Physics 280: Session 17

Plan for This Session

Student questions

Next session: Midterm Exam (100 MSEB)

Module 6: Nuclear Arsenals

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

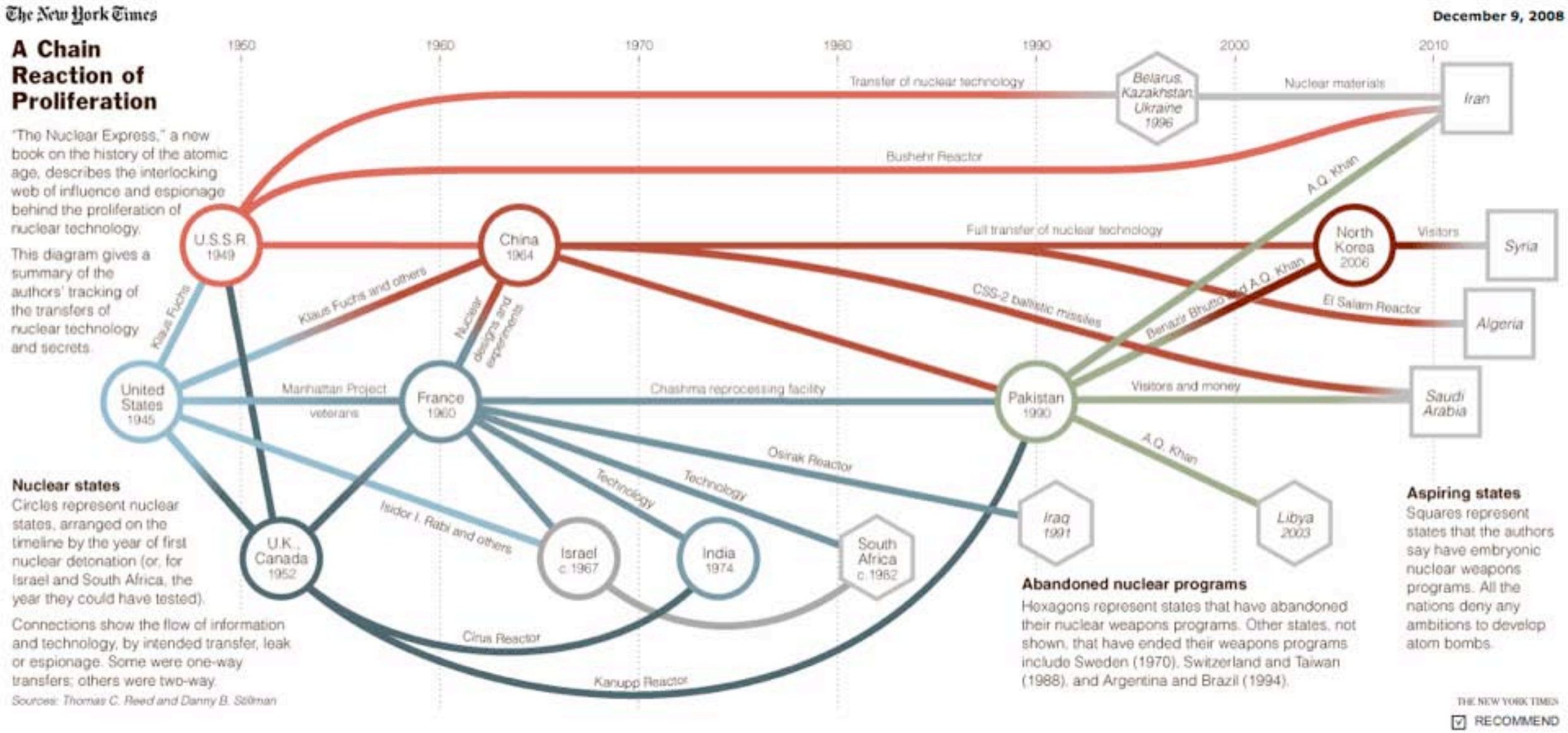
Part 3: Arsenals of non-NPT and Emerging Nuclear-Weapon States:
India, Pakistan, Israel, North Korea, and Iran

Part 4: Threat Perceptions

Module 6: Programs and Arsenals

Part 1: Overview of Programs and Arsenals

Module 6: Nuclear Arsenals and Proliferation

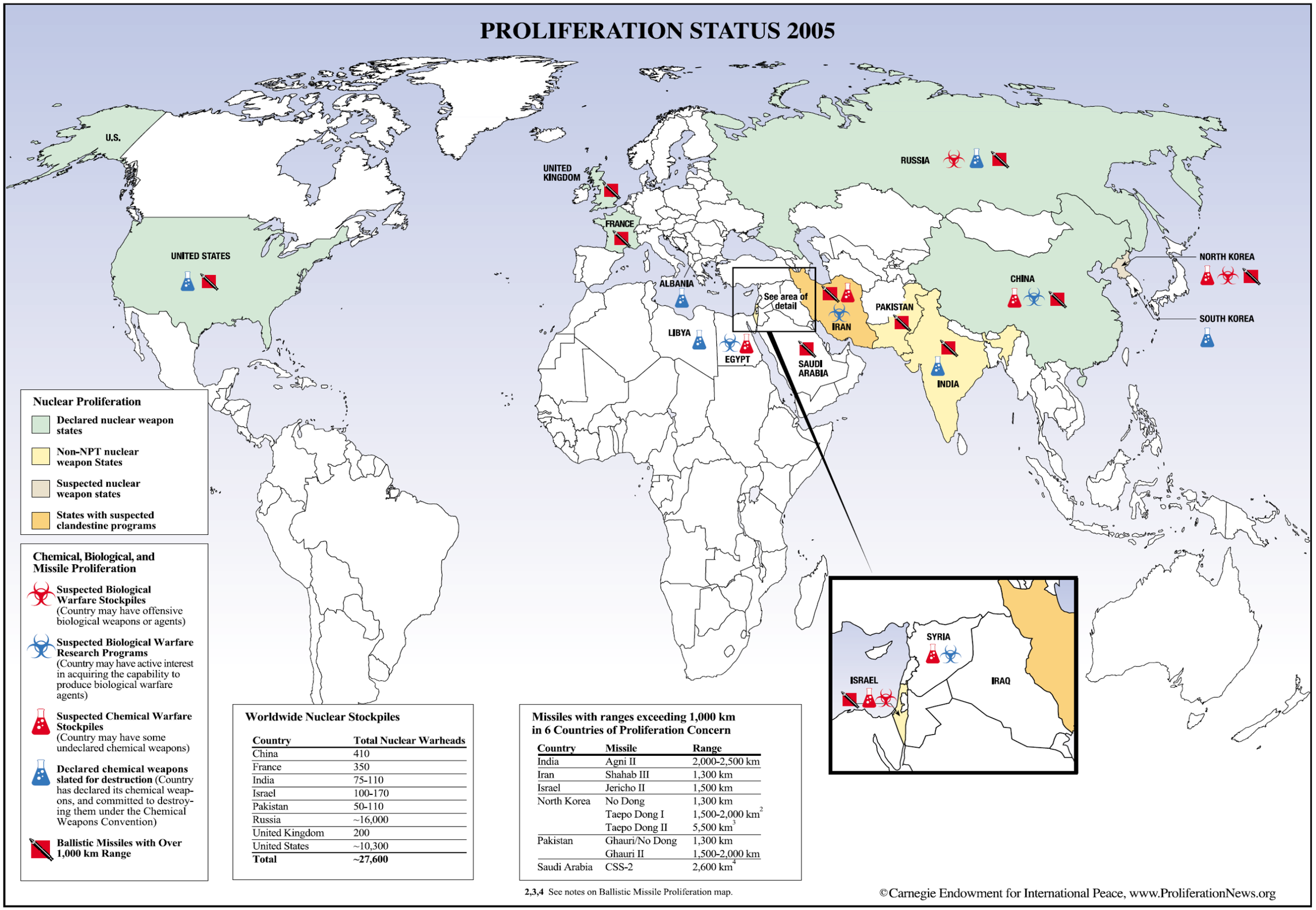


This article has been revised to reflect the following correction:

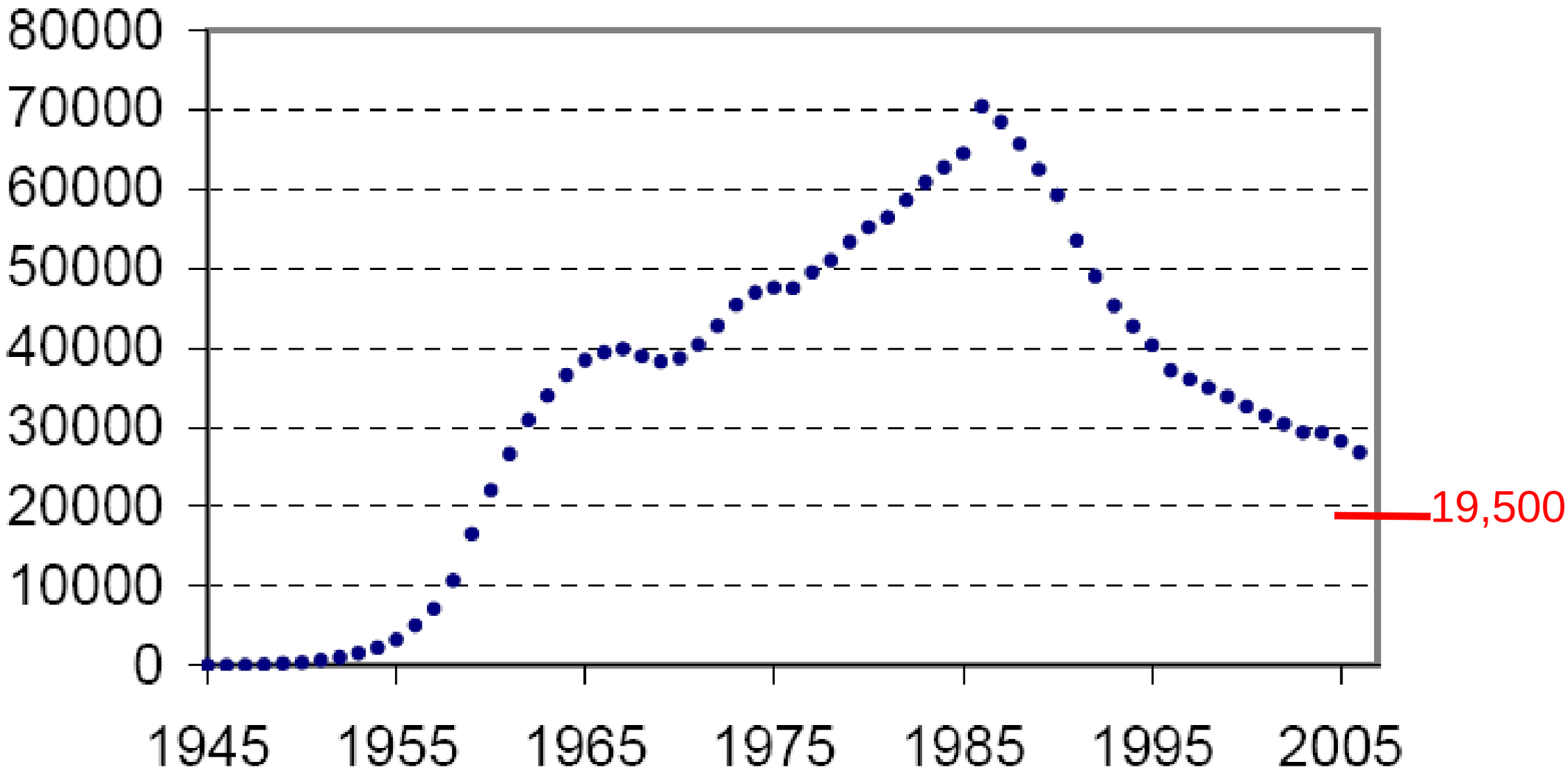
Correction: December 15, 2008

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.

Nuclear Weapons and Proliferation



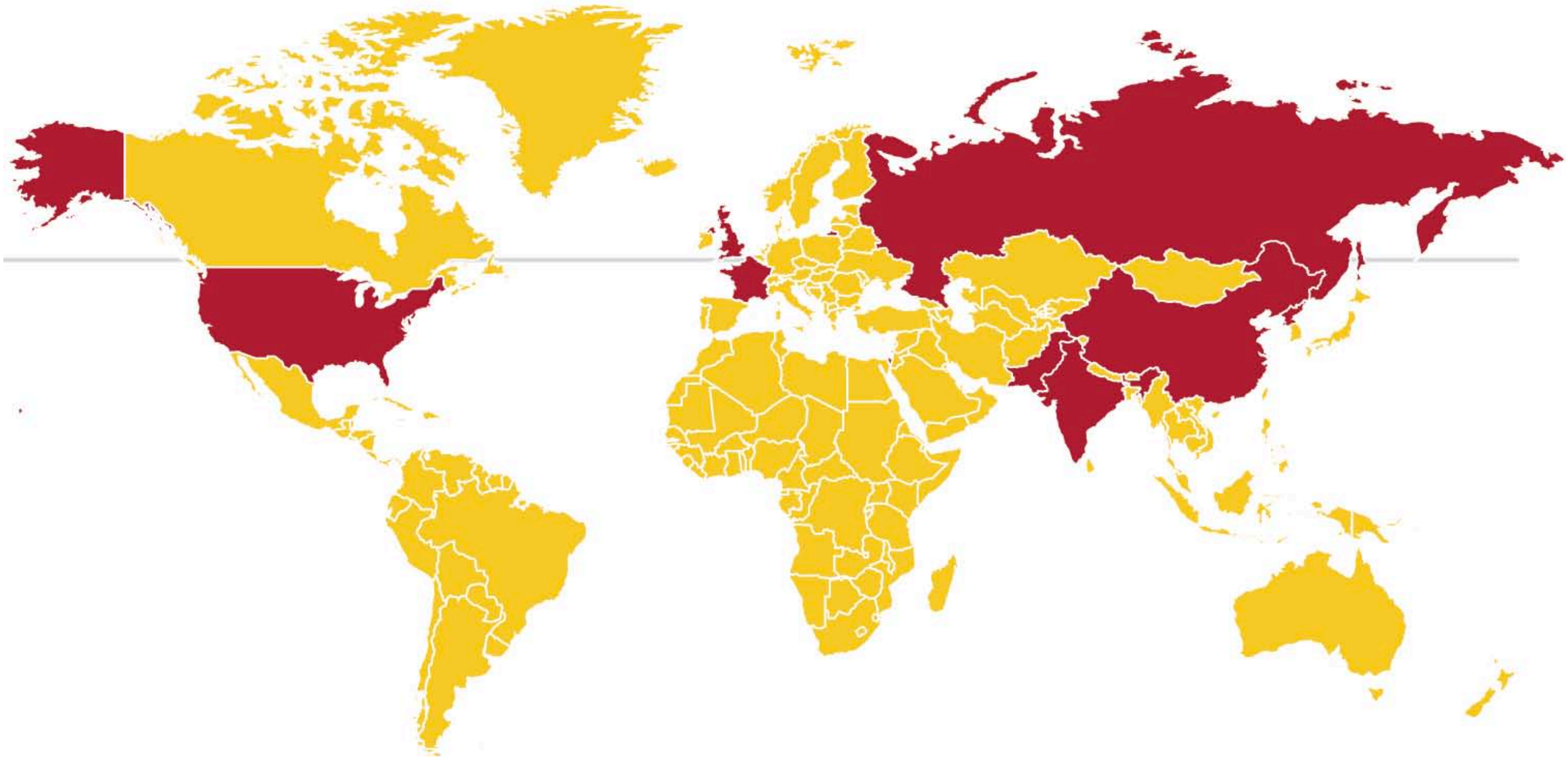
World Nuclear Weapon Stockpiles 1945–2012 (Important)



NRDC, Global nuclear stockpiles, 1945-2006, Bulletin of the Atomic Scientists, Jul-Aug 2006

~ 19,500 total nuclear weapons in 2012

States With Nuclear Weapons in 2012



PLOUGHSHARES FUND ploughshares.org

Global Nuclear Weapon Inventory 2012 (Important)

NPT Nuclear Weapon States (Total Weapons)

China: ~ 240

France: ~ 300

Russia: ~ 10,000

UK: ~ 225

US: ~ 8,500

PLOUGHSHARES FUND ploughshares.org

Global Nuclear Weapon Inventory 2012 (Important)

Non-NPT Nuclear Weapon States (Total Weapons)

Pakistan: ~ 90–110

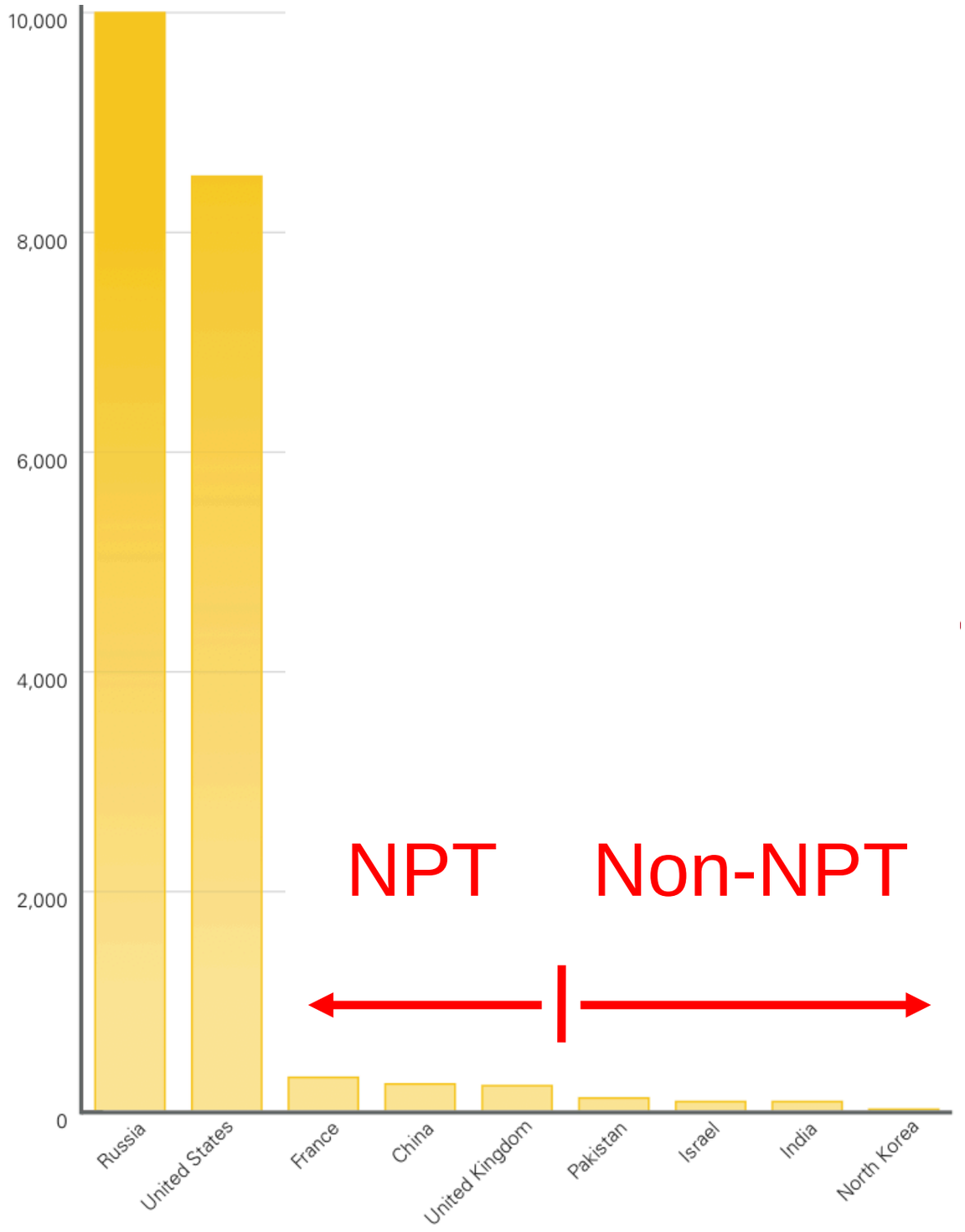
Israel: ~ 60–80

India: ~ 60–80

North Korea: < 10

PLOUGHSHARES FUND ploughshares.org

States With Nuclear Weapons in 2012



Status of World Nuclear Forces 2012

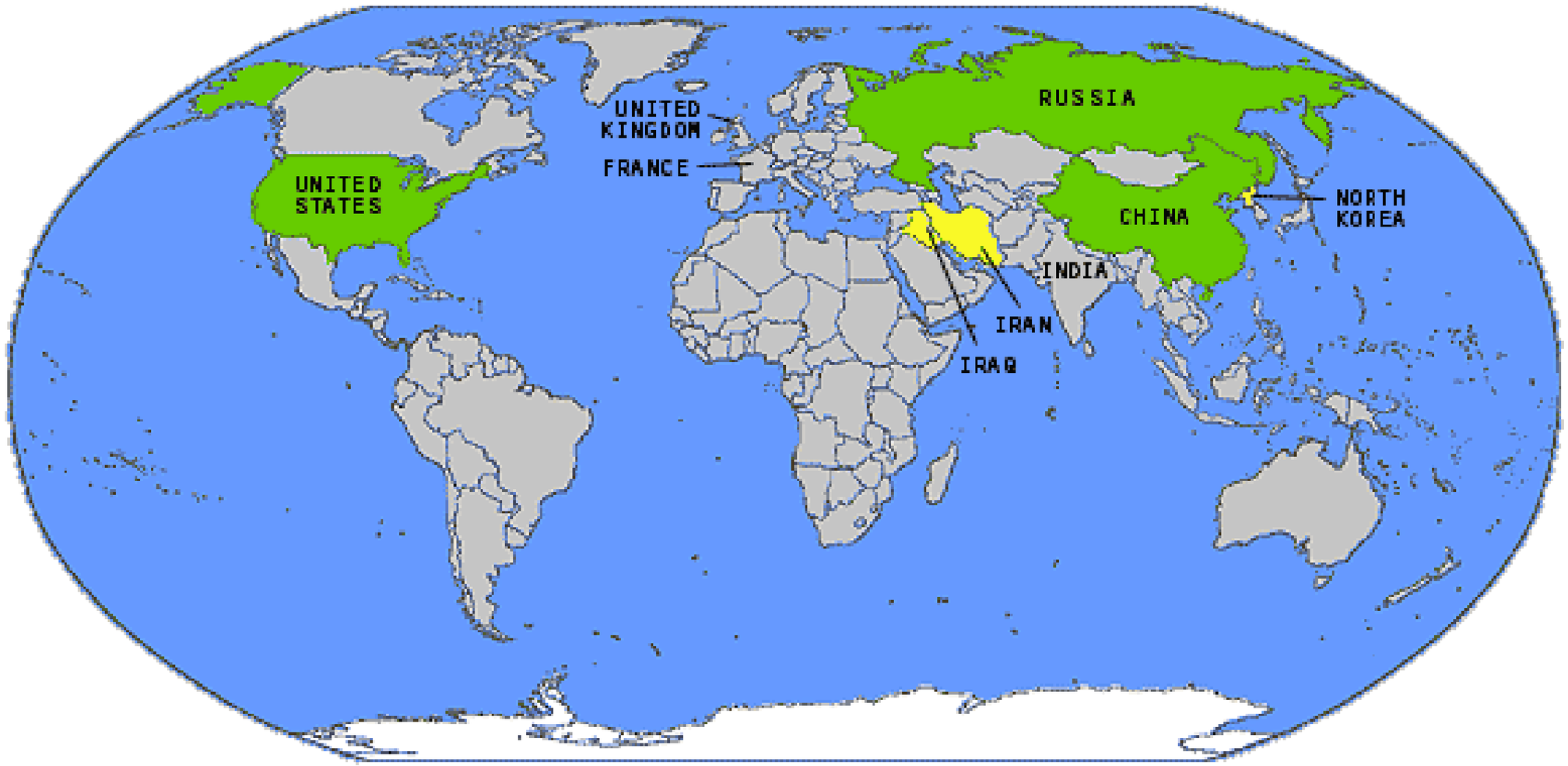
Country	Operational Strategic	Operational Nonstrategic	Reserve/ Nondeployed	Military Stockpile	Total Inventory
Russia	2,430[a]	0[b]	3,000[c]	5,500	10,000[d]
United States	1,950[e]	200[f]	2,850[g]	5,000	8,500[h]
France	290	n.a.	?[i]	300	300
China	0[j]	?[j]	180	240	240[j]
United Kingdom	160[k]	n.a.	65	225	225[k]
Israel	0	n.a.	80	80	80[l]
Pakistan	0	n.a.	90-110	90-110	90-110[m]
India	0	n.a.	80-100	80-100	80-100[n]
North Korea	0	n.a.	<10	<10	<10[o]
Total:[p]	**~4,830**	**~200**	**~6,400**	**~11,500**	**~19,500**

* All numbers are estimates and further described in the Nuclear Notebook in the *Bulletin of the Atomic Scientists*, and the nuclear appendix in the SIPRI Yearbook. Additional reports are published on the FAS Strategic Security Blog. Unlike those publications, this table is updated continuously as new information becomes available. Current update: **March 6, 2012**.

http://www.fas.org/programs/ssp/nukes/nuclearweapons/nukestatus.html

Overview of Programs and Arsenals

Map of ICBM Threats (2001 NIC Assessment)



Ballistic Missiles and Missile Programs

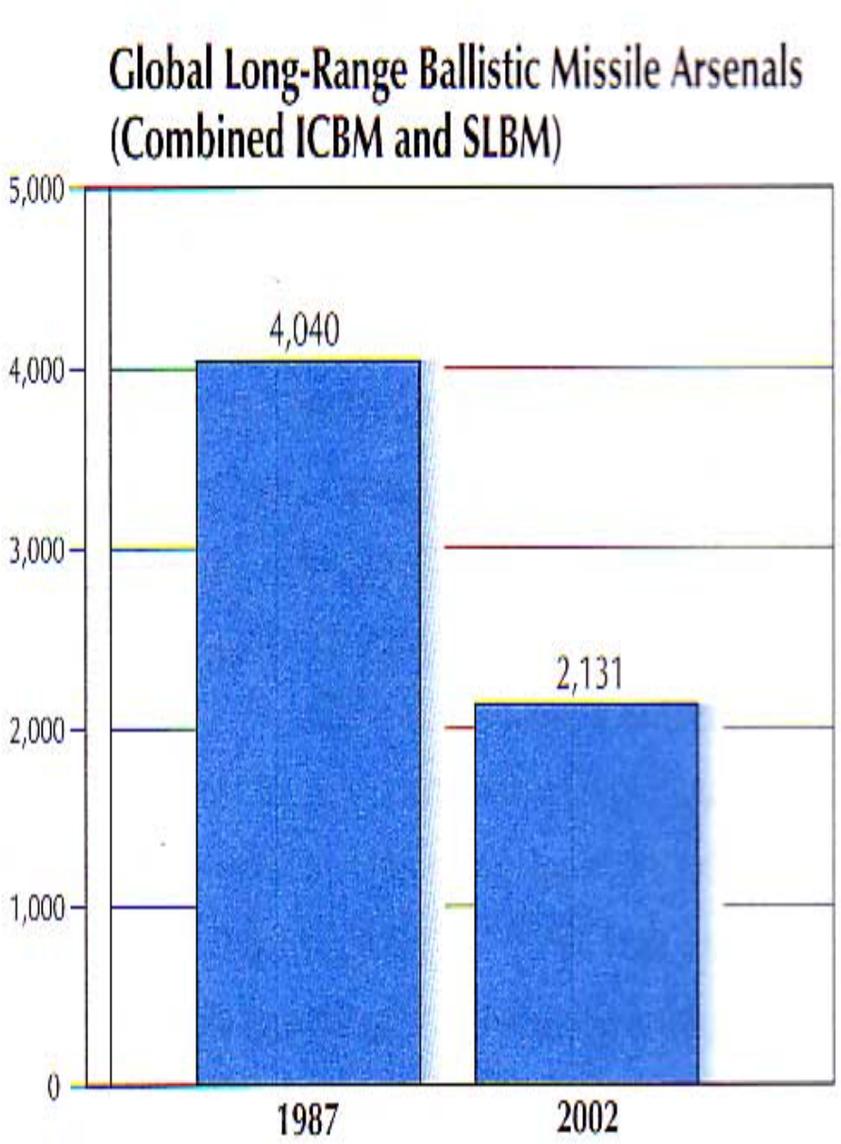
Afghanistan
Argentina
Armenia
Azerbaijan
Bahrein
Belarus
Bulgaria
Egypt
Georgia
Greece
Iraq
Kazakhstan
Kongo
Libya
Slovakia
South Korea
Syria
Taiwan
Turkey
Turkmenistan
U.Arab.Emir.
Ukraine
Vietnam
Yemen

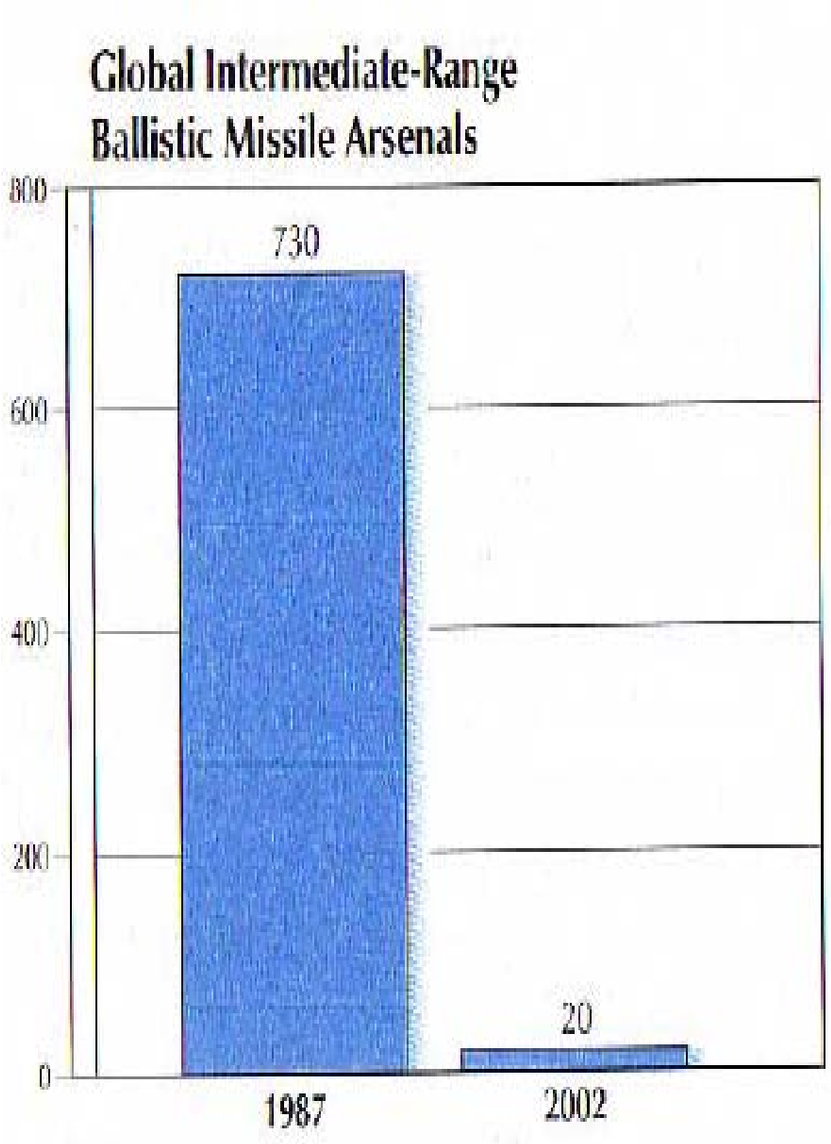
Country	Missile	Range
India	Agni II	2.000 km
Iran	Shahab III	1.300 km
Israel	Jericho III	1.500 km
North Korea	No Dong	1.300 km
	Taepo Ding I	2.000 km
	Taepo Dong II	5.500 km
Pakistan	Ghauri I/No Dong	1.300 km
	Ghauri II	2.000 km
Saudi Arabia	CSS-2	2.600 km

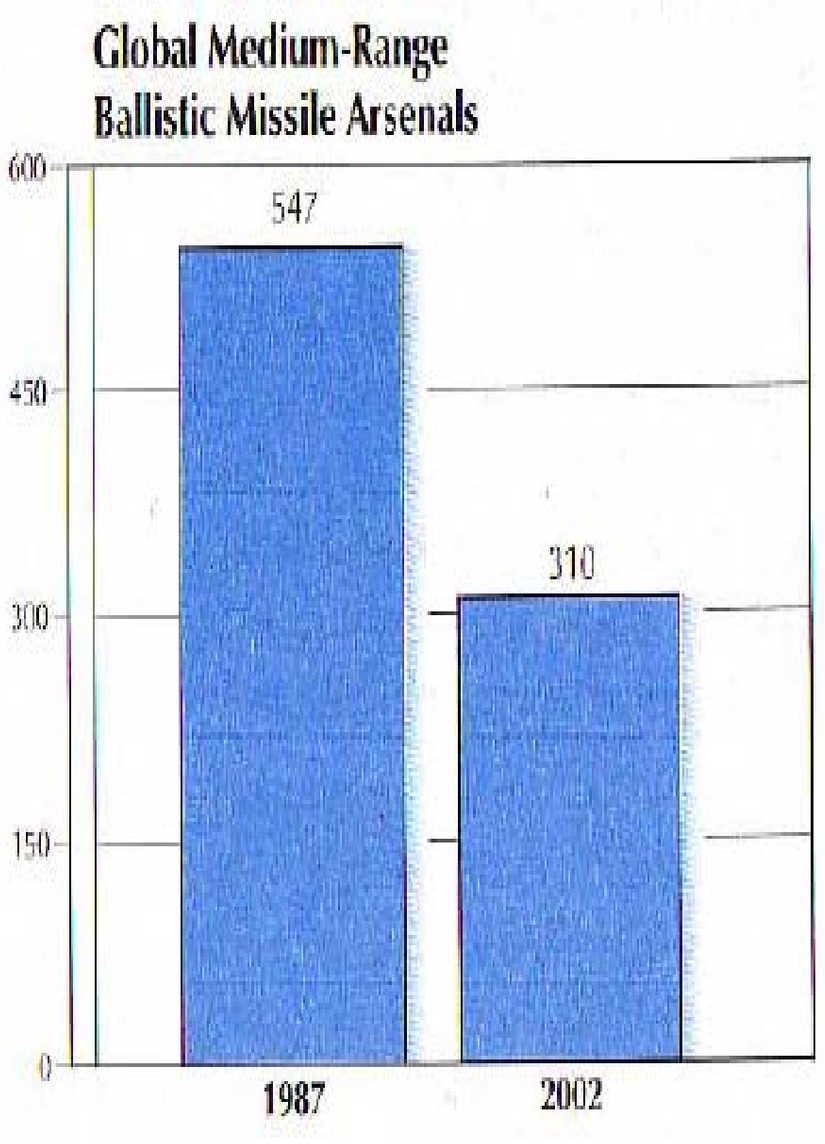
Country	Missile	Range
China	DF-4	13.000 km
France	M45 SLBM	6.000 km
	M4 SLBM	6.000 km
U.K.	Trident II/D-5 SLBM	7.400 km
Russia	SS-18	11.000 km
	SS-19	10.000 km
	SS-24	10.000 km
	SS-25	10.500 km
	SS-27	10.500 km
	SS-N-18 SLBM	6.500/8.000 km
	SS-N-20 SLBM	8.300 km
	SS-N-23 SLBM	8.300 km
USA	Minuteman II	9.650 km
	MX Peacekeeper	9.650 km
	Trident I/C-4 SLBM	7.400 km
	Trident I/D-5 SLBM	7.400 km

100 km 550 km **Range**

Reductions in Ballistic Missile Numbers 1987–2002







Cirincione, Deadly Arsenals, 2002.

Non-U.S. Nuclear Cruise Missiles 2009

Maximum System	Launch Mode	Warhead Type	Range (miles)	IOC
CHINA				
YJ-63	Air	Conventional	Undetermined	Undetermined
DH-10	Undetermined	Conventional or nuclear	Undetermined	Undetermined
PAKISTAN				
RA'AD	Air	Conventional or Nuclear	200	Undetermined
Babur	Ground	Conventional or Nuclear	200	Undetermined
RUSSIA				
AS-4	Air	Conventional or nuclear	185+	Operational
AS-15	Air	Nuclear	1,500+	Operational
SS-N-21	Submarine	Nuclear	1,500+	Operational

COUNTRY	TYPE*	RANGE (KILOMETERS)	YEAR DEPLOYED	STATUS AS OF 1987	STATUS AS OF 2007
United States	Advanced cruise missile (AGM-129A)	> 2,500	1990	in production	deployed
	Air-launched cruise missile (AGM-86B)	2,500	1986	deployed	deployed
	Enhanced cruise missile	—	—	not deployed	not deployed
	Ground-launched cruise missile (BGM-109)	2,500	1983	deployed	not deployed
	Sea-launched cruise missile (BGM-109A)	2,500	1984	deployed	deployed

Sources: 2009 NASIC Report,
Arms Control Association

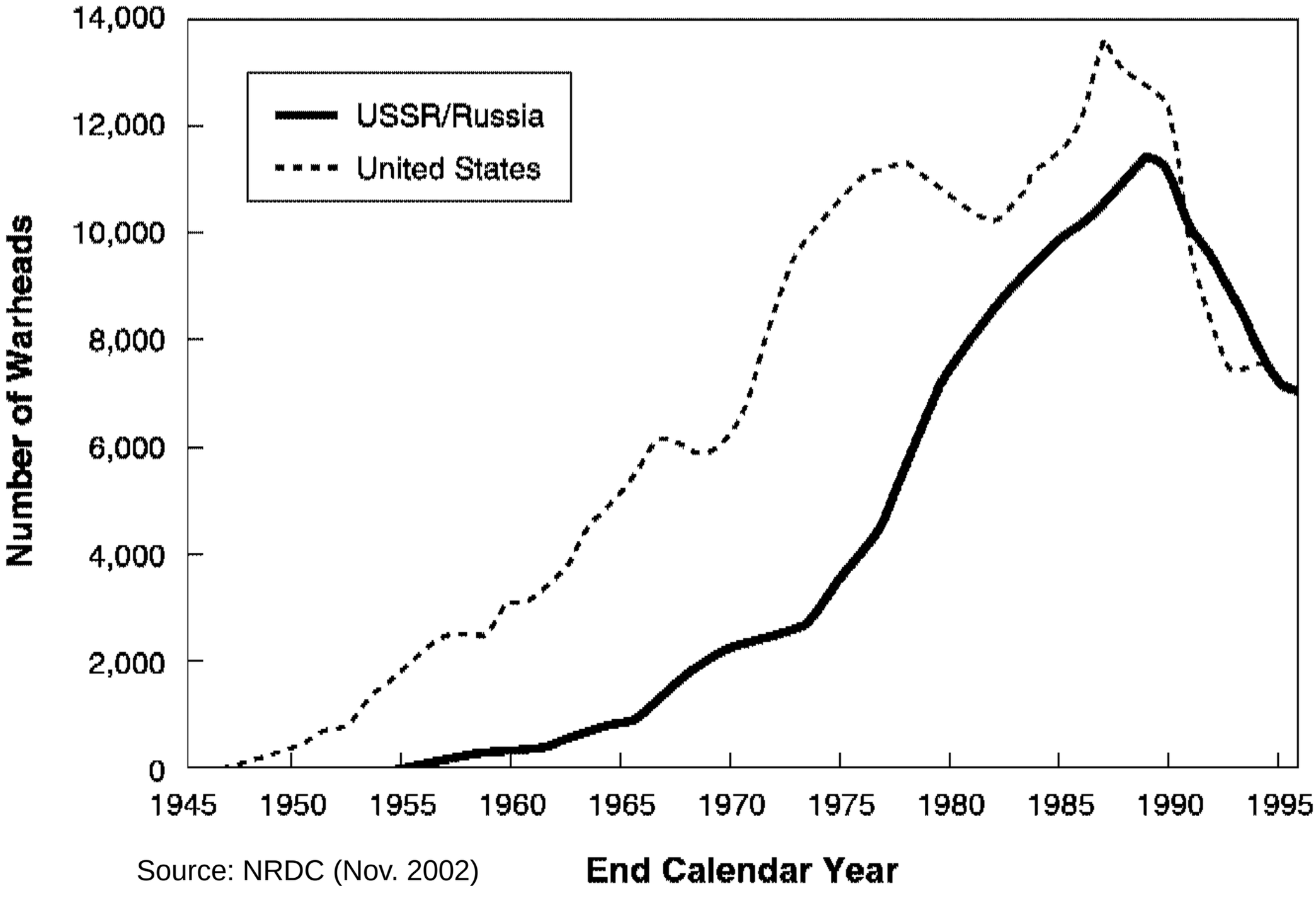
Pakistani Ra’ad Air-Launched Cruise Missile

Pakistani Ra’ad Air Launched Cruise Missile

Part 2: Arsenals of the NPT Nuclear-Weapon States

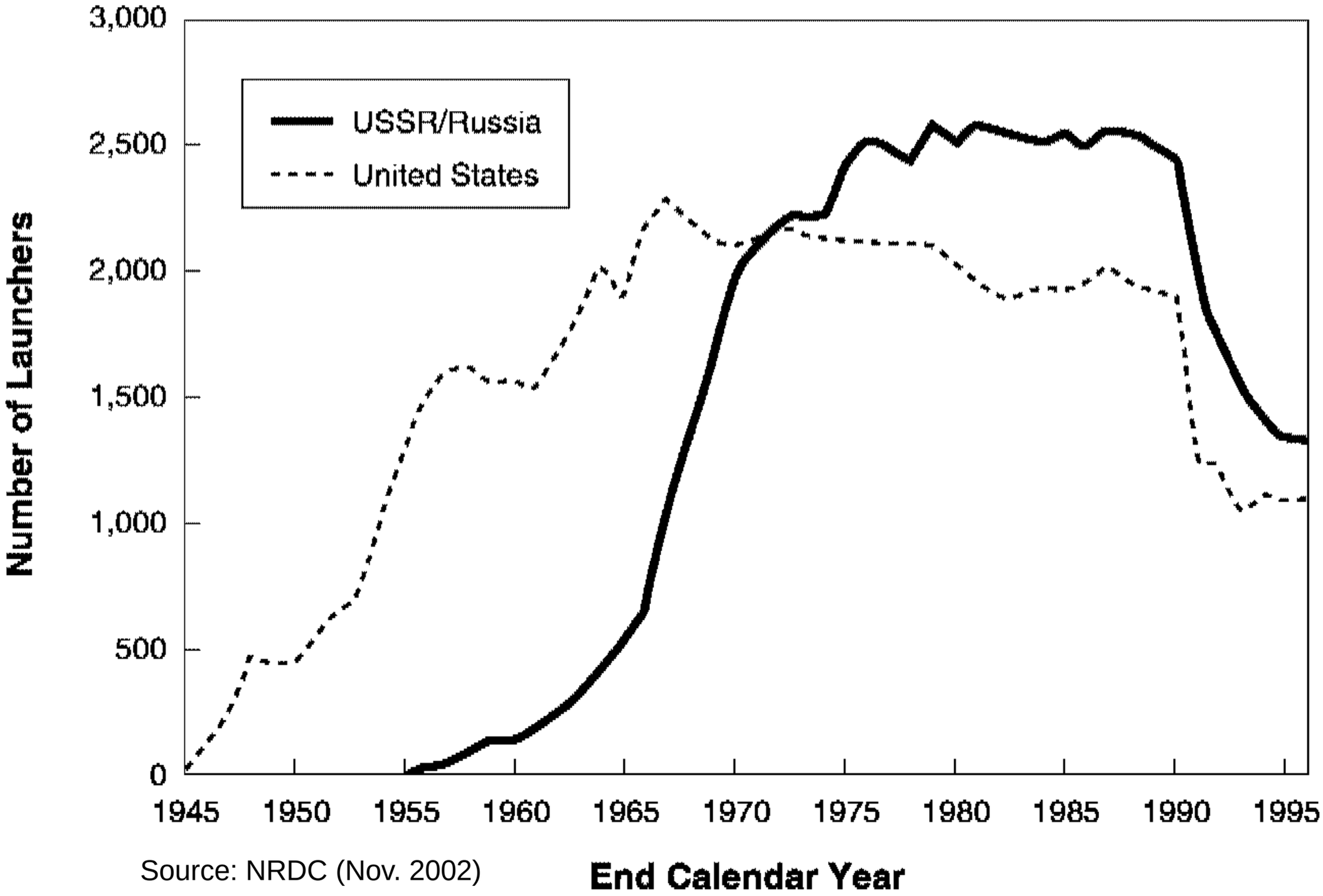
The United States, Russia, the United Kingdom, France, and China

Evolution of US and SU-Russian Nuclear Warhead Numbers



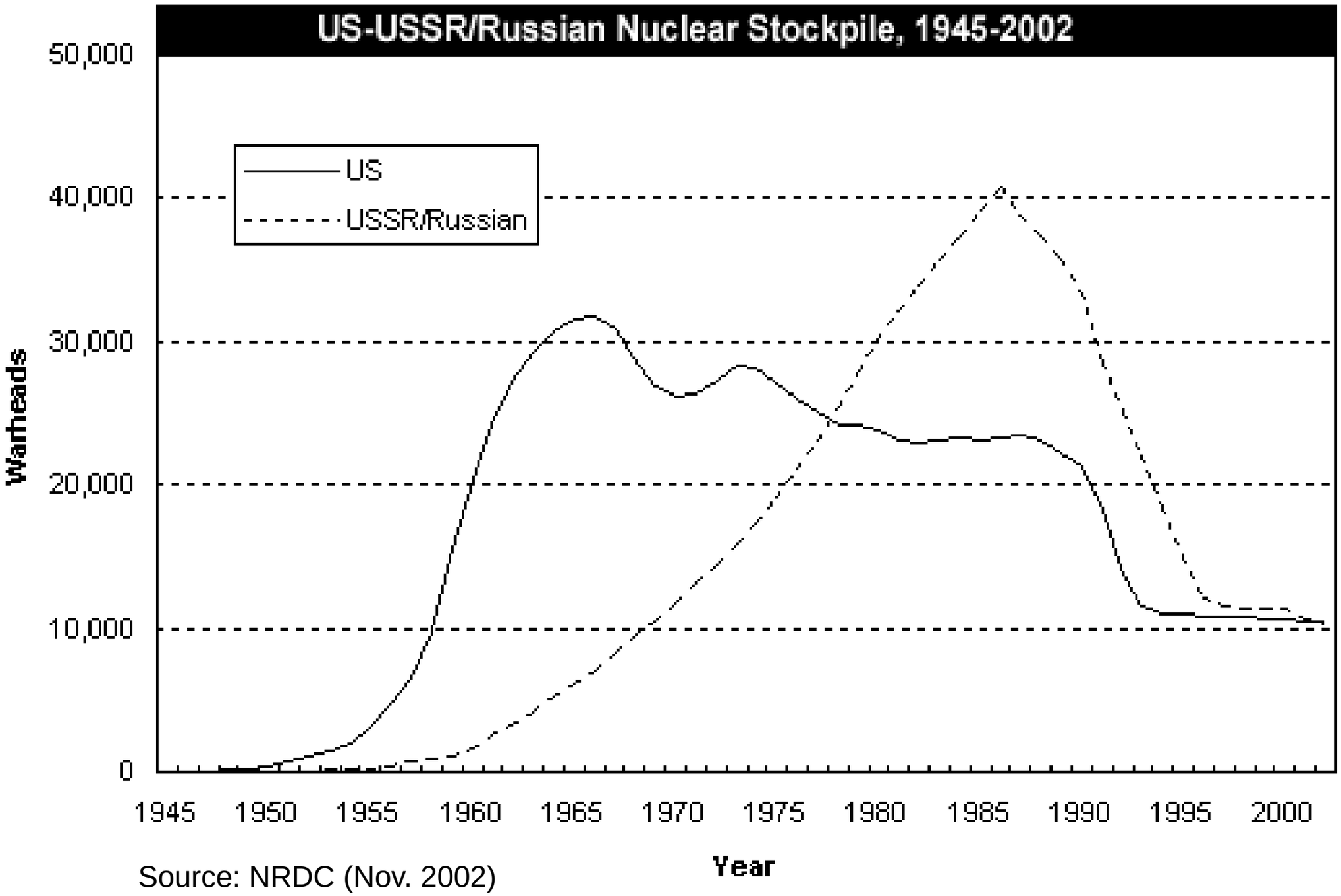
Source: NRDC (Nov. 2002)

Evolution of US and SU-Russian Nuclear Launcher Numbers



Source: NRDC (Nov. 2002)

Evolution of US and SU-Russian Nuclear Stockpiles



Source: NRDC (Nov. 2002)

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

- The U.S. is thought to have 150 – 240 “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.

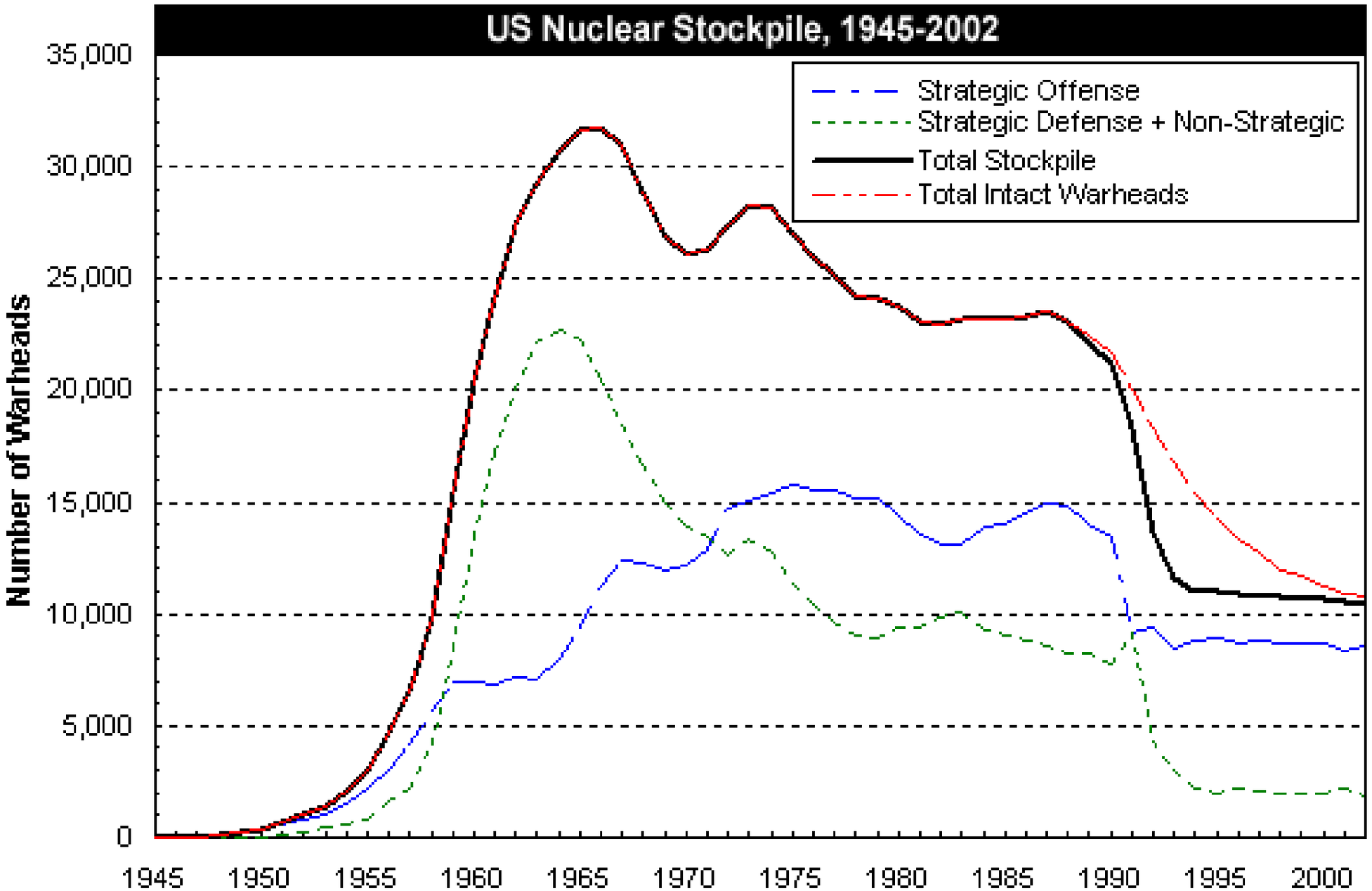
Tactical Nuclear Weapons in Europe

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 Warhead Numbers



Source: NRDC (Nov. 2002)

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**

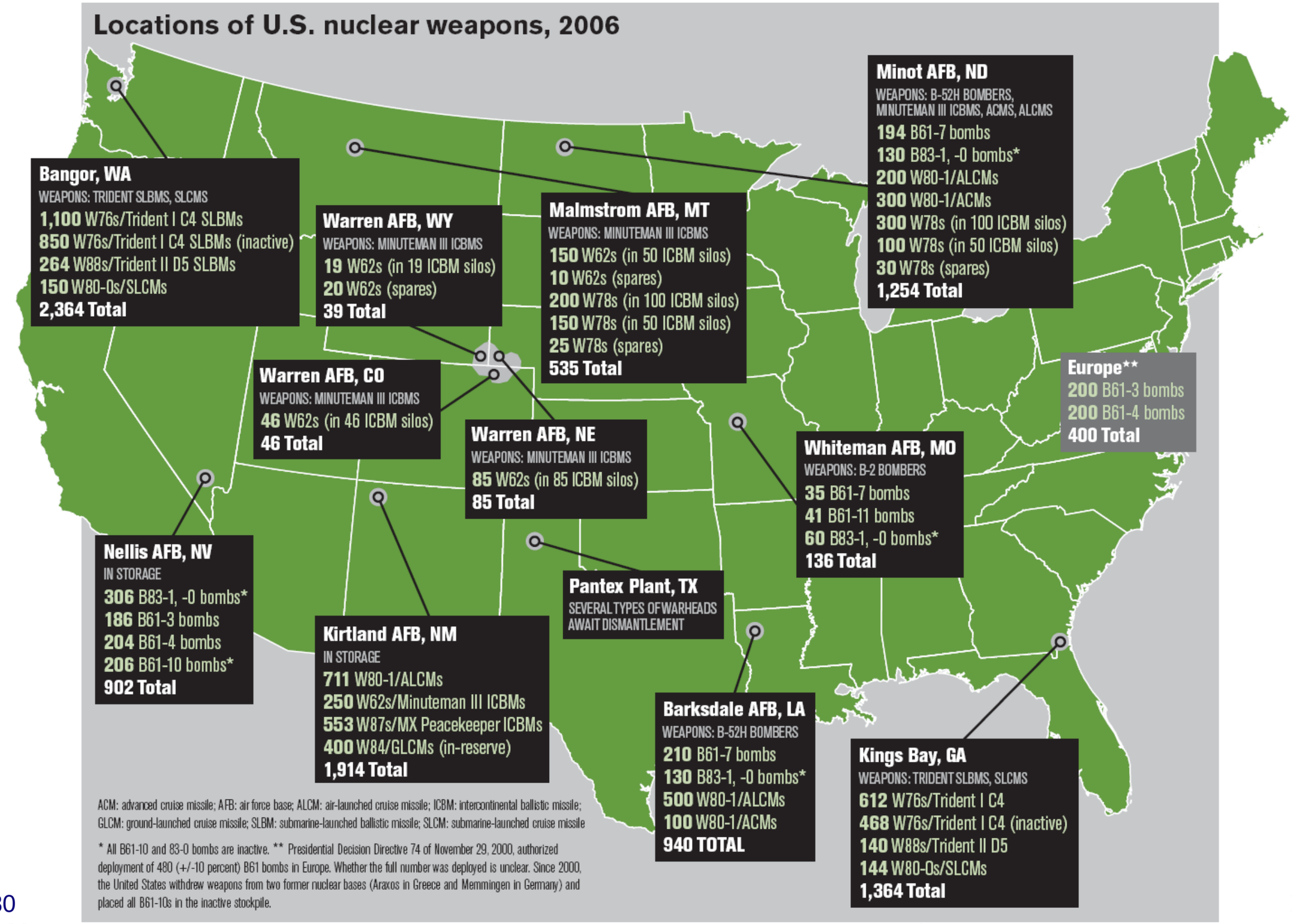
Source: NRDC

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

Discussing his approach to nuclear security the day before formally releasing his new strategy, Mr. Obama described his policy as part of a broader effort to edge the world toward making nuclear weapons obsolete, and to create incentives for countries to give up any nuclear ambitions. To set an example, the new strategy renounces the development of any new nuclear weapons, overruling the initial position of his own defense secretary.

Mr. Obama's strategy is a sharp shift from those of his predecessors and seeks to revamp the nation's nuclear posture for a new age in which rogue states and terrorist organizations are greater threats than traditional powers like Russia and China.

2010 U.S. Nuclear Posture Review

It eliminates much of the ambiguity that has deliberately existed in American nuclear policy since the opening days of the cold war. For the first time, the United States is explicitly committing not to use nuclear weapons against nonnuclear states that are in compliance with the Nuclear Nonproliferation Treaty, even if they attacked the United States with biological or chemical weapons or launched a crippling cyberattack.

Those threats, Mr. Obama argued, could be deterred with "a series of graded options," a combination of old and new conventional weapons. "I'm going to preserve all the tools that are necessary in order to make sure that the American people are safe and secure," he said in the interview in the Oval Office.

2010 U.S. Nuclear Posture Review

The release of the new strategy, known as the Nuclear Posture Review, opens an intensive nine days of nuclear diplomacy geared toward reducing weapons. Mr. Obama plans to fly to Prague to sign a new arms-control agreement with Russia on Thursday and then next week will host 47 world leaders in Washington for a summit meeting on nuclear security.

The strategy to be released on Tuesday is months late, partly because Mr. Obama had to adjudicate among advisers who feared he was not changing American policy significantly enough, and those who feared that anything too precipitous could embolden potential adversaries. One senior official said that the new strategy was the product of 150 meetings, including 30 convened by the White House National Security Council, and that even then Mr. Obama had to step in to order rewrites.

2010 U.S. Nuclear Posture Review

He ended up with a document that differed considerably from the one President George W. Bush published in early 2002, just three months after the Sept. 11 attacks. Mr. Bush, too, argued for a post-cold-war rethinking of nuclear deterrence, reducing American reliance on those weapons.

But Mr. Bush's document also reserved the right to use nuclear weapons "to deter a wide range of threats," including banned chemical and biological weapons and large-scale conventional attacks. Mr. Obama's strategy abandons that option — except if the attack is by a nuclear state, or a nonsignatory or violator of the nonproliferation treaty.

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.

In 2011, the United States Planned to Greatly Increase its Spending on Nuclear Weapons

ARMS CONTROL ASSOCIATION

The authoritative source on arms control

Funding for U.S. Nuclear Triad Set to Grow

Tom Z. Collina

President Barack Obama last month sent Congress a budget request for fiscal year 2012 that would significantly increase funding for maintenance of the nuclear stockpile, modernization of the weapons production complex, upgrades to strategic delivery systems, and deployment of ballistic missile interceptors.

All told, these commitments, which were key to winning Department of Defense and Senate support for the New Strategic Arms Reduction Treaty (New START), would add up to almost $300 billion over the next decade. The budget documents add specifics to the earlier commitments.

In 2012, the United States Plans to Increase its Spending on Nuclear Weapons

FY13. The total request for the National Nuclear Security Administration (NNSA), the quasi-independent unit within DOE that manages the US nuclear weapons program, is $11.536 billion, a 5% increase over FY12 enacted.

Even with NCTIR (Nuclear Counterterrorism and Incident Response) classified as a nonproliferation project, the request for weapons activities is $4.6 billion (170%) higher than the request for nonproliferation funds.

Due both to fiscal constraints imposed by the Budget Control Act (BCA) and proposals under development by the Pentagon, the future shape and size of the U.S. nuclear deterrent is unclear.

iClicker Question

About when did the total worldwide nuclear arsenal peak?

1955

1965

1975

1985

1995

Blank

iClicker Answer

About when did the total worldwide nuclear arsenal peak?

1955

1965

1975

1985

1995

iClicker Question

About how many nuclear weapons were there at the peak?

10,000

30,000

50,000

70,000

90,000

Blank

iClicker Answer

About how many nuclear weapons were there at the peak?

10,000

30,000

50,000

70,000

90,000

iClicker Answer

About how many nuclear weapons are in the global inventory today?

5,500

8,500

13,500

16,500

19,500

Blank

iClicker Answer

About how many nuclear weapons are in the global inventory today?

5,500

8,500

13,500

16,500

19,500

iClicker Answer

About how many nuclear weapons does China now have *in total*?

50

100

250

3,000

5,000

Blank

iClicker Answer

About how many nuclear weapons does China now have *in total*?

50

100

250

3,000

5,000

iClicker Question

About how many nuclear weapons does France now have *in total*?

50

100

300

1,000

5,000

Blank

iClicker Question

About how many nuclear weapons does France now have *in total*?

50

100

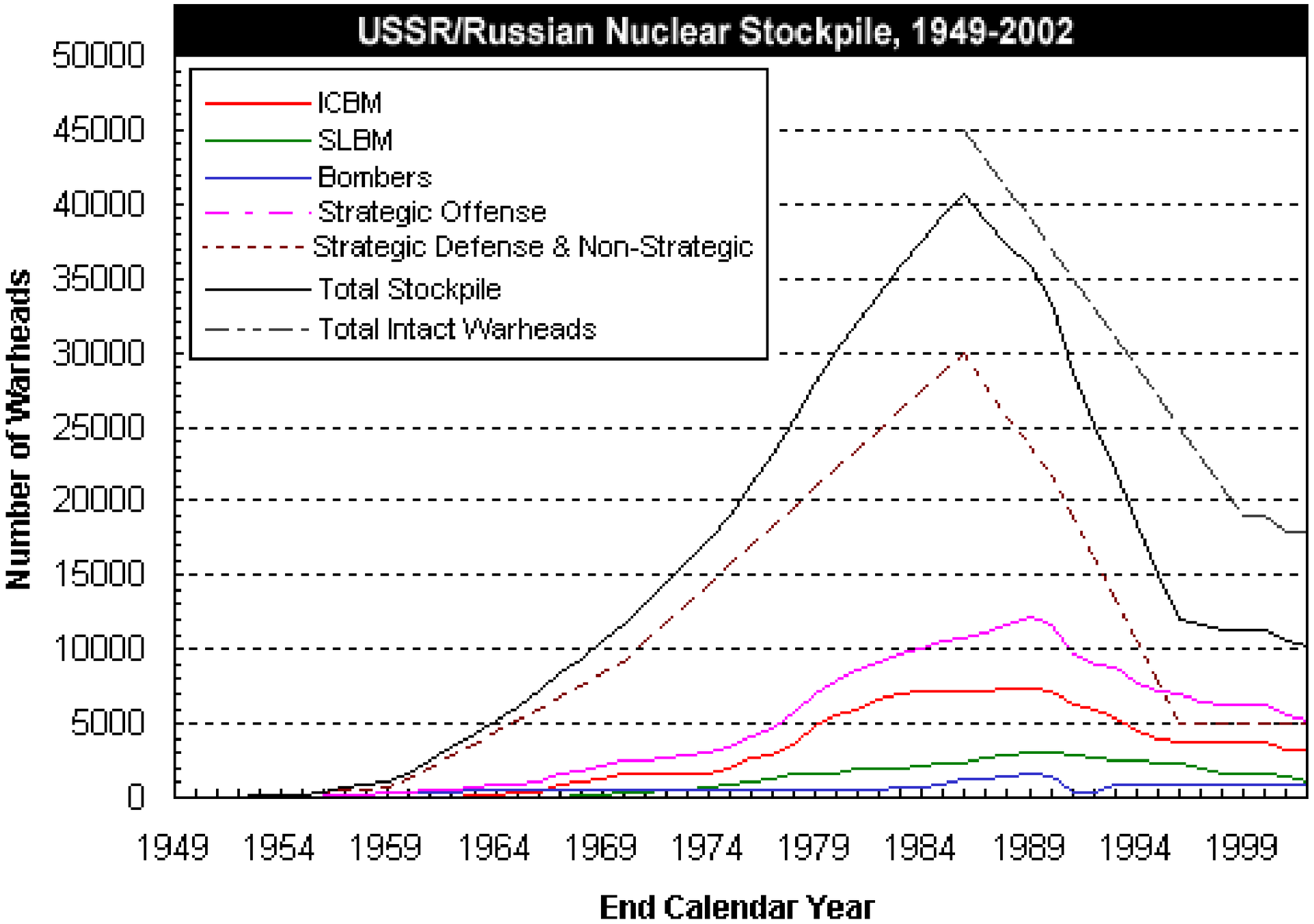
300

1,000

5,000

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.

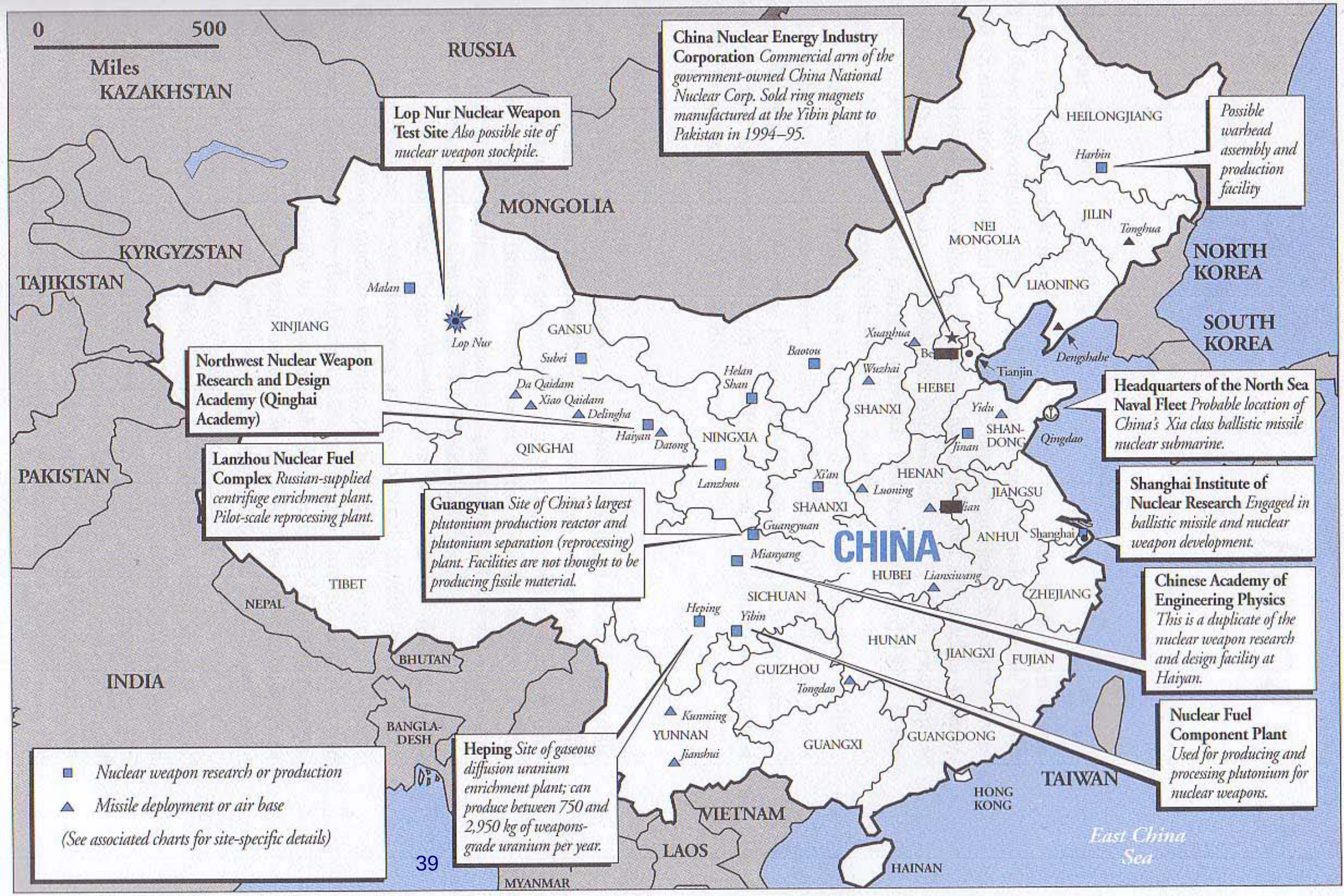
ABM: Antiballistic missile
ALCM: Air-launched cruise missile
ASM: Air-to-surface missile
ASW: Antisubmarine weapon
DB: Depth bomb
ICBM: Intercontinental ballistic missile
MIRV: Multiple independently targetable reentry vehicle
SAM: Surface-to-air missile
SLBM: Submarine-launched ballistic missile
SLCM: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

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

SUBMARINE-LAUNCHED BALLISTIC MISSILES

TYPE	NATO DESIGNATION	NO.	YEAR DEPLOYED	WARHEADS x YIELD (KILOTONS)	RANGE (KILOMETERS)	WARHEADS
JL-1*	CSS-NX-3	0	1986	1,000+	1 x 200–300	0
JL-2	CSS-NX-4	0	2009–10?	7,200+	1 x 200–300 ?	0

AIRCRAFT **

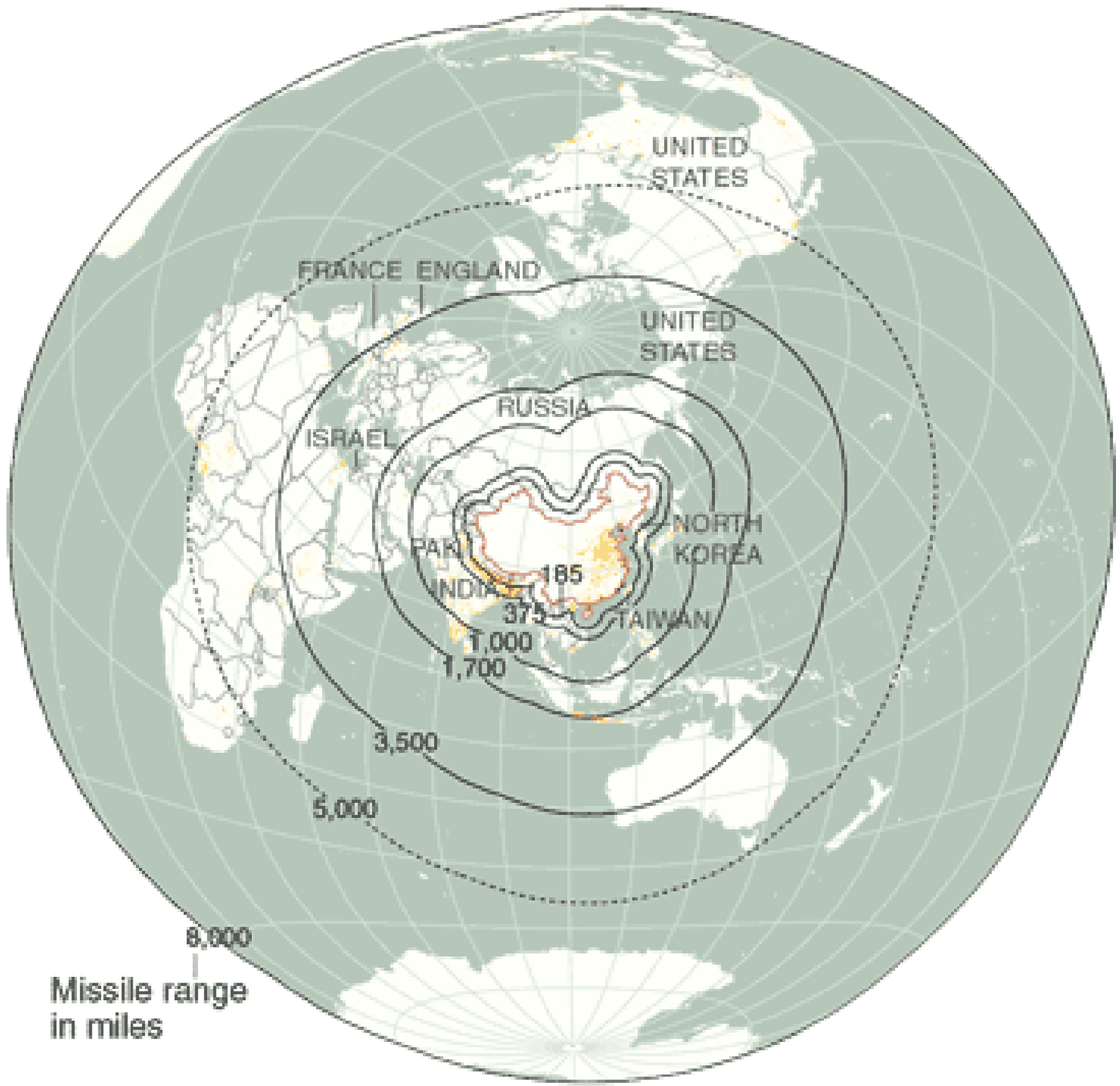
TYPE	NATO DESIGNATION	NO.	YEAR DEPLOYED	WARHEADS x YIELD (KILOTONS)	RANGE (KILOMETERS)	WARHEADS
Hong-6	B-6	20	1965	3,100	1 x bomb	~20
					DH-10	~15
Qian-5, others?	Q-5	?	1972–?	—	1 x bomb	~20

TOTAL* ~176**

Chinese Nuclear Forces

Chinese CSS-10 Road-Mobile Launcher

Ranges of China's Missiles



French Nuclear Forces (2008)

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)

Physics 280: Session 18

Plan for This Session

RE4v1 due this Thursday, 3-29

Questions

News and Discussion

Module 6: Nuclear Arsenals (cont'd)

Announcement

Thursday, March 29
10:00 - 11:30 am
Location: Alice Campbell Alumni Center Ballroom, 601 S.Lincoln, Urbana

State of the European Union Address
João Vale de Almeida
EU Ambassador and Head of the EU Delegation to the US

Topics include:

EU policy, including the eurozone crisis, the EU's approach to Iran's nuclear program, transatlantic cooperation in addressing the Arab Spring, and European integration of new member countries as well as minority immigrant populations

News and Discussion

2nd Nuclear Security Summit in Seoul, North Korea

History:

President Obama identified nuclear terrorism as the “most immediate and extreme threat to global security,” in a speech in Prague in April 2009. The President announced “a new international effort to secure all vulnerable nuclear material around the world within four years.”

The President hosted the first Nuclear Security Summit in Washington, DC, in April 2010. Heads of state from 47 countries gathered to lay out their priorities and focus the world’s attention on the issue.

Results included voluntary measures of about half of the attending countries to reduce or better secure nuclear materials and the reaffirmation of existing efforts, for example UN resolution 1540, committing states to prevent no-state actors from acquiring nuclear weapons or the ratification of Convention on the Physical Protection of Nuclear Materials (CPPNM).

see Securing Nuclear Materials: The 2010 Summit and Issues for Congress
by Mary Beth Nikitin, Specialist in Nonproliferation , October 31, 2011
→ http://www.fas.org/sgp/crs/nuke/R41169.pdf

The New York Times

Fears About North Korea and Iran Will Dominate Nuclear Summit Meeting in Seoul

By MARK LANDLER

SEOUL, South Korea — President Obama will join the leaders of more than 50 countries here next week for a nuclear security summit meeting, where fears about two rogue states, North Korea and Iran, will loom over a gathering ostensibly about the perils of nuclear terrorism.

The flare-up of tensions with North Korea is a reminder, experts say, of how crafty a negotiator the country can be. Days after announcing the satellite launch, the North Koreans invited inspectors from the International Atomic Energy Agency to tour nuclear facilities there.

That could put the United States in an awkward position, the experts said. If North Korea goes ahead with the launch and the administration rescinds its food aid, the North will have a pretext to expel the inspectors from the country and blame Washington.

News and Discussion

Bloomberg Businessweek

World Leaders to Strengthen Nuclear Security: Statement Text

Posted on March 27, 2012

Nuclear Materials

4. Recognizing that highly enriched uranium (HEU) and separated plutonium require special precautions, we reemphasize the importance of appropriately securing, accounting for and consolidating these materials. We also encourage States to consider the safe, secure and timely removal and disposition of nuclear materials from facilities no longer using them, as appropriate, and consistent with national security considerations and development objectives.

5. We recognize that the development, within the framework of the IAEA, of options for national policies on HEU management will advance nuclear security objectives. We encourage States to take measures to minimize the use of HEU, including through the conversion of reactors from highly enriched to low enriched uranium (LEU) fuel, where technically and economically feasible, taking into account the need for assured supplies of medical isotopes, and encourage States in a position to do so, by the end of 2013, to announce voluntary specific actions intended to minimize the use of HEU. We also encourage States to promote the use of LEU fuels and targets in commercial applications such as isotope production, and in this regard, welcome relevant international cooperation on high-density LEU fuel to support the conversion of research and test reactors.

News and

Bloomberg Businessweek

World Leaders to Strengthen Nuclear Security: St

Posted on March 27, 2012

Nuclear Materials

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5. We recognize that the development, within the frame
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(LEU) fuel, where technically and economically feasible
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specific actions intended to minimize the use of HEU. V
and targets in commercial applications such as isotope
international cooperation on high-density LEU fuel to s

12p280 Programs and Arsenals, p. 71

Structure of Statement

Global Nuclear Security Architecture
→Strengthen existing agreements/efforts

Role of the IAEA
→IAEA plays central role in international nuclear security, pledge to increase funding

Nuclear Materials
→Announce voluntary measures to reduce use & storage of HEU by the end of 2013

Radioactive Sources

Nuclear Security and Safety

Transportation Security

Combating illicit trafficing

Nuclear Forensics

Nuclear Security Culture

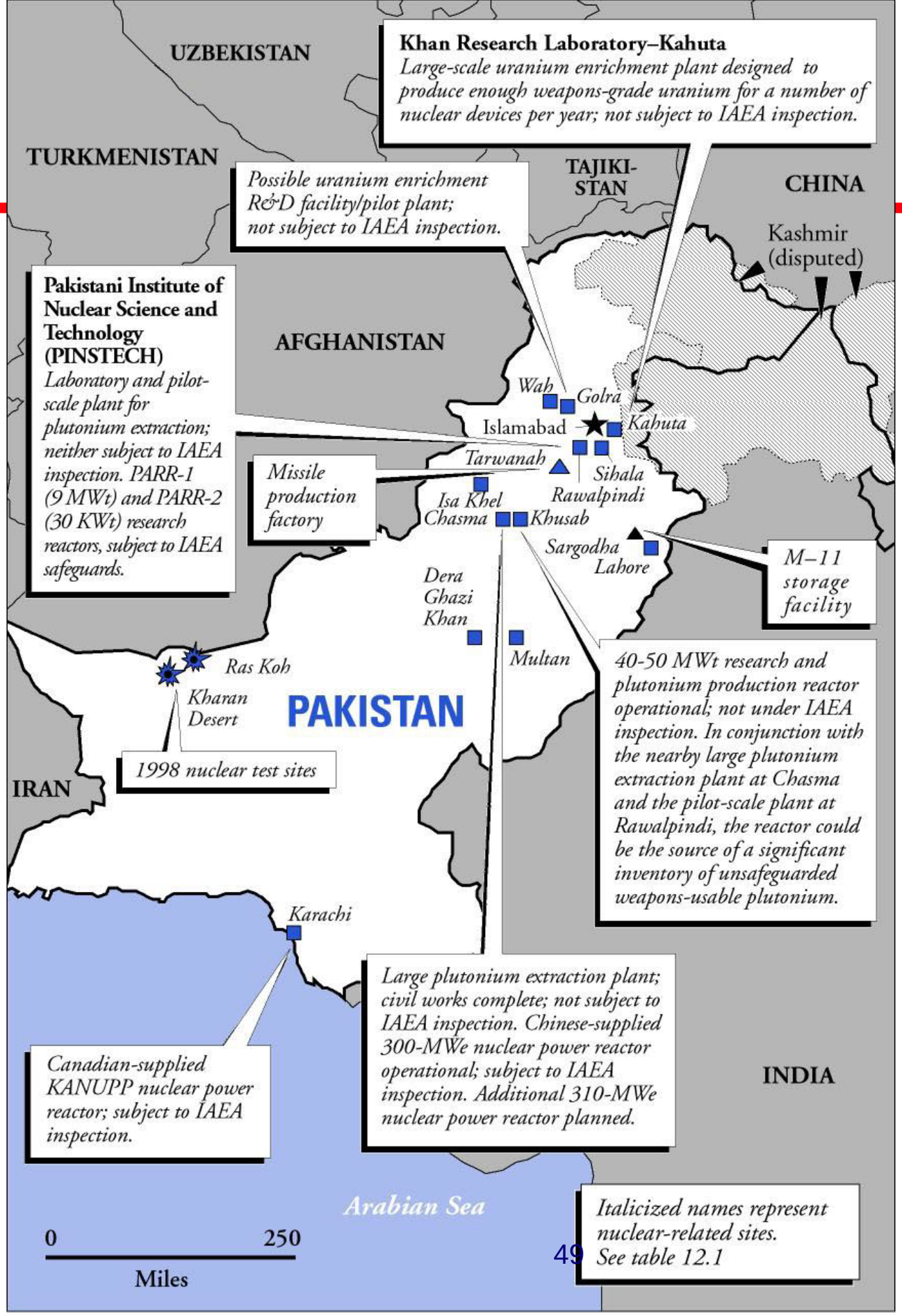
Information Security

International Coorparation

Module 6: Programs and Arsenals

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

India, Pakistan, Israel, North Korea, and Iran



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 50–100 nuclear weapons
- The NRDC estimates that India has 30–35 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 also developed and in 1999 successfully tested the medium-range Agni II, with a declared range of 2,000–2,500 km
- However, fighter-bombers are thought to be the only delivery system that could be used before 2010

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
- ACA estimates that it could have 70–90 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)

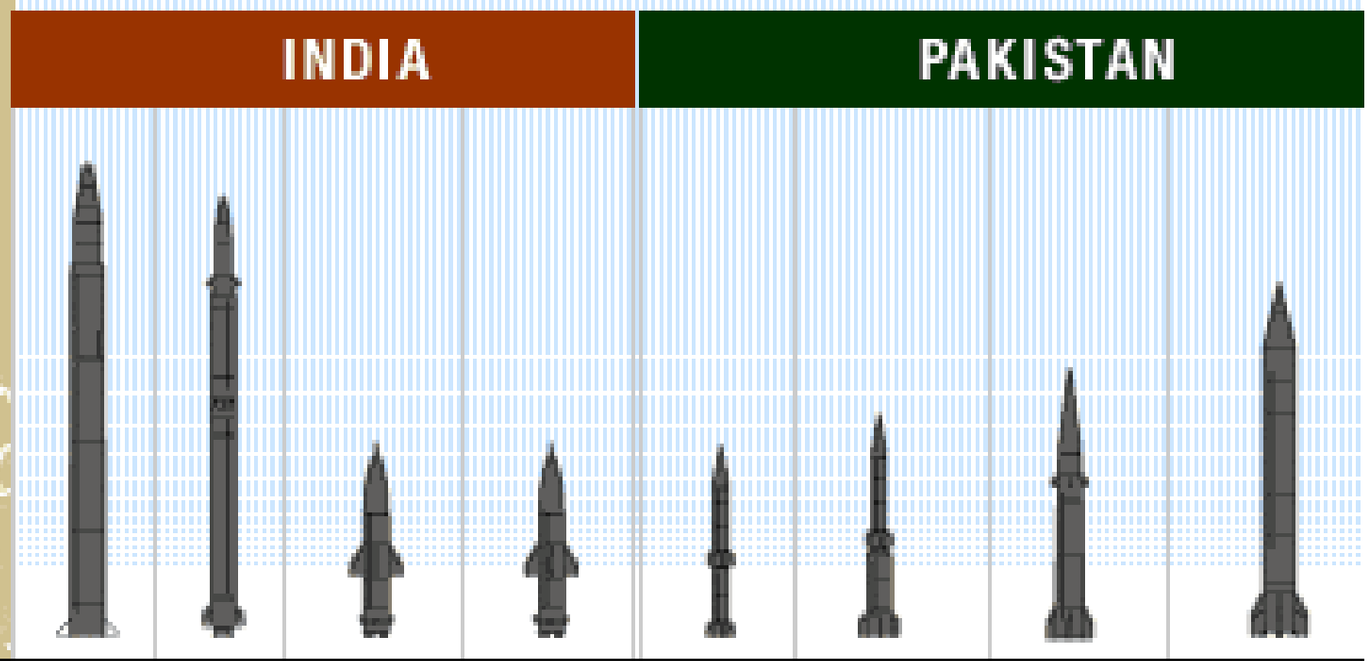
We estimate that Pakistan has produced 70-90 nuclear warheads that can be deployed on the following delivery vehicles:

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)

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 (but 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. Operational?
- 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 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)

iClicker Question

About when did the number operational U.S. nuclear warheads peak?

1970

1975

1980

1985

1990

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iClicker Question

About when did the number operational U.S. nuclear warheads peak?

1970

1975

1980

1985

1990

iClicker Question

About how many operational nuclear warheads did the U.S. have when the number peaked?

1,000

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iClicker Question

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1,000

5,000

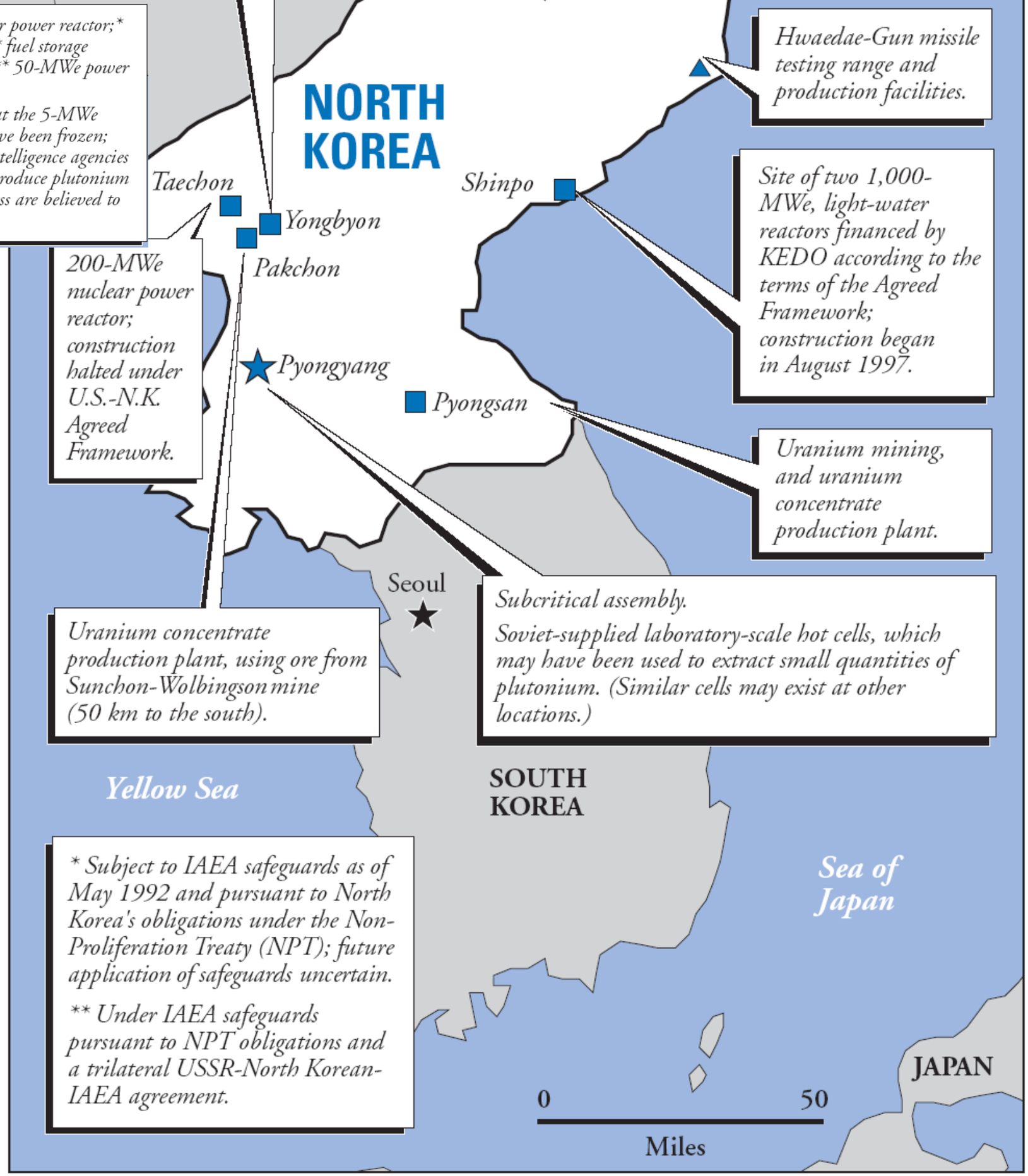
10,000

15,000

20,000

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.



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

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.
- 1989: Reports in the open press indicate for the first time that NK has a plutonium production reactor and extraction capability.

North Korea's Nuclear Program – 2

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)

North Korea's Nuclear Program – 4

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 – 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; 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 March 7: Clinton administration official says agreement for NK to eliminate its medium- and long-range missiles and cease exports was very close. President Bush rejects existing understandings with NK, delays further discussions, and publicly insults the Presidents of SK and NK.
- 2001 June: President Bush announces desire for "serious discussions" with NK.
- 2002 January: Bush II 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 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.
- 2007 February 28: New 6-party agreement announced (see next 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.

New 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

Current situation (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, with a total capacity of 8,000 SWU/year (got 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.
- Experts believe that NK has fundamentally changed its nuclear strategy.

North Korea's Nuclear Program – 11

- 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 – 12

- 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 – 13

- 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?

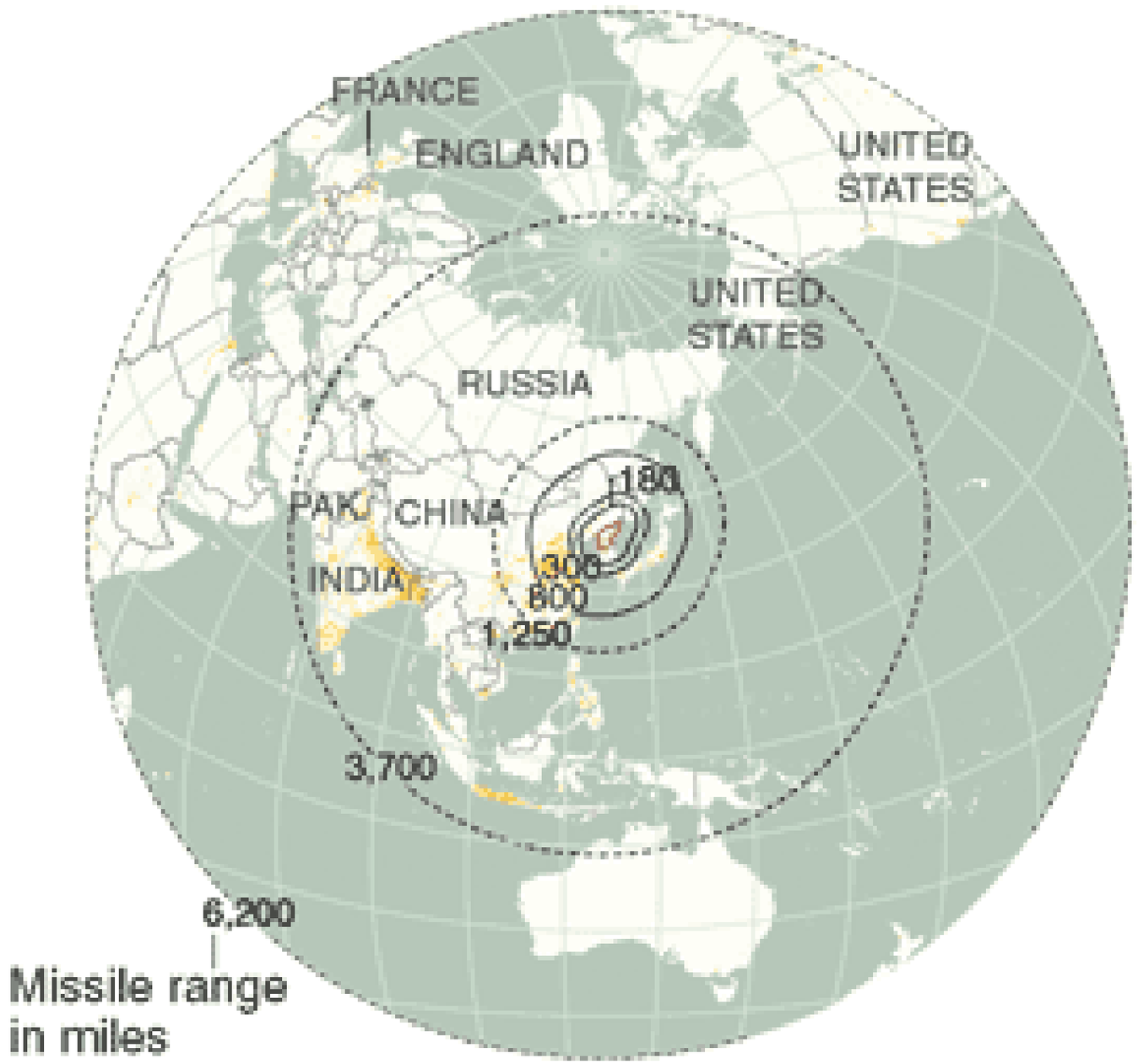
- Top priority: prevent NK from expanding its arsenal or exporting its nuclear technologies
- Long-term goal: denuclearize the Korean peninsula
- Few options but to reengage NK diplomatically
- Hecker advocates 3 No's supported by 1 Yes:
  - —No more bombs
  - —No better bombs (which means no more testing)
  - —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
  - —Starting point could be the October 2000 agreement abandoned by Bush

North Korea's Ballistic Missile Capabilities

NORTH KOREAN BALLISTIC MISSILES			
	Range (kilometers)	Payload (kilograms)	Comment
Scud B	320	1,000	Reverse-engineered Soviet Scud B
Scud C	500	770	Conventional explosives, chemical, and cluster warheads
Nodong	1,350–1,500	770–1,200	Test fired in May 1993; flew 500 kilometers. Close to 100 deployed. Designed to carry a nuclear warhead
Taepodong-1	1,500–2,500	1,000–1,500	Test-launched August 31,1998
Taepodong-2	3,500–6,000	700–1,000	Not yet tested
Taepodong-2 (three-stage)	up to 15,000	several hundred	More than a decade away

Source: NRDC (April 2003)

Ranges of North Korea's Missiles



Physics 280: Session 20

Plan for This Session

Questions

Module 6: Nuclear Arsenals (cont'd)

Kim's Nuclear Gambit

Iran's Nuclear Complex

12p280 Programs and Arsenals, p. 1

Iran's Nuclear and Missile Programs – 1

Iran's nuclear weapon capability —

- Iran has the basic nuclear technology and infrastructure needed to build nuclear weapons
- The intelligence services of Germany, Israel, the United Kingdom, and the United States have publicly confirmed that it has a long-term program to manufacture nuclear weapons
- It is thought that Iran has not yet made a nuclear weapon (in February 2003, the U.S. Defense Intelligence Agency estimated that Iran could have a nuclear weapon by 2010)
- Iran's rate of progress in developing nuclear weapons will depend strongly on what assistance it receives from Russia and China and whether it can illicitly acquire the needed special nuclear material

Iran’s Nuclear and Missile Programs – 2

Iran’s nuclear program has continued to advance —

- It has completed a large gas-centrifuge uranium enrichment facility at Natanz.
- No nuclear material was in the centrifuges at Natanz when the IAEA visited.
- A 1000-centrifuge pilot plant could produce material for one bomb every 1–2 years.
- The IAEA believes Iran probably introduced nuclear material into centrifuges at another, undisclosed location in order to test the centrifuges; this would be a violation of the NPT.

Iran's Nuclear and Missile Programs – 3

In 2003, Iran announced a change in its nuclear program —

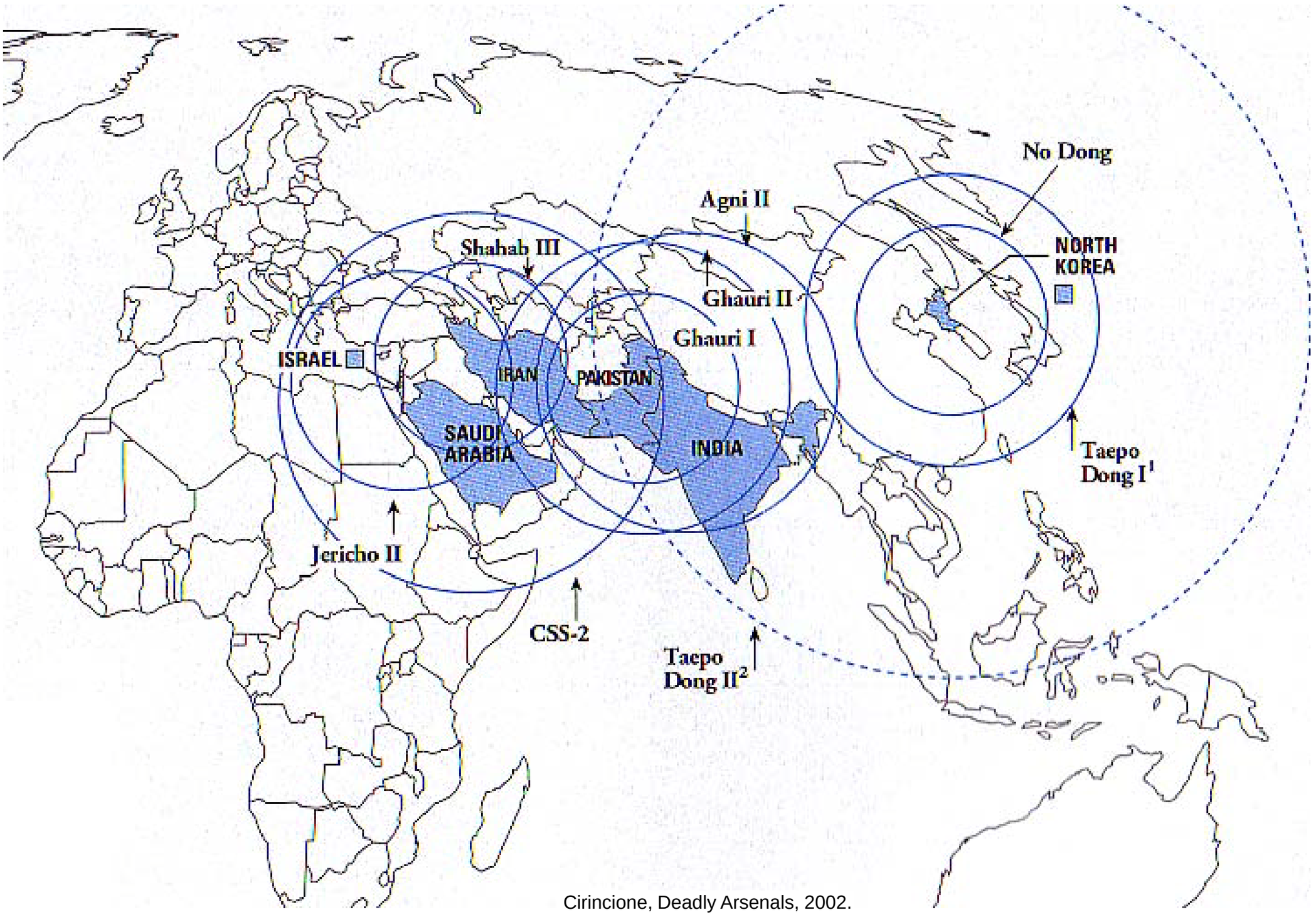
- Iranian President Mohammad Khatami announced that Iran has started mining uranium and is developing the facilities for a complete nuclear fuel cycle
- On March 3, 2003, Hassan Rowhani, the Secretary of the Supreme National Security Council, announced that a plant near Isfahan designed to convert uranium oxide to uranium hexafluoride was now complete.
- Iran is dragging its feet on more rigorous IAEA inspections.
- Russia is constructing a nuclear reactor at Bushehr that will provide dual-use technology that Iran does not now have.

Iran’s Nuclear and Missile Programs – 4

Iran’s nuclear delivery capability —

- About 300 Scud-B short-range missiles (range = 300 km, payload =1,000 kg)
- About 100 Scud-C short-range missiles (range = 500 km)
- Iran is manufacturing Scuds with North Korean assistance
- Iran has 200 Chinese-supplied CSS-8 short-range missiles (range = 150 km, payload = 150 kg)
- Iran has tested the medium-range Shahab III, a derivative of the North Korean No Dong (range = 1,300 km, payload = 750 kg)
- Iran appears to have abandoned development of the Shahab IV (range = 2,000 km, payload = 1,000 kg)

Ranges of Current and Projected Ballistic Missile



Cirincione, Deadly Arsenals, 2002.

End of Module 6: Programs and Arsenals