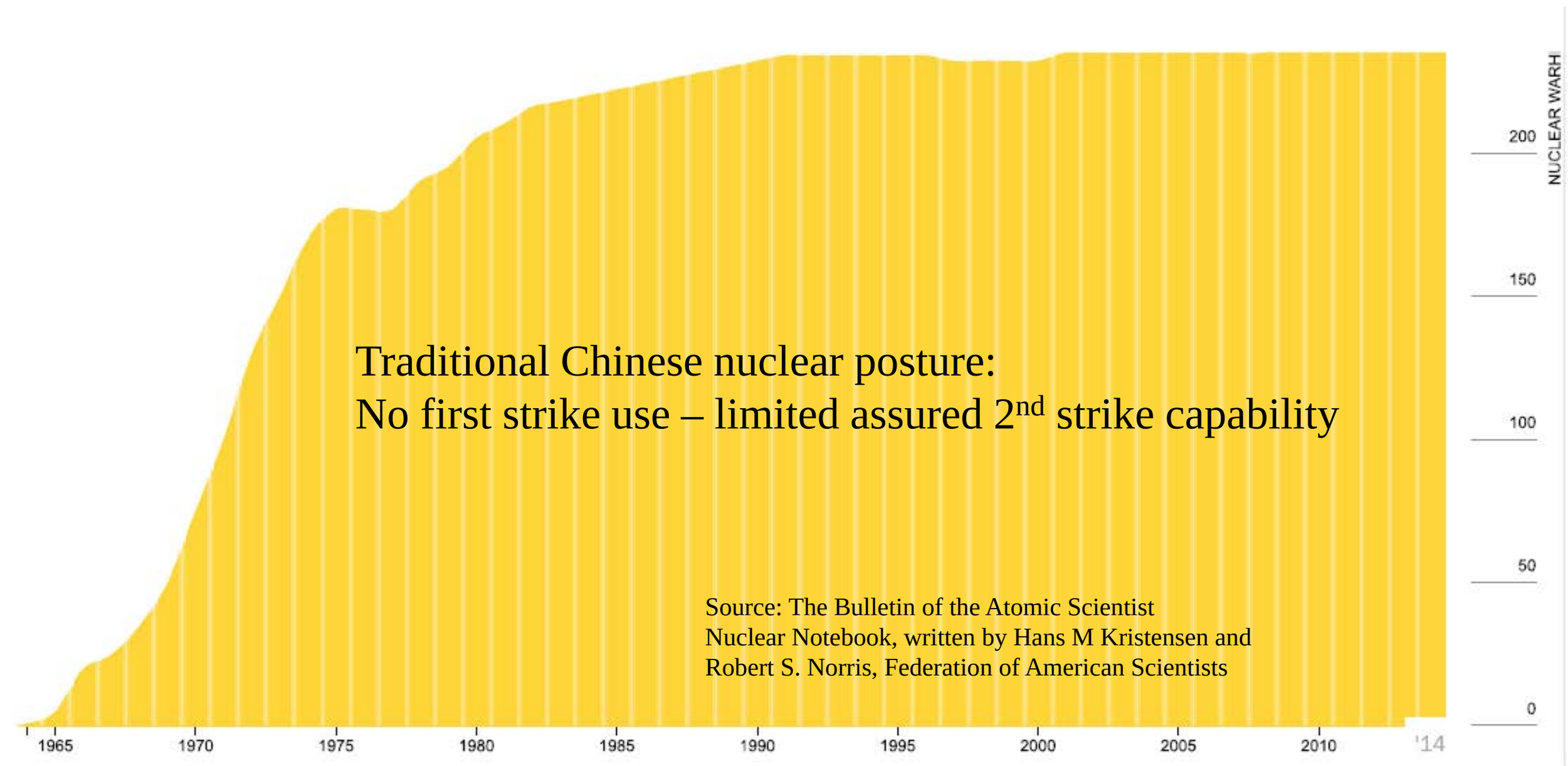
Unlike the US, for geopolitical reasons Russia deploys more warheads on its ICBMs than on its SLBMs.

China's Nuclear Infrastructure



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

Total Chinese Nuclear Warheads vs Time



Traditional Chinese nuclear posture:
No first strike use – limited assured 2nd strike capability

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 (2008):

LAND-BASED MISSILES

TYPE	NATO DESIGNATION	NO.	YEAR DEPLOYED	WARHEADS x YIELD (KILOTONS)	RANGE (KILOMETERS)	WARHEADS
DF-3A	CSS-2	17	1971	3,100	1 x 3,300	17
DF-4	CSS-3	17	1980	5,400+	1 x 3,300	17
DF-5A	CSS-4	20	1981	13,000+	1 x 4,000–5,000	20
DF-21	CSS-5	55	1991	2,100	1 x 200–300	55
DF-31	?	~6	2008	7,200+	7,200	~6
DF-31A	?	~6	2008	11,200+	11,200	~6

Currently: Modernizing nuclear forces to strengthen assured 2nd strike capability

- ➔ road mobile ICBM launchers
- ➔ development of new DF-41
- ➔ submarine based missiles

See for example:

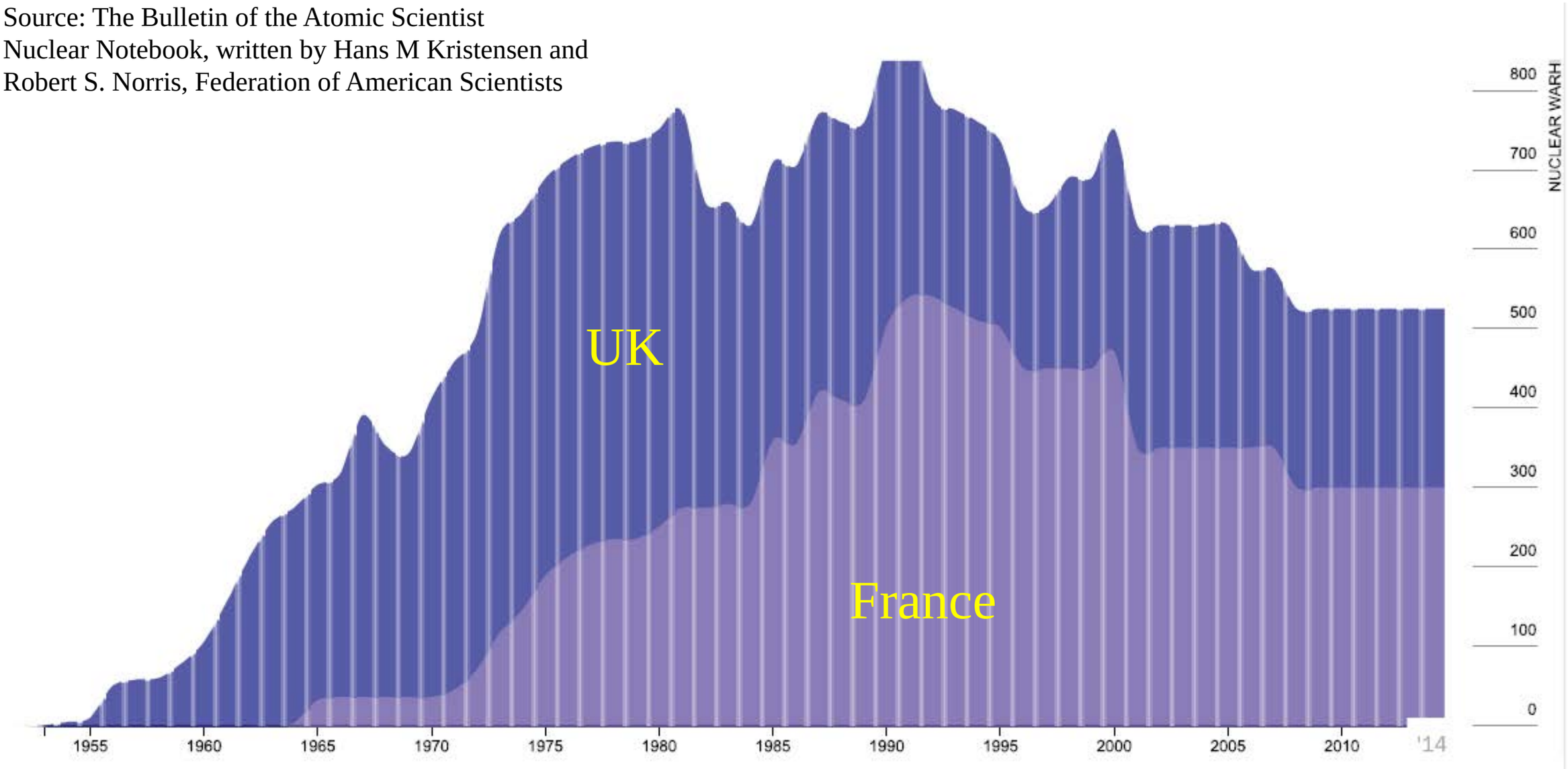
China's Transition to a More Credible Nuclear Deterrent: Implications and Challenges for the United States

Michael S. Chase in Asia Policy, July 2013

Qian-5, others?	Q-5	?	1972–?	—	1 x bomb	~20
					TOTAL***	~176

French and British Nuclear Forces

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



French Nuclear Forces

THE FRENCH ARSENAL

LAND-BASED AIRCRAFT	NO.	YEAR OPERATIONAL	RANGE (KILOMETERS)	WARHEADS x YIELD (KILOTONS)	ACTIVE WARHEADS
Mirage 2000N/ASMP	50	1988*	2,750**	1 TN81 X VARIABLE TO 300	50
Rafale F3/ASMP-A	?	2008	2,000	1 TNA X VARIABLE TO ?	—

CARRIER-BASED AIRCRAFT	NO.	YEAR OPERATIONAL	RANGE (KILOMETERS)	WARHEADS x YIELD (KILOTONS)	ACTIVE WARHEADS
Super Étendard/ASMP	10	1978	650**	1 TN81 X VARIABLE TO 300	10
Rafale MK3/ASMP-A	?	(2010)	2,000	1 TNA X VARIABLE TO ?	—

SLBMs	NO.	YEAR OPERATIONAL	RANGE (KILOMETERS)	WARHEADS x YIELD (KILOTONS)	ACTIVE WARHEADS
M45***	48	N/A	4,000+	4–6 TN75 X 100	240

* The ASMP first became operational on the Mirage IV in 1986.
** Maximum range of the ASMP is 300 kilometers; for the ASMP-A it is 500 kilometers.
*** Three sets of 16 M45 missiles are deployed on three of four SSBNs in the operational cycle.

TOTAL: 300

FRENCH SSBNs

NAME/SLBM*	YEAR OPERATIONAL	MISSILE RANGE (KILOMETERS)	WARHEADS x YIELD (KILOTONS)	TOTAL WARHEADS
Le Triomphant/M45	1997	4,000+	4–6 TN75 x 100	80
Le Téméraire/M45	1999	4,000+	4–6 TN75 x 100	80
Le Vigilant/M45	2005	4,000+	4–6 TN75 x 100	80
Le Terrible/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

U.K. Strategic Nuclear Forces

Weapon System	Warheads					
	No. deployed	Year deployed	Range (km)	Warhead x yield	Type	No. in stockpile
SLBMs						
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)

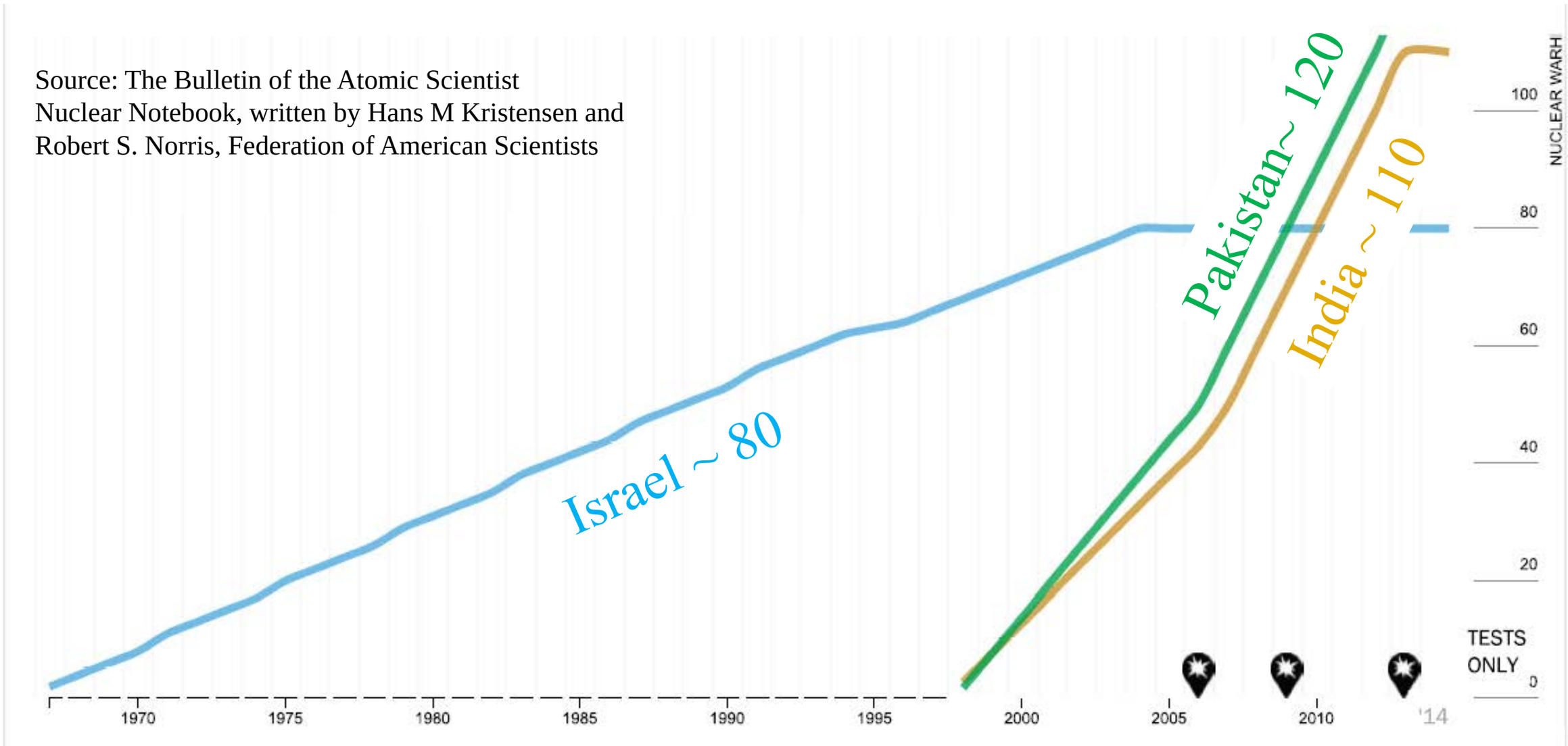
The United Kingdom and France (largely) rely on a nuclear deterrent in form of a naval submarine based nuclear arsenal

Part 3: Arsenals of non-NPT and Emerging Nuclear-Weapon States

India, Pakistan, Israel and North Korea

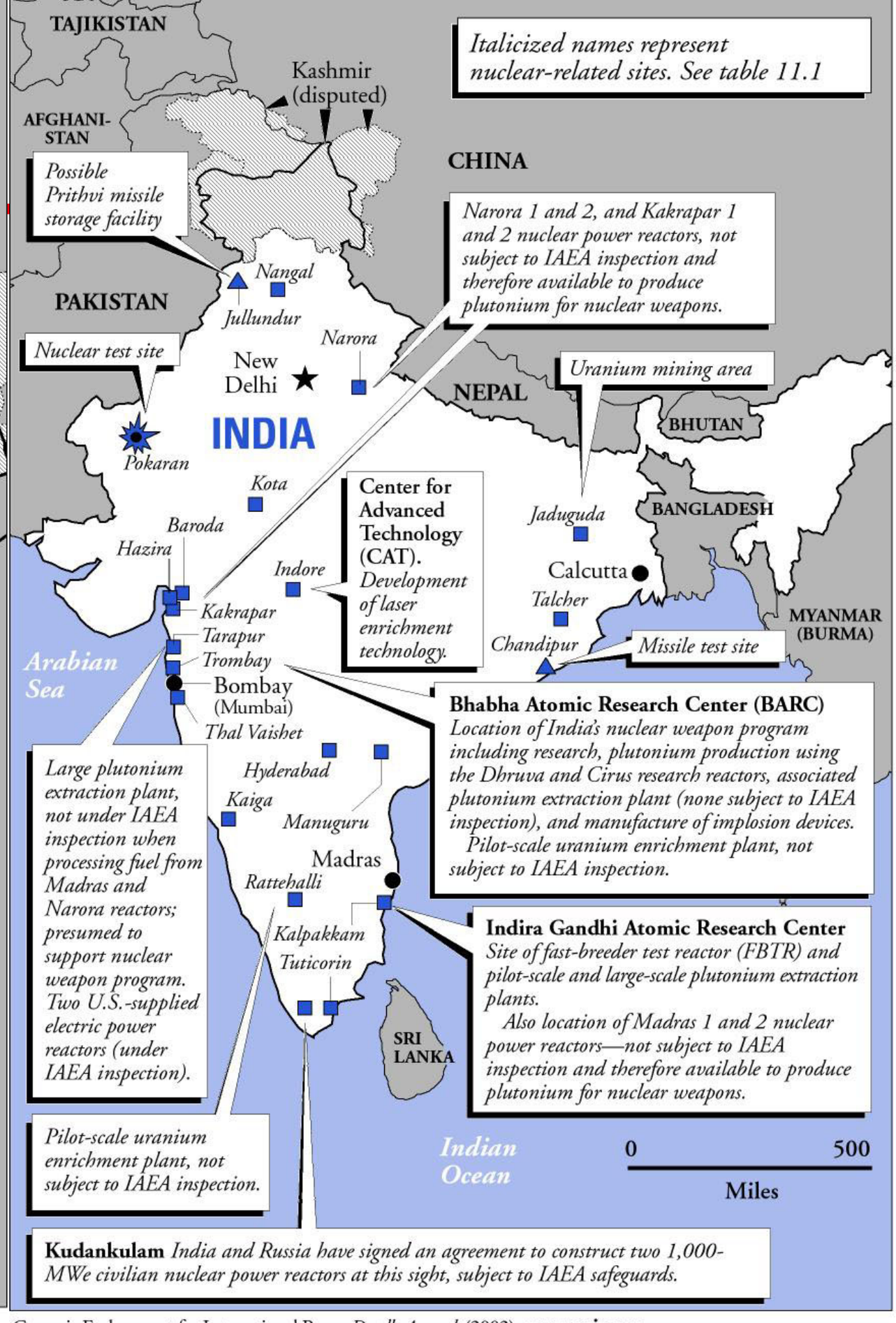
Estimates for Arsenals in India, Israel, North Korea and Pakistan

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



North Korea < 10

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



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

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 225–370 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 ~50-90 nuclear weapons
- The FAS estimates that India has about 110 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’s nuclear delivery capability

- 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 3 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.
- Longer range missiles Agni IV and V are under development.
- Prior to 2010 the main delivery vehicles where bomber planes

Indian Nuclear Forces (2008)

AIRCRAFT	RANGE (KILOMETERS)	PAYLOAD (KILOGRAMS)	COMMENT
Mirage 2000H/Vajra	1,800	6,300	Squadron 1 or 7 at Gwalior Air Force Station.
Jaguar IS/IB/Shamsher	1,600	4,775	At Ambala Air Force Station.

LAND-BASED MISSILES	RANGE (KILOMETERS)	PAYLOAD (KILOGRAMS)	COMMENT
Prithvi I	150	1,000	Nuclear version entered service after 1998 with the 333rd and 355th Missile Groups. Will be converted from liquid fuel to solid fuel.
Agni I	700	1,000	First operational training test in 2007; second in 2008. Deployed with army's 334th Missile Group in 2004.
Agni II	2,000	1,000	Under development. Tested August 29, 2004. Deployed with army's 335th Missile Group.
Agni III	3,000	1,500	Under development. Test-launched in 2006 (failed), 2007, and 2008.

SEA-BASED MISSILES	RANGE (KILOMETERS)	PAYLOAD (KILOGRAMS)	COMMENT
Dhanush	350	1,000	Under development. Naval version of Prithvi II. Fourth test March 30, 2007.
Sagarika/K-15	300–700	500–600	Under development. K-15 test-launched February 26, 2008, from a submerged platform; deployment expected after 2010.

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

Pakistan			
Date			
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)
- Displayed but never tested the 2,000-km Shaheen II
- 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 (2009)

We estimate that Pakistan has produced 70-90 nuclear warheads that can be deployed on the following delivery vehicles:

TYPE	RANGE [1] (kilometers)	PAYLOAD (kilograms)
Aircraft		
F-16A/B	1,600	1 bomb (4,500)
Mirage V	2,100	1 bomb (4,000)
Ballistic missiles		
Ghaznavi (Hatf-3)	~400	Conventional or nuclear (500)
Shaheen-1 (Hatf-4)	450+	Conventional or nuclear (1,000)
Shaheen-2 (Hatf-6)*	2,000+	Conventional or nuclear (1,000)
Ghauri (Hatf-5)	1,200+	Conventional or nuclear (1,000)
Cruise missiles		
Babur (Hatf-7)*	320+	Conventional or nuclear (n/a)
Ra'ad (Hatf-8)*	320+	Conventional or nuclear (n/a)

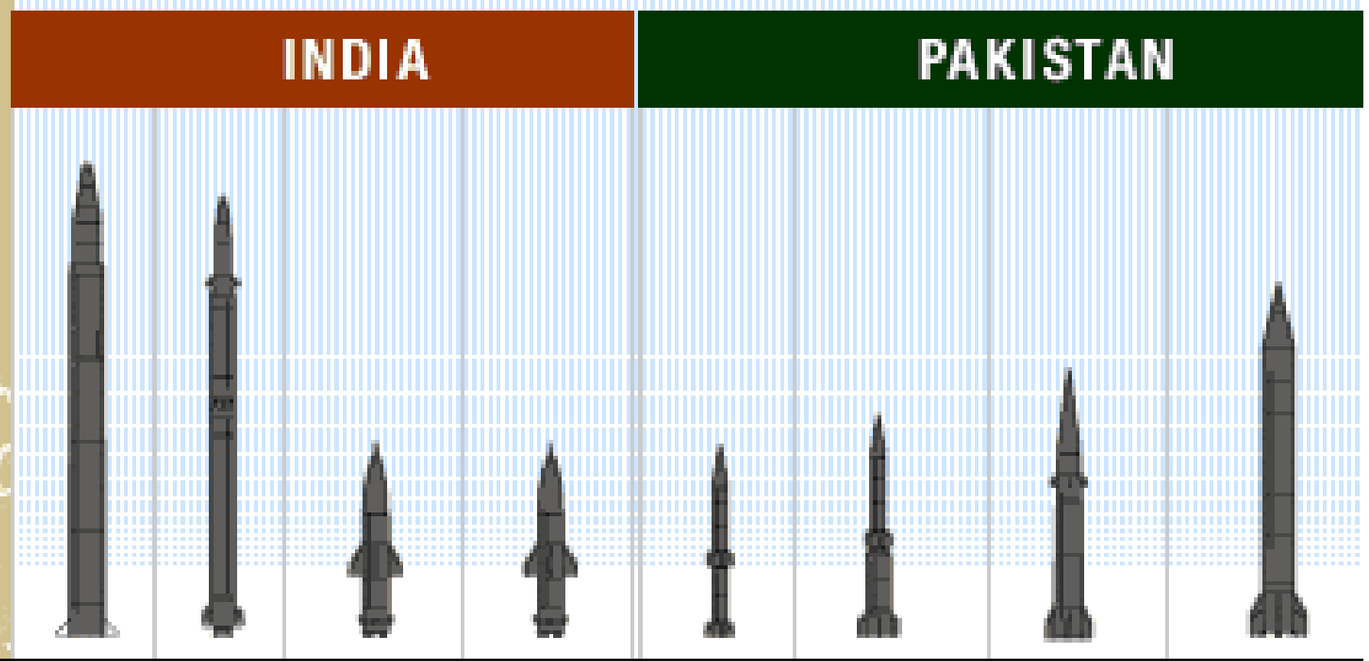
Pakistani Ra’ad Air-Launched Cruise Missile

Pakistani Ra’ad Air Launched Cruise Missile

Summary of India's and Pakistan's Ballistic Missile Systems

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:

SOURCES: Associated Press; Pakistan Armed Forces; Jane's Information Group



Missile name	Agni 1	Agni 2	Prithvi 1	Prithvi 2	Ghauri 1	Shaheen 1	Ghauri 2	Shaheen 2
Length (ft.)	69.3	66	28.2	28.2	28	33	39.6	52.5
Payload* (lbs.)	2,200	2,200	1,760	1,100**	1,100	1,100	2,200	2,640
Range (mi.)	1,560	2,190	94	156	375	940	1,440	1,560
Accuracy (ft.)	495	330	165	248	660	n/a	660	8,250

*Single warhead **up to 1,650 lbs.

Source: CNN (May 2003)

Israel's Nuclear Weapons Complex

Carnegie Endowment for International Peace, *Deadly Arsenals* (2002), 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 ~ 400–700 kg of weapons-grade plutonium
- 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

Strategic forces

	Year deployed	Range (kilometer)	Comment
Aircraft			
F-16A/B/C/D/I Fighting Falcon	1980	1,600	Bombs possibly stored at Tel Nof, Nevatim, Ramon, Ramat-David, and Hatzor
F-15I Ra'am (Thunder)	1998	4,450	Could be used for long-range strike role
Land-based missiles			
Jericho I	1972	1,200	Possibly 50 at Zekharyeh
Jericho II	1984–85	1,800	Possibly 50 at Zekharyeh, on TELs in caves
Sea-based missiles			
Dolphin-class submarines	2002 (?)	?	Modified Harpoon missiles for land-attack

Non-strategic forces

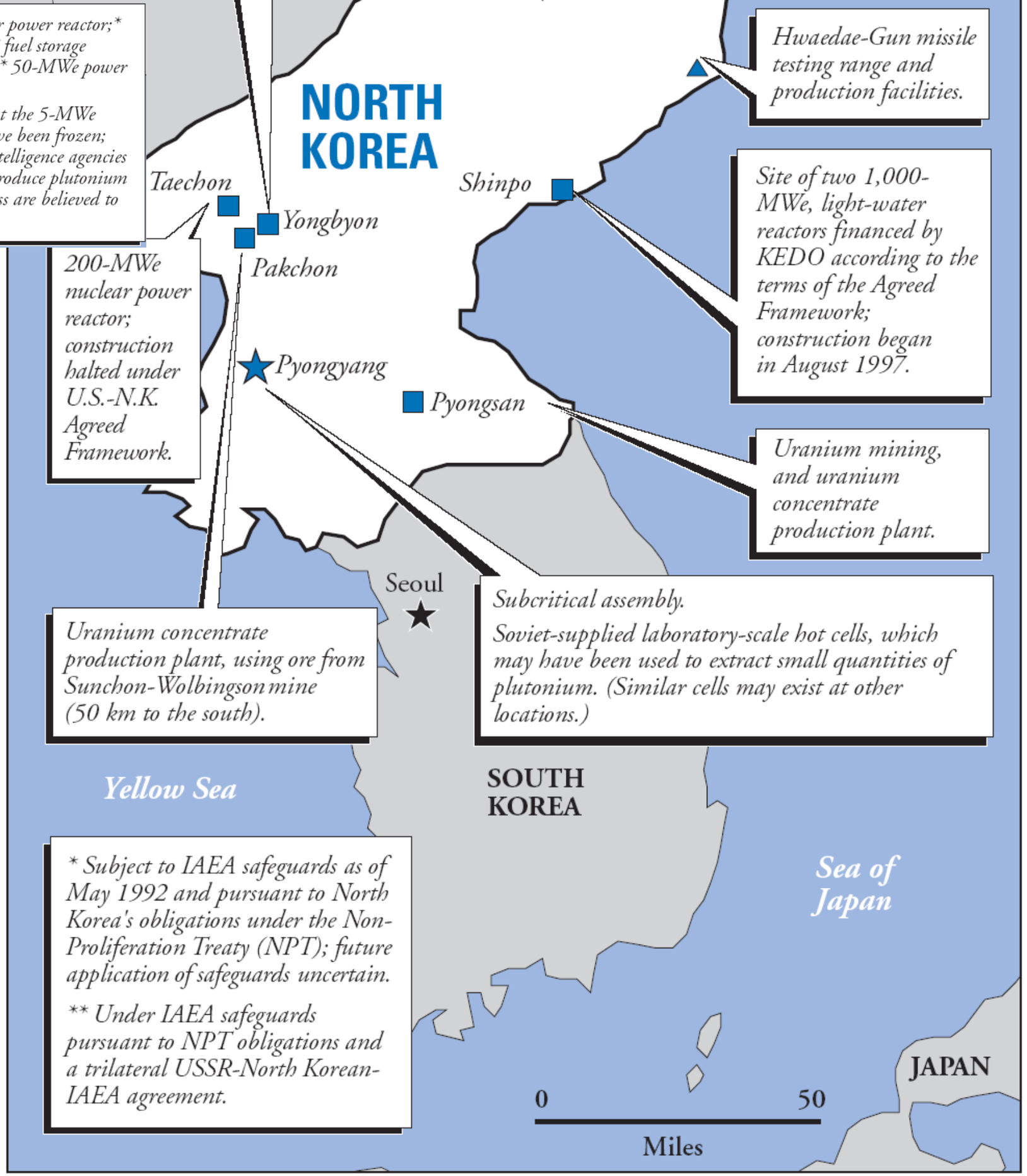
Artillery and landmines	?	?	Reports of these weapons cannot be confirmed

Source: Bulletin of the Atomic Scientists (Sept./Oct. 2002)

Dolphin class submarines, if nuclear armed, provide secure nuclear 2nd strike capability.

Yongbyon Nuclear Research Center *Site of a 5-MWe experimental nuclear power reactor;* a partially completed plutonium extraction facility;* a fuel fabrication plant;* fuel storage facilities;* and a Soviet-supplied IRT research reactor** and critical assembly.** 50-MWe power reactor previously under construction.*

Under the Oct. 21, 1994, U.S.-North Korean Agreed Framework, activities at the 5-MWe gas-graphite reactor, the fuel fabrication facility, and the reprocessing plant have been frozen; construction also has been halted on the 50-MWe gas-graphite reactor. U.S. intelligence agencies believe that North Korea has used the 5-MWe reactor and extraction plant to produce plutonium (possibly enough for 1 or 2 nuclear weapons). Wastes from the extraction process are believed to be stored at two undeclared sites near the center.



* Subject to IAEA safeguards as of May 1992 and pursuant to North Korea's obligations under the Non-Proliferation Treaty (NPT); future application of safeguards uncertain.

** Under IAEA safeguards pursuant to NPT obligations and a trilateral USSR-North Korean-IAEA agreement.

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

Kim’s Nuclear Gambit

Video Presentation:

Kim’s Nuclear Gambit

North Korea's Nuclear Program – 1

History —

- 1950s: NK nuclear research reportedly begins.
- At this time NK was a Soviet Client state and its nuclear engineers were largely trained at Soviet scientific institutes.
- 1965: NK begins operating a small research reactor it received from the USSR.
- 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.

North Korea's Nuclear Program – 2

History (cont'd) —

- 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.

- 1986: NK publicly makes withdrawal of US nuclear weapons from SK a condition of its completion of the safeguard agreement required by the NPT, completes negotiation of the safeguard agreement with the IAEA within 18 months after acceding to the NPT, as the NPT requires.

- 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. (The United States had stationed a large number — sometimes more than 700 — nuclear weapons in SK as part of its alliance with SK and its Cold War strategy of flexible response to a possible attack by the USSR or its allies.)

North Korea's Nuclear Program – 3

History (cont'd) —

- 1989: NK is reported to have shut down its main research and plutonium production reactor for approximately 100 days.
- The US Intelligence Community judges that this was enough time for NK to extract enough nuclear material to build a nuclear device and to refuel the entire reactor
- Neither the US nor any other country takes any direct action in response to this development.
- Instead, the international community presses NK to join the NPT and come into full compliance with its obligations under the NPT and makes this a condition for further progress on diplomatic issues.
- NK is believed to have extracted enough Pu for 1 or 2 nuclear bombs.

North Korea's Nuclear Program – 3

APPROXIMATE FISSILE MATERIAL REQUIREMENTS FOR PURE FISSION NUCLEAR WEAPONS								
	technical capability			Yield	*technical capability*			
	low	*medium*	*high*	(kilotons)	*low*	*medium*	*high*	
weapon-grade plutonium (kilograms)	3	1.5	1	1	8	4	2.5	**highly enriched uranium** (kilograms)
	4	2.5	1.5	5	11	6	3.5	
	5	3	2	10	13	7	4	
	6	3.5	3	20	16	9	5	

Source: NRDC (April 2003)

Physics/Global Studies 280: Session 19

Plan for This Session

RE4v1 will be due Thursday March 29th

RPv1 will be due Thursday April 5th

News and Discussion

Module 6: Nuclear Arsenals (cont'd)

News The New York Times

U.S. Experts Say Why Trump Should Support Iran Deal

By RICK GLADSTONE MARCH 26, 2018

The Iran nuclear accord, assailed by President Trump and his revamped retinue of advisers, received a strong endorsement Monday from a bipartisan group of more than 100 national security veterans, who said the United States gains nothing by scrapping it.

The group, including 50 retired military officers and at least four former American ambassadors to Israel, added its voice to a fractious debate over the accord, which Mr. Trump has called “the worst deal” ever.

In a statement, the group, which calls itself the National Coalition to Prevent an Iranian Nuclear Weapon, enumerated 10 reasons that, in its view, preserving the accord is in the best interests of the United States.

They included the determination by United Nations inspectors that the accord is working; the importance of preserving close relations with major European allies, which all support the accord; and the possibility of reaching a nuclear agreement with North Korea, which might not negotiate if it believes that the United States abrogates international pledges.

News The New York Times

U.S. Experts Say Why Trump Should Support Iran Deal

By RICK GLADSTONE MARCH 26, 2018

"President Trump should maintain the U.S. commitment to the Iran nuclear deal," the signers said in the statement. "Doing so will bring substantial benefits and strengthen America's hand in dealing with North Korea, as well as Iran, and help maintain the reliability of America's word and influence as a world leader. Ditching it would serve no national security purpose."

The signers cover a range of prominent diplomatic and military figures, Democrat and Republican, spanning decades of foreign policy experience. They include Brent Scowcroft, a former national security adviser; Gen. Michael V. Hayden, former director of the National Security Agency and the Central Intelligence Agency; former Senators Richard G. Lugar and Sam Nunn; Adm. Eric T. Olson, former commander of Special Operations Forces; and Adm. William J. Fallon, former commander of the United States Central Command.

Former ambassadors who signed include Ryan C. Crocker, who served in Afghanistan, Iran, Pakistan, Syria, Kuwait and Lebanon; Daniel C. Kurtzer, who served in Israel and Egypt; James B. Cunningham, who served in the United Nations, Israel and Afghanistan; Thomas R. Pickering, a former under secretary of state who served in Israel, Russia, India, El Salvador, Nigeria, Jordan and the United Nations; and William C. Harrop, who served in Israel and as the State Department's inspector general.

News The New York Times

U.S. Experts Say Why Trump Should Support Iran Deal

By RICK GLADSTONE MARCH 26, 2018

The release of their statement came less than two months before an American law requires Mr. Trump to decide whether to restore nuclear-related sanctions on Iran. He has suggested that he will restore them, which would effectively terminate the American pledge to heed the nuclear agreement's provisions.

The 2015 agreement, negotiated under President Barack Obama, curtails Iran's nuclear activities in exchange for eased economic sanctions. It provides for unprecedented international inspections of Iranian facilities to ensure compliance with Iran's repeated vow that it will never develop a nuclear weapon.

Mr. Trump has criticized provisions of the agreement that expire after a number of years, arguing they should be permanent. He also has complained that the accord does not prohibit Iran's ballistic missile activities.

His views have been welcomed by the governments of Israel and Saudi Arabia, which both see Iran as a regional menace, and in Israel's view, an existential threat. Britain, France and Germany, which signed the nuclear accord, agree with Mr. Trump's concern about Iranian missiles, but say that issue should be discussed separately.

News The New York Times

U.S. Experts Say Why Trump Should Support Iran Deal

By RICK GLADSTONE MARCH 26, 2018

Iran has said it will not renegotiate the nuclear agreement.

The prospects that Mr. Trump will terminate American participation rose significantly in the past few weeks, when he dismissed his secretary of state and national security adviser, replacing them with loyalists who are outspoken in their antipathy toward Iran.

Mr. Trump's new choices for secretary of state, the C.I.A. director Mike Pompeo, and for national security adviser, the former ambassador John R. Bolton, have both denounced the nuclear agreement.

Wendy R. Sherman, a former under secretary of state who was the lead American negotiator for the nuclear agreement, said in an Op-Ed essay published in The New York Times on Monday that Mr. Bolton's elevation, in particular, "has only cemented the expectation that the nuclear deal's life expectancy is short."

North Korea's Nuclear Program – 5

History (cont'd) —

- 1992 April 9: NK finally approves its NPT safeguard agreement.
- 1992 May: Inspections to verify the accuracy of NK's initial declaration begin. NK informs the IAEA it conducted a one-time Pu extraction experiment on "damaged" fuel rods removed from the reactor at Yongbyon in 1989 but extracted only 90 grams of Pu (< 1/40 of the amount needed to produce a nuclear device).
- 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
North Korea freezes its operation and construction of nuclear facilities under IAEA supervision.	The United States agrees to provide heavy fuel oil to replace the electrical production potential of the shutdown 5-MW reactor.
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.	The United States agrees to establish an international consortium to construct two modern, light-water reactors in North Korea.
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	International consortium agrees to complete a significant portion of the reactor complex, not including key components.
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.	International consortium to deliver key components for first light-water reactor.
North Korea agrees to complete dismantling of its nuclear facilities and removal of its spent fuel upon delivery of key components for second reactor.	International consortium to deliver key components for second light-water reactor.

North Korea's Nuclear Program – 6

History (cont'd) —

- 1994 October: The US and NK sign the 1994 Agreed Framework. A key goal of the Agreed Framework is for NK to replace its indigenous gas-graphite reactors with imported LWRs, which are good for electrical power generation but less useful for making bomb material.

- 1994 November: The new Republican majority in the US Congress rejects the Agreed Framework and refuses to fund its execution.

- 1994–1998: Execution of the Agreed Framework is plagued with political and technical problems and fails to make much progress.

- 1998 August: NK launches a 3-stage Taepo Dong-1 rocket with a range of 1,500–2,000 km; 3rd stage explodes at ignition.

- 1999 September: NK agrees to a moratorium on testing of long-range missiles as long as arms talks with the US continue.

North Korea's Nuclear Program – 7

History (cont'd) —

- 2000 September: US and NK resume direct talks in New York on nuclear weapons, missiles, and terrorism.
- 2000 October: NK 2nd in command visits Washington, DC, meets President Clinton and US Secretaries of State and Defense.
- 2000 October: US and NK issue Joint Communique:
  - —Neither government has hostile intent toward the other.
  - —Both commit to building a new relationship free from past enmity.
- 2000 October: NK states that it will not further test the Taepo Dong-1 missile. Secretary Albright visits NK. President Clinton announces he will travel to NK.
- 2000 December: Clinton announces he will not leave US to travel to NK during the constitutional crisis created by the Presidential election dispute; time runs out.

North Korea's Nuclear Program – 8

History (cont'd) —

- Secretary of State Colin Powell says President Bush will continue the engagement with NK currently in progress.
- 2001 June: President Bush announces desire for "serious discussions" with NK.
- 2002 January (post 9-11): President Bush labels NK part of "an axis of evil".
- 2002 October: Visiting US official publicly challenges NK, US claims NK has uranium enrichment effort that violates the 1994 Agreed Framework.
- 2002 November: KEDO (Korean Energy Development Organization) consortium suspends fuel oil deliveries to NK, alleging NK has violated the Agreed Framework.

North Korea's Nuclear Program – 9

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 – 10

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 war head, 7-9kT, claimed thermo nuclear device
- 2016 Sep. 9: NK tests fifth nuclear war head, 15-25kT.
- 2017 Sep. 3: NK tests sixth nuclear war head, 70-280kT.

Agreement Aid for Stopping Nuclear Work in February 2012

The New York Times

North Koreans Agree to Freeze Nuclear Work; U.S. to Give Aid

=> 240,000 metric tons of food aid

By STEVEN LEE MYERS and CHOE SANG-HUN

WASHINGTON — North Korea announced on Wednesday that it would suspend its nuclear weapons tests and uranium enrichment and allow international inspectors to monitor activities at its main nuclear complex. The surprise announcement raised the possibility of ending a diplomatic impasse that has allowed the country's nuclear program to continue for years without international oversight.

The Obama administration called the steps "important, if limited." But the announcement seemed to signal that North Korea's new leader, Kim Jong-un, is at least willing to consider a return to negotiations and to engage with the United States, which pledged in exchange to ship tons of food aid to the isolated, impoverished nation.

Impact of Aid

Los Angeles Times

North Korea: What does 240,000 metric tons of food mean?

February 29, 2012 | 1:20 pm

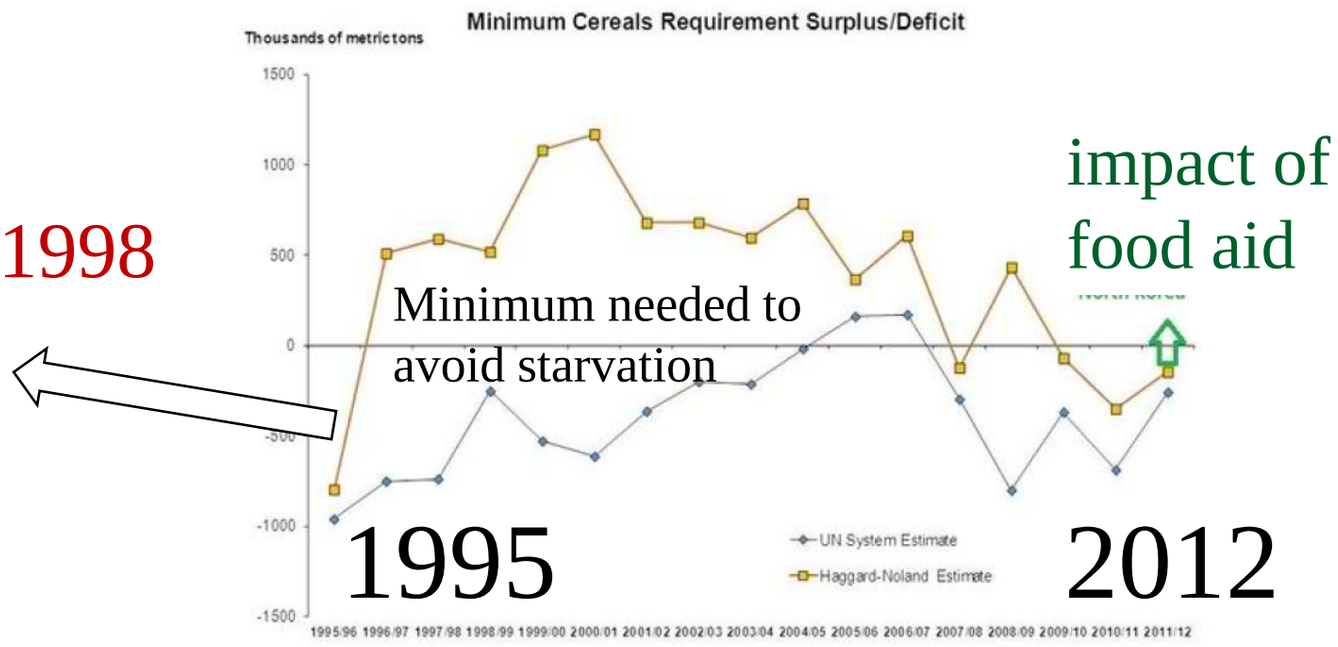
Hunger is a known menace in North Korea: In most of the country, even a bowl of rice is a rare treat. North Korea and the U.S. are poised to stri
would bring 240,000 metric tons of food aid to the impoverished country if it suspends nuclear weapons tests and enrichment.

What would all that food really mean for North Korea? Here's a quick look.

Experts Stephan Haggard and Marcus Noland have estimated that North Korea has been falling below the minimum grain supplies needed for ea
have enough food, as the graph below shows.

The yellow line represents their estimates; the blue line is U.N. estimates, which are somewhat lower. The Times added a green arrow to show h
metric tons of U.S. aid could change that.

Famine in North Korea 1995 – 1998
unknown number of victims
estimates 600,000 – 3,000,000
in a population of 23 million



North Korea's Nuclear Program – 11

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 – 12

- 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 – 13

- 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.

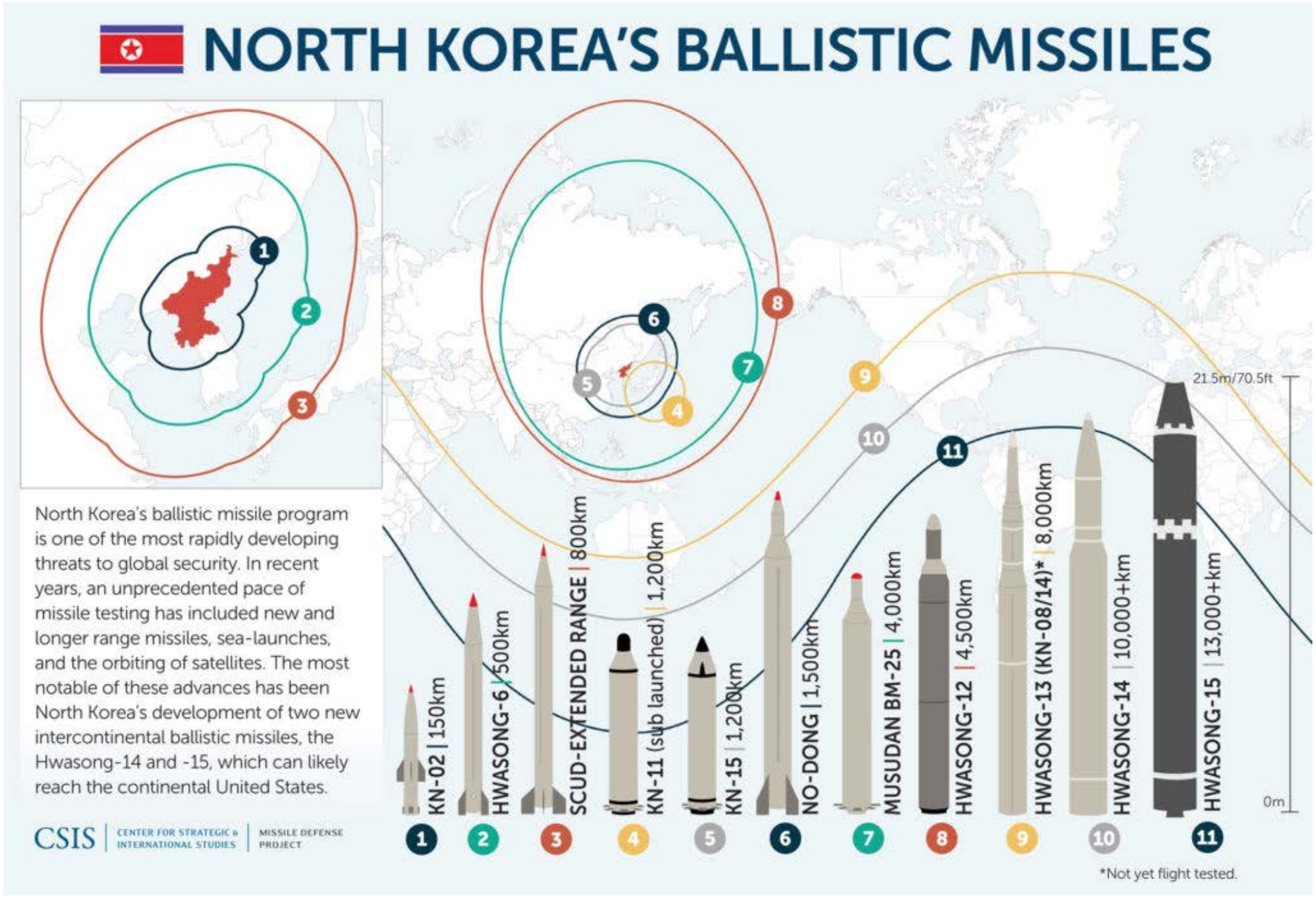
North Korea's Nuclear Program – 14

- 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

North Korea’s Ballistic Missile Capabilities



End of Module 6: Programs and Arsenals