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The Basics of Nuclear Weapons:
Physics, Fuel Cycles, Effects and Arsenals

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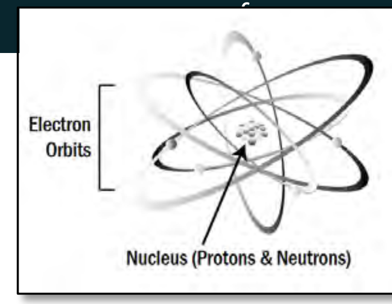
Nuclear Chain Reactions: Fission and Fusion



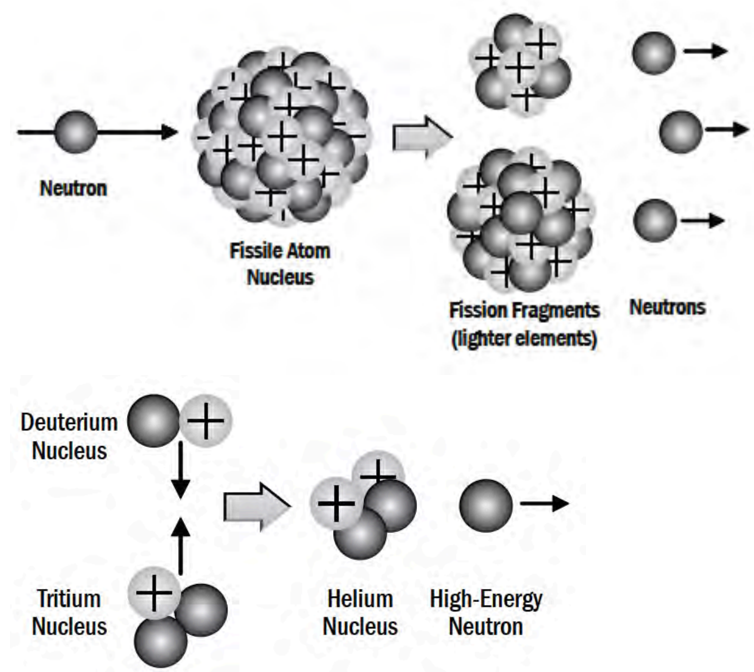
A nuclear weapon is a explosive device that uses a controlled uncontrolled nuclear chain reaction to release huge amounts of energy.

Nuclear weapons make use of one or two forms of interactions between atoms:

Fission: uses a neutron to split a nucleus to release neutrons that split more nuclei to create a supercritical fission process.

Fusion: the opposite of fission, combines (melts) two light nuclei into one heavier nucleus. The released neutron can, if necessary, be used to drive another fission event.

A nuclear weapon uses one or a combination of these two processes.

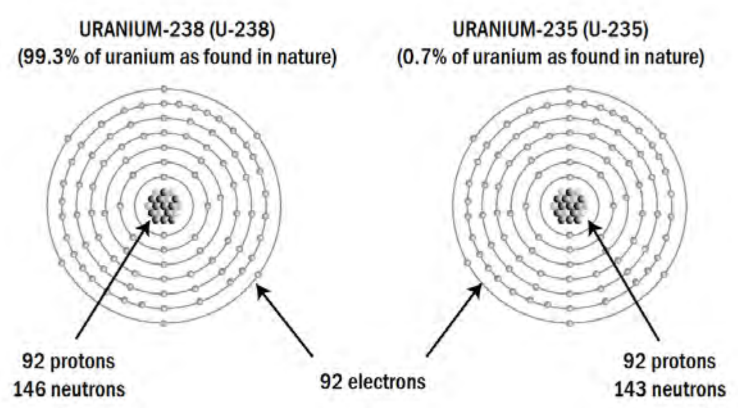


Nuclear Fuel Cycle

All bomb fuel comes from the ground (Uranium) but...

Uranium ore typically contains less than 1% uranium

Of that 1%, only 0.7% is U-235:



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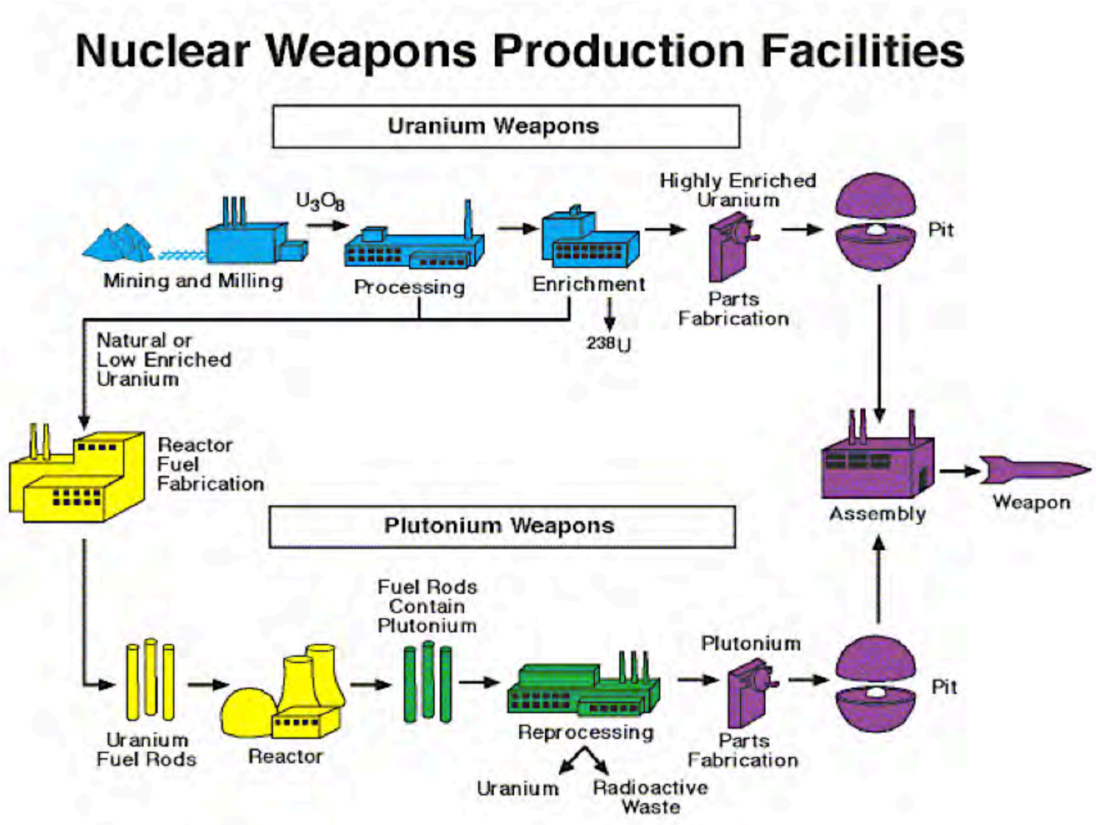
Nuclear Fuel Cycle

Nuclear weapons fuel cycle is focused on processing the fuel to those isotopes most effective in weapons.

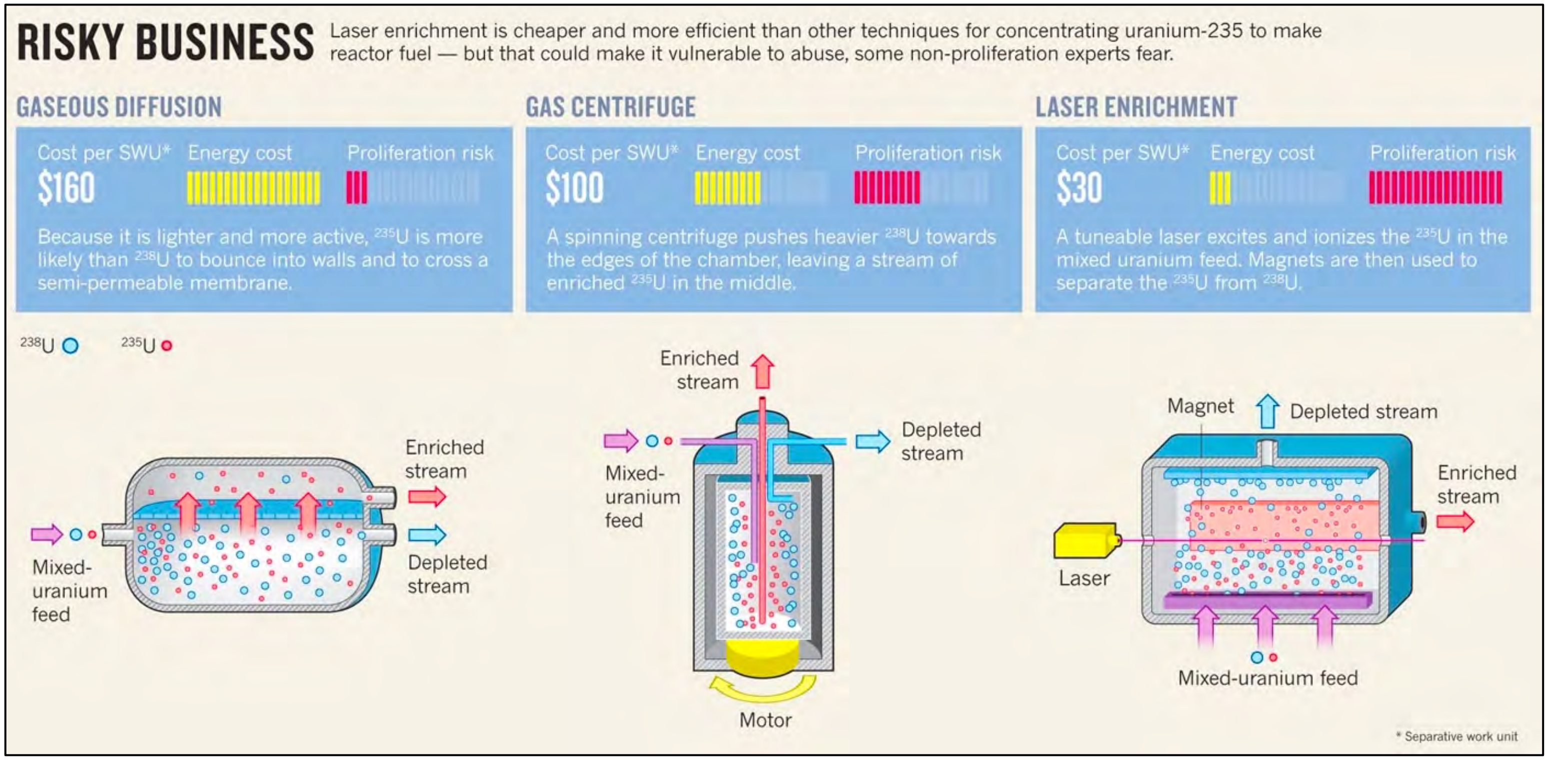
Uranium weapons require simpler and shorter fuel cycle than plutonium weapons.

Plutonium weapons require processing of spent reactor fuel and extraction, purification, and engineering of plutonium.



Nuclear Fuel Cycle

Three basic types of uranium enrichment



Nuclear Fuel Cycle

Enrichment effort (energy expenditure) is measured in terms of "separative work units" (SWU):

- About 4 SWU → 1 kg of LEU (~3%) from about 6 kg of natural uranium*
- About 200 SWU → 1 kg weapons-grade HEU from about 200 kg of natural U*
- About 5,000 SWU → 1 weapon (25 kg) from about 5,000 kg of natural U*
- About 100,000 SWU → fuel for 1,000 MW(e) LWR for 1 year's operation (e.g. Iran's Bushehr reactor)

Important to realize that much of the SWU/kg work to produce weapons-grade HEU is already done in producing LEU from natural U; starting from LEU would give a proliferator a huge head start

*Assumes a nominal waste assay of 0.25% uramium.

Grades of Uranium:

Depleted uranium (DU): <7% U-235
Natural uranium: 7% U-235
Low-enriched uranium (LEU): >7% but <20% U-235
Highly-enriched uranium (HEU): >20% U-235
Weapons-grade uranium: >90% U-235

Nuclear Fuel Cycle

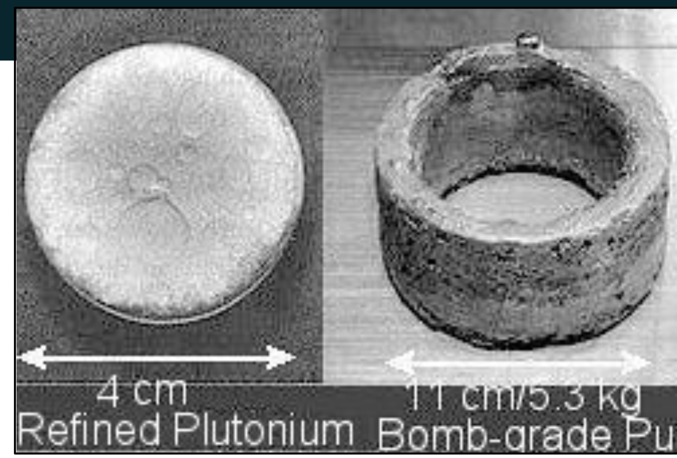
Pu-239 is readily fissionable and more so than U-235. Pu-239 also has a much higher rate of spontaneous fission than U-235.

Grades of Plutonium:

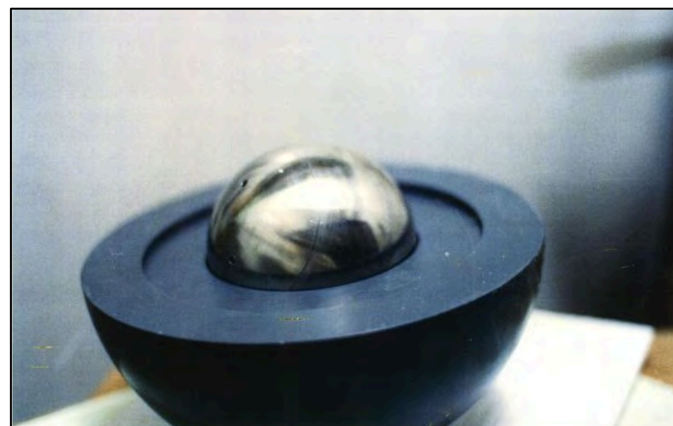
For weapons purposes the Pu-239 percentage should be as large as possible:*

- Weapon-grade: < 6% Pu-240 and other non-Pu-239 isotopes;
- Fuel-grade: from 6 to 18% Pu-240;
- Reactor-grade: > 18% Pu-240.
- "Super-grade": < 3% Pu-240.
- "Weapon-usable" refers to plutonium that is in separated form and therefore relatively easy to fashion into weapons.

* But all plutonium is potentially useable for a weapon.



Plutonium button (left) allegedly used in Nagasaki bomb. Plutonium ring (right) used for storage.



Plutonium core production model allegedly photographed by Mordechai Vanunu inside the Israeli Dimona reactor complex

Nuclear Fuel Cycle

The IAEA defines the amounts of fissile material "required for a single nuclear device" as 8 kg of plutonium, 8 kg of U-233, and 25 kg of U-235. But that apparently depends on the skills and technical capability of the producer:

Approximate Fissile Material Required for Pure Fission Nuclear Weapons*						
	Weapon-Grade Plutonium (kg)			Highly-Enriched Uranium (kg)		
Yield	Technical Capability			Technical Capability		
(kt)	Low	Medium	High	Low	Medium	High
1	3	1.5	1	8	4	2.5
5	4	2.5	1.5	11	6	3.5
10	5	3	2	13	7	4
20	6	3.5	3	16	9	5

* Reproduced from Thomas B. Cochran and Christopher E. Paine, *The Amount of Plutonium and Highly-Enriched Uranium Needed for Pure Fission Nuclear Weapons*, Nuclear Weapons Databook, Natural Resources Defense Council, Revised April 13, 1995, p. 9.

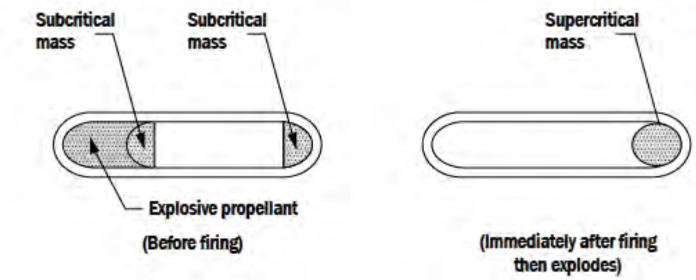
Nuclear Warhead Types

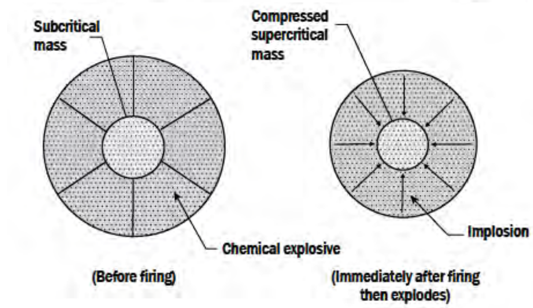
A bomb is a bomb is a bomb is a…

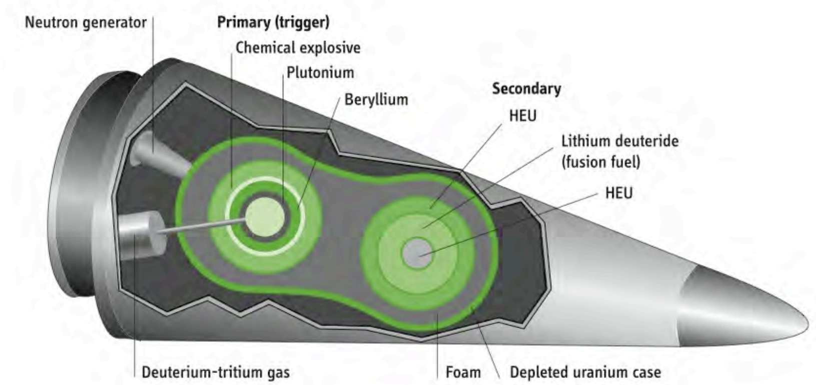
Gun-type fission weapon: uses chemical explosives to combine two subcritical masses of HEU into one supercritical mass of HEU. 50-60 kg (110-132 lbs) Example: Hiroshima bomb (yield: ~13.5 kt).

Single-stage, fission weapon: uses chemical explosives to compress HEU (12-18 kg; 26-39 lbs) or Pu (4-6 kg; 8-13 lbs) subcritical mass into supercritical mass.
Example: Nagasaki bomb (yield: ~22 kt).
Can be “boosted” by deuterium-tritium gas to ~80 kt.

Two-stage, thermonuclear weapon: combines fission device (primary or trigger) with fusion device (secondary or Canned Sub-Assembly). All US nuclear weapon designs current are of this type. Yields range from 0.3 to 1,200 kilotons; most yield comes from secondary.







Nuclear Weapons Effects

Not just a bigger bomb…

The destructive effect of nuclear weapons is unlike any other created my human beings.

100% fission of 1 kg Pu-239 or U-235 can produce an explosion equivalent to more than 18,000 tons of TNT.

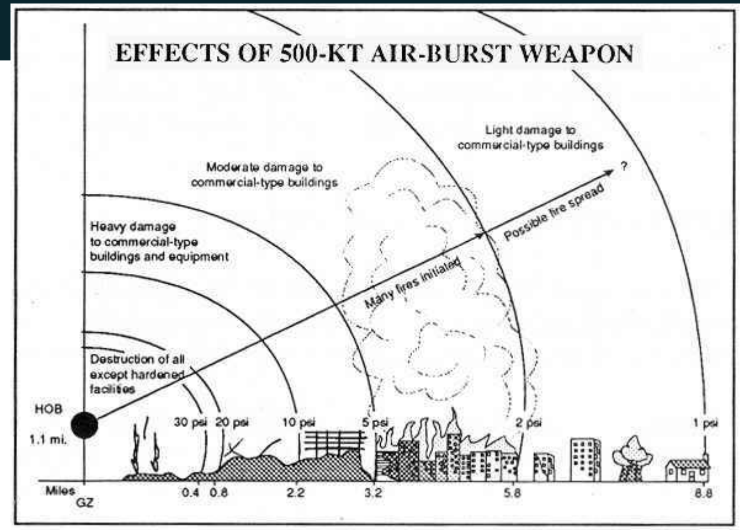
Downtown Hiroshima days after air burst of 13.5 kt HEU gun-type bomb

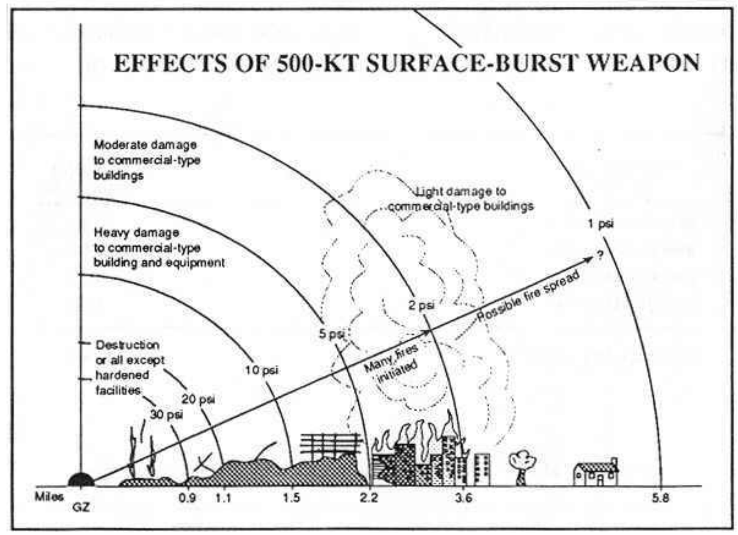
(Above) The most powerful U.S. conventional bomb – the GBU-43/B Massive Ordnance Air Blast (MOAB) – has an explosive yield of approximately 0.011 kt TNT, roughly 30 times less than the lowest yield setting (0.3 kt) on the B61 nuclear bomb (below). The B61-12 weighs 850 lbs (385 kg), nearly thirty times less that the MOAB's 22,600 lbs (10,300 kg).

Nuclear Weapons Effects

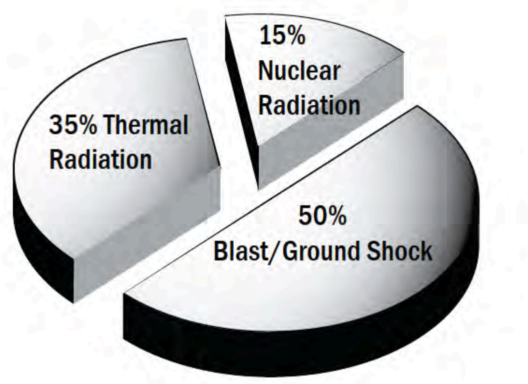
Main types of effects from nuclear weapons detonation:

- **Fireball:** x-rays instantly create large sphere tens of millions of degrees hot
- **EMP:** instantaneously crates electromagnetic pulse that can destroy or disrupt electronic equipment
- **Heat and light wave:** causes fires and burns in seconds (fires can significantly add to effects)
- **Prompt radiation:** harmful to life and damaging to electronic equipment
- **Air blast wave** (lower atmosphere): hundreds of miles per hour winds
- **Shock wave** (surface or near-surface burst): causes damage to underground structures
- **Residual radiation**: emitted over extended period of time
- **Electronic**: extended interference of communications equipment





Nuclear Weapons Effects



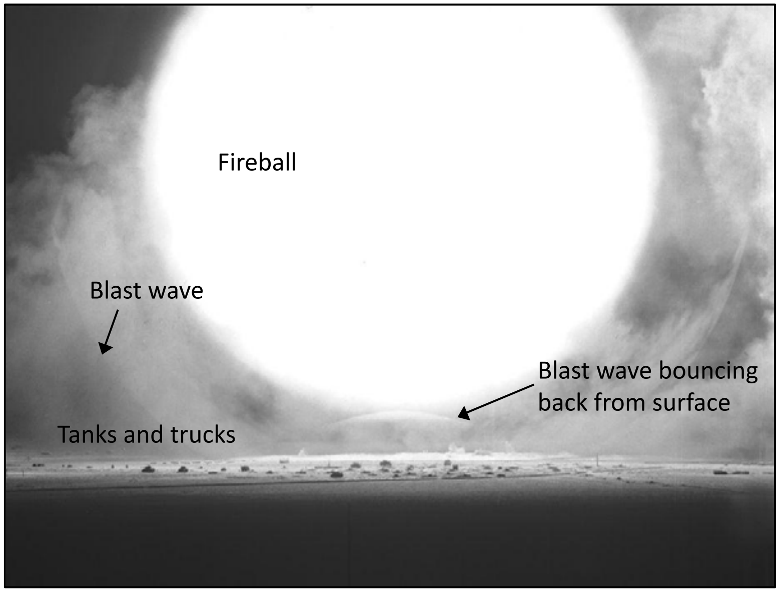
Nuclear tests (atmospheric before 1963) were used to study effects of nuclear weapons – and to develop more effective nuclear weapons.

Grable test (15 kt), Operation Upshot-Knothole, Nevada, May 25, 1953

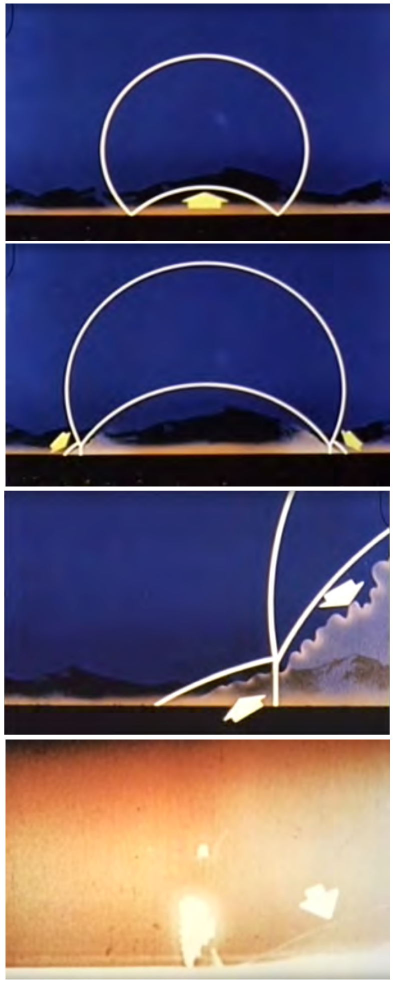
Nuclear Weapons Effects

Strike planning seeks to maximize effectiveness of nuclear blast against different targets to kill target by detonating the weapons at the optimum height of burst (HOB).

Surface targets are destroyed by combination of heat and blast wave.



The interaction between the blast (incident) wave and reflected wave creates a precursor wave that reinforces the incident wave traveling along the ground. Because of this, air blast is maximized with a low-air burst rather than a surface burst.



An F-15E drops one of two B61-12 guided nuclear bomb shapes at Tonopah Test Range in Nevada on October 20, 2015. Official images from the test indicate that the B61-12 demonstrated an accuracy of less than 30 meters (98 feet) and that the guided bomb has earth-penetrating capability against underground targets.

Kristensen/FAS, 2016

Nuclear Weapons Effects

Destruction of underground facilities require ground- or shallow sub-surface bursts to ensure shock wave causes an underground fracture or "damage zone".

In a sub-surface burst the shock wave moving upward is trapped by the surface material and reflected downward where it reinforces the original chock wave. This "coupling" effect enables an earth-penetrator to destroy underground targets 2-5 times deeper than ground burst weapons.

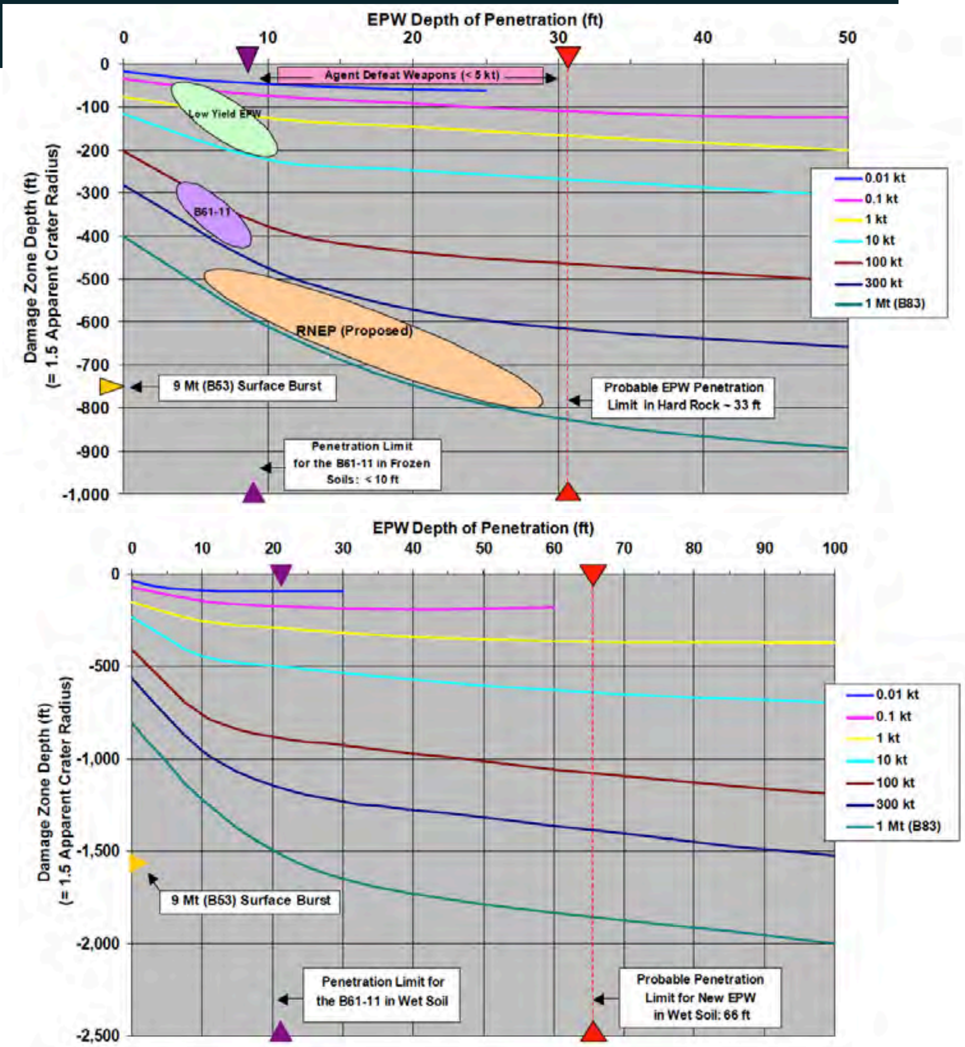
1 kt: destroys to a few 10s of meters
1 MT: destroys to a few 100s of meters

B61-11 drop test into frozen soil

Nuclear Weapons Effects

With a penetration capability in hard rock (top right) of 10 feet (3 meters), the damage zone from a 400-kt B61-11 blast would extend to around 500 feet (150 meters).

In wet soil (bottom right), the damage zone from a 400-kt B61-11 blast at 25 feet (8 meters) would reach 1,200 feet (365 meters).

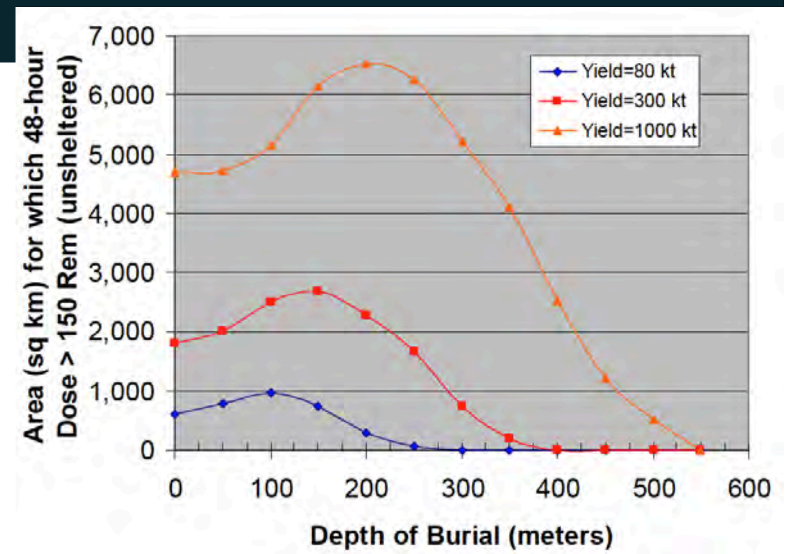


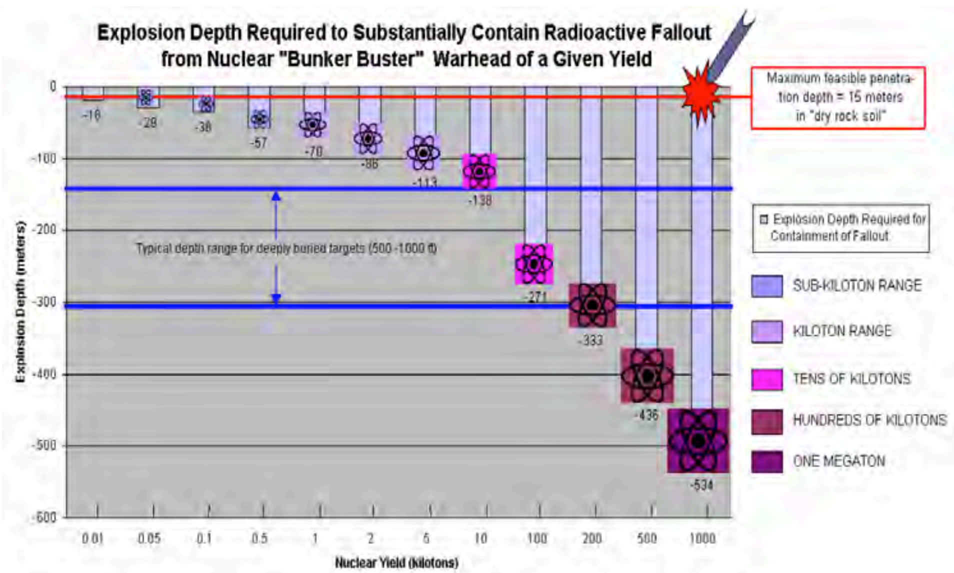
Source: Countering Proliferation of Compounding It?, NRDC 2003

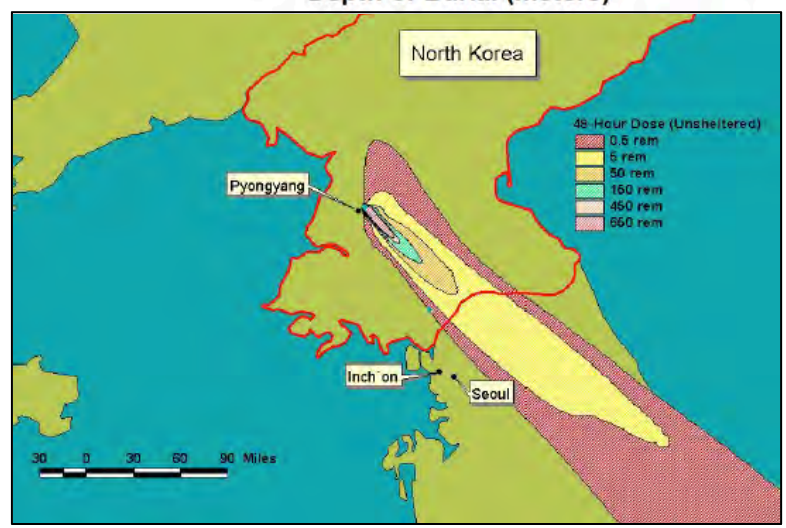
Nuclear Weapons Effects

Radioactive contamination area is significant for the yields required to be effective against hard and deeply buried targets (~2,000 sq km for B61-11).

Radioactive fallout would also contaminate allies.







Source: Countering Proliferation of Compounding It?, NRDC 2003

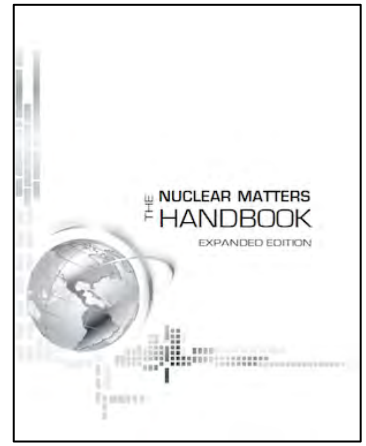
Nuclear Weapons Effects: Strategies

(Very) Simply speaking, there are two general types of nuclear employment strategies:

Counter-force: employs nuclear nuclear forces "to destroy the military capabilities of an enemy or render them impotent. Typical counter force targets include: **bomber bases, ballistic missile submarine bases, intercontinental ballistic missile (ISBM) silos, antiballistic and air defense installations, command and control centers, and weapons of mass destruction storage facilities**. Generally, **the nuclear forces required to implement a counter-force targeting strategy are larger and more accurate** than those required to implement a counter-value strategy. Counter-value targets generally tend to be harder, more protected, more difficult to find, and more mobile than counter-value targets."

Counter-value: directs the "destruction or neutralization of selected enemy military and military-related targets such as **industries, resources, and/or institutions that contribute to the ability of the enemy to wage war**. In general, **weapons required to implement this strategy need not be as numerous nor as accurate as those required to implement a counter-force targeting strategy** because counter-value targets tend to be softer and less protected than counter-force targets."

Obama administration did not change counter-force focus: The 2013 Nuclear Employment Strategy "requires the United States to maintain significant counterforce capabilities against potential adversaries. The new guidance does not rely on a 'counter-value' or 'minimum deterrence' strategy."

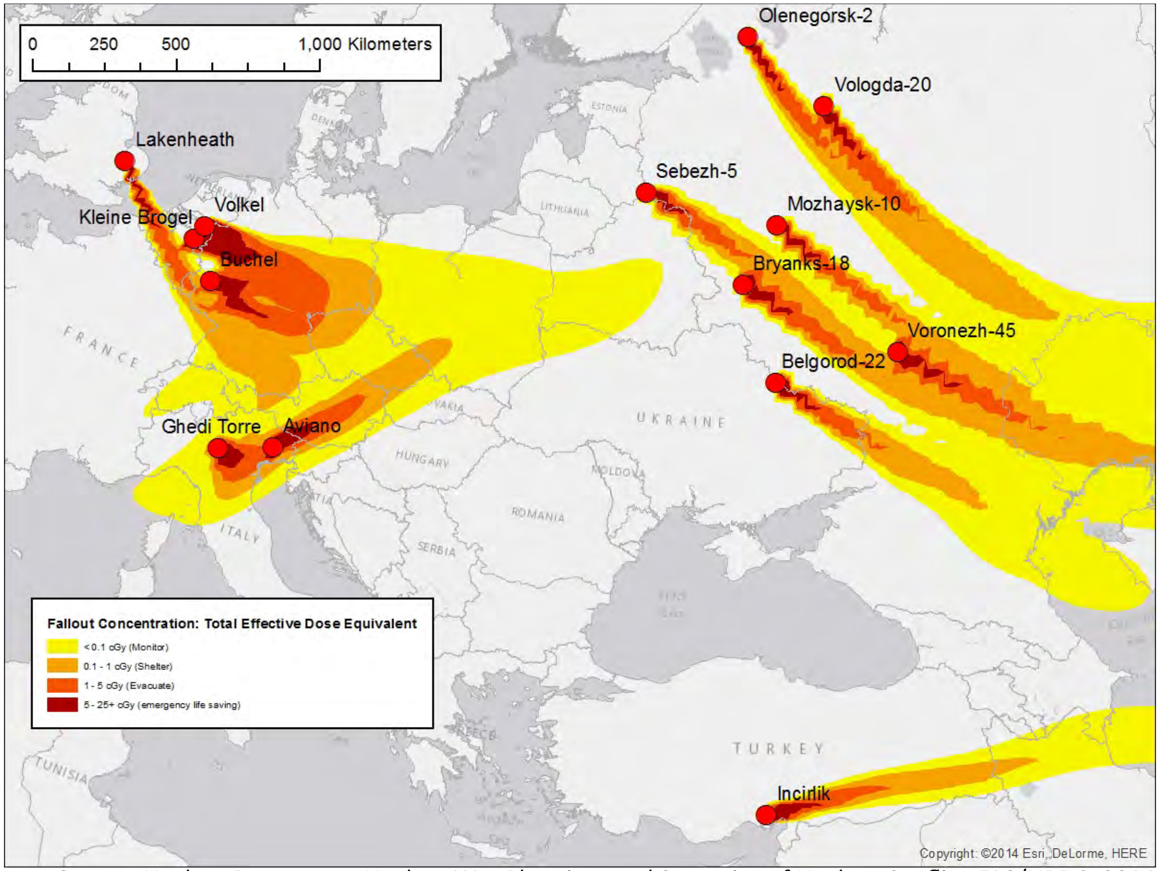


Nuclear Weapons Effects

There is no "clean" nuclear war.

Even "limited" counter-force attacks would have create extensive collateral damage.

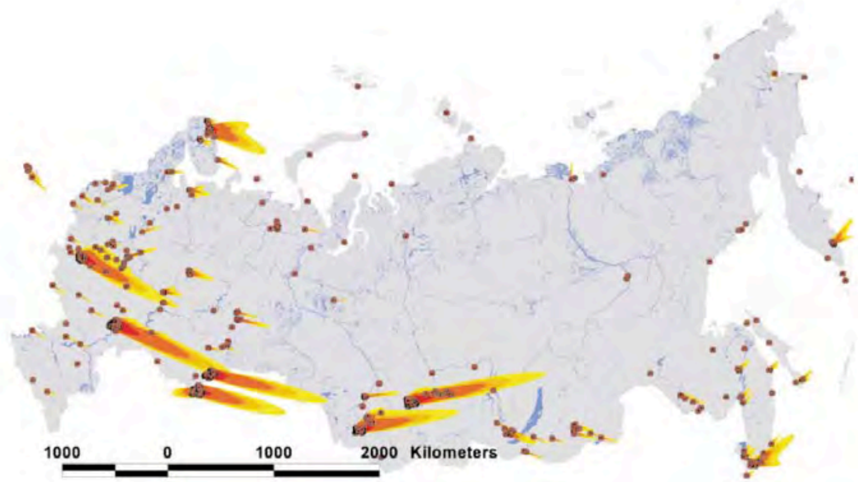
Limited counter-force attacks are important scenarios in post-Cold War planning.



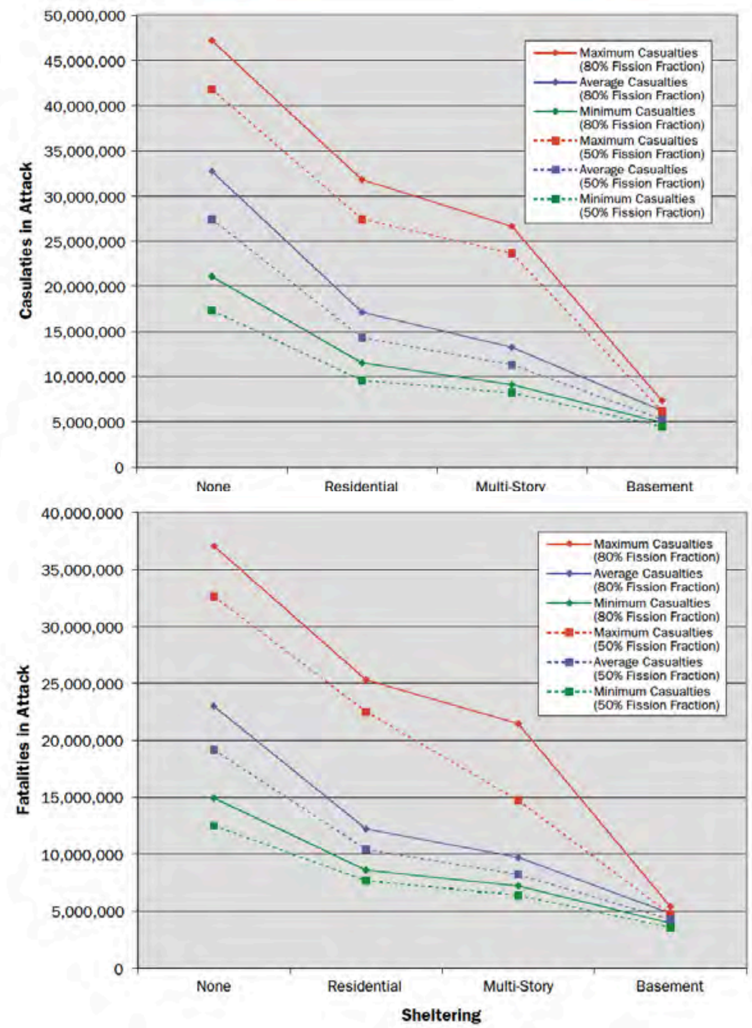
Source: Nuclear Deterrence, Nuclear War Planning, and Scenarios of Nuclear Conflict, FAS/NRDC, 2014

Nuclear Weapons Effects

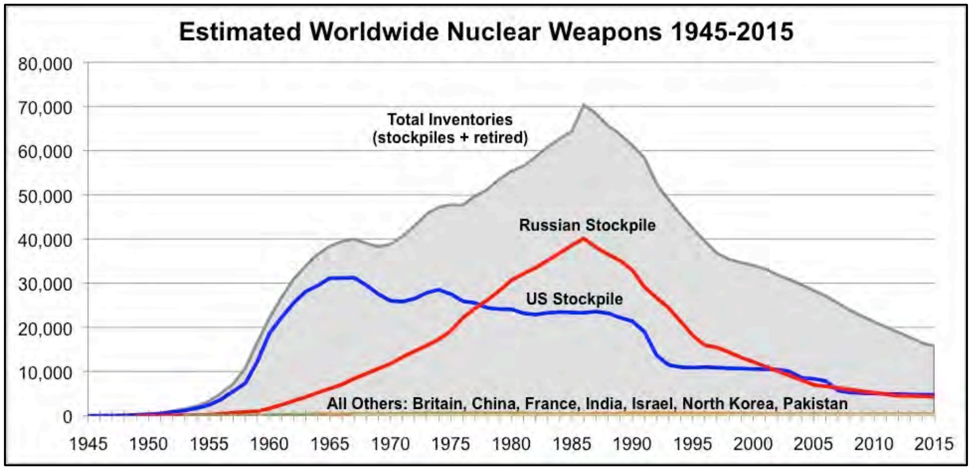
Large-scale attacks, even purely counterforce, would have devastating civilian consequences and cause climatic effects and famine on a global scale.



Source: The Nuclear War Plan: A Time For Change, NRDC 2001



Nuclear Arsenals: Global Inventories



More than 125,000 warheads produced since 1945

Peak of 64,500 stockpiled warheads in 1986 (70,300 if including retired warheads)

- US stockpile peaked early (1967)
- Russian stockpile peaked late (1986)

Enormous reductions since 1986 peak:

- ~54,000 warhead stockpile reduction
- ~47,000+ warheads dismantled

~10,000 warheads in stockpiles (~15,000 if counting retired warheads awaiting dismantlement)

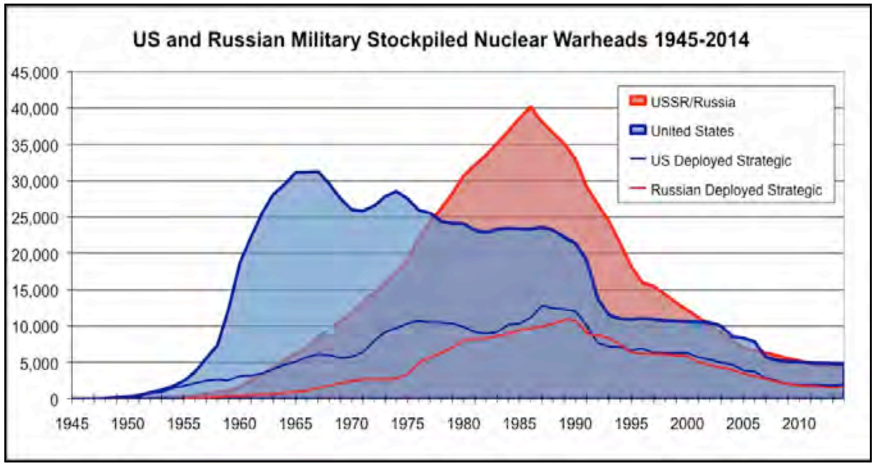
US and Russia possess 90% of global inventory (94% if counting retired warheads); **each has more than 4 times more warheads than rest of world combined**; 15 times more than third-largest stockpile (France)

Decreasing: US, Russia, Britain, France

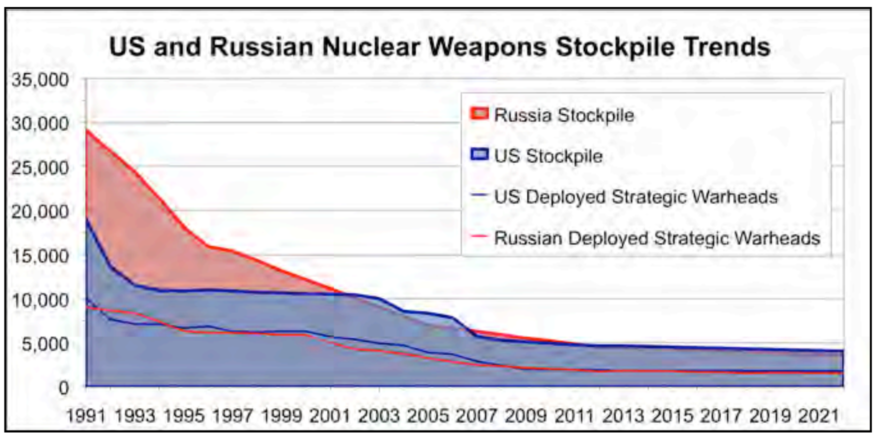
Increasing: China, Pakistan, India

Israel relatively steady; North Korea trying

Nuclear Arsenals: Trends



Note: retired, but still intact, warheads awaiting dismantlement are not shown



With more than 90% of world inventory, US and Russia have special responsibility to reduce

Reduction of deployed strategic warheads from some 23,000 in 1989 to 3,500 in 2015 (New START counts 3,185)

Readiness level of remaining strategic forces is high: about 1,800 warheads on prompt alert

No official de-alerting, but significant reduction of overall alert numbers: heavy bombers de-alerted, US ICBMs and SLBMs downloaded, non-strategic forces de-alerted

Trend: pace of reduction is slowing

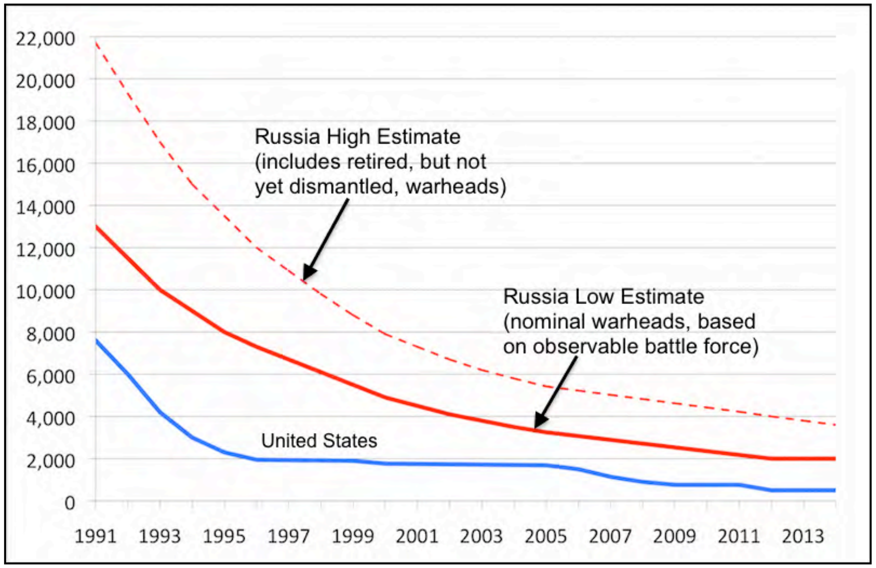
US cut only 396 warheads in 2010-2014, compared with 3,457 warheads cut in 2005-2009

Russia cut an estimated 1,100 warheads in 2010-2014, compared with 2,600 in 2005-2009

Instead of continuing pace or increasing reductions, US and Russian stockpiles appear to be leveling out for the long haul; new emphasis on modernization

New initiatives needed to prevent stalling of arms control

Nuclear Arsenals: Non-Strategic



- Some 2,500 warheads remain assigned to non-strategic forces (Russia ~2,000; United States ~500)
- Several thousands additional retired, but still relatively intact, warheads in storage are awaiting dismantlement
- Stockpiles will likely continue to decline in next decade with or without arms control agreements

- U.S. and Russian combined stockpiles of non-strategic nuclear warheads reduced by roughly 90 percent since 1991. Neither side has disclosed actual numbers
- Russia: two public declarations:

  2005: Russian "non-strategic nuclear forces" have been reduced "by four times" since 1991.

  2010: "the Russian arsenal of non-strategic nuclear weapons is reduced four times [75%]* in comparison with the USSR arsenal." All are in central storage

  * Note: PNI declarations do not add up to 75%

- United States: two public declarations:

  2010: "The number of U.S. non-strategic nuclear weapons declined by approximately 90 percent from September 30, 1991 to September 30, 2009."

  2014: "The number of U.S. non-strategic nuclear weapons has declined by approximately 90 percent since September 30, 1991."

~180 US B61 bombs forward-deployed in Europe

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Nuclear Arsenals: Russia

Gradual phase-out of soviet-era systems and partial replacement with "new" systems by early-mid 2020s

Replacement began two decades ago

Old System	New System	MIRV	First Deployed
SS-18	Sarmat (RS-28)	Yes	2020-2025?
SS-19	SS-27 Mod 1 (Topol M) SS-27 Mod 2 (RS-24)	No Yes	2097 2014
SS-25	SS-27 Mod 1 (Topol-M) SS-27 Mod 2 (RS-24) SS-27 Mod 3 (RS-26) SS-27 Mod 4 (Rail)	No Yes Yes Yes	2006 2010 2016? 2020?
SS-N-18 SS-N-23	SS-N-32 (Bulava) SS-N-32 (Bulava)	Yes Yes	2016-2018? 2020-2030?
Tu-95MS Tu-160	PAK-DA PAK-DA		2020-2030? 2020-2030?

Diverse Nuclear Forces

Strategic

ICBM: 3 types being replaced by 2 in 6 versions

SLBM: 2 types being placed by 1

Bombers: 2 types being replaced by 1

Non-Strategic

Navy: SLCM, SAM, ASW missiles, torpedoes, depth bombs

Air Force: cruise missile, bombs

Army: short-range ballistic missiles, intermediate-range cruise missile

Defense: ballistic missile defense, air-defense, coastal defense

Nuclear Arsenals: Russia






ICBM
- SS-27 Mod 2 (mobile): replacing SS-25s at Novosibirsk, Tagil, Yoshkar-Ola
- SS-27 Mod 2 (silo): replacing SS-19s at Kozelsk
- SS-27 Mod 2 (rail): planned but uncertain
- RS-26 (compact SS-27): to replace SS-25s at Irkutsk and Vypolzovo
- RS-28 (Sarmat): to replace SS-28s at Dombarovsky and Uzhur

SSBN / SLBM
- SS-N-23 SLBM life-extension (Sineva/Layner) in Delta IV SSBN
- Borei SSBN: 8 planned (possibly 10-12)
- SS-N-32 (Bulava): fielding

Bombers
- Upgrades of some Tu-160 (Blackjack) and Tu-95 (Bear)
- New bomber (PAK PA) in development
- ALCM (Kh-102) in development

Tactical
- Tu-22M (Backfire) upgrade underway
- Su-34 (Fullback) fielding
- Yasen (Sverodvinsk) SSGN fielding
- SLCM (SS-N-30, Kalibr) fielding
- GLCM test-launched; not deployed
- SSM (SS-26, Iskander) fielding
- SAM (S-400/SA-21) fielding (nuclear?)
- ABM (A-135) upgrade planned

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Nuclear Arsenals: Russia (ICBM)

Nuclear Arsenals: Russia (ICBM)

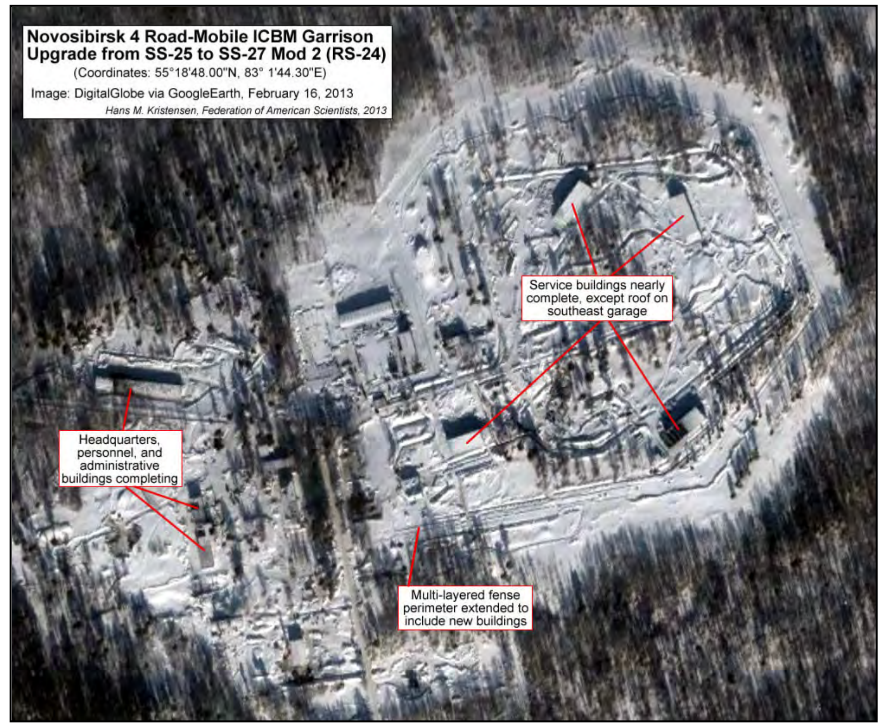
Third SS-27 unit (39 Guards Missile Division).

First regiment with 9 SS-27 Mod 2 (RS-24) placed on “experimental combat duty” in 2013; second in 2014; third in 2015.

Satellite images show upgrade of regiment base and media photos show SS-27 Mod 2 launchers.

Remaining SS-25s are being phased out.

SS-27 Mod 2 TEL under camouflage (top) and upgrade of first of several regiment bases.



Nuclear Arsenals: Russia (ICBM)

Fourth SS-27 unit (42 Missile Division).

Part of first regiment with 6 SS-27 Mod 2 (RS-24) placed on "experimental combat duty" in 2013; second regiment in 2014; third in 2015.

Satellite images show complete reconstruction of regiment base (bottom) with 9 TEL garages for 3 SS-27 Mod 2 battalions, as well as upgrade of warhead storage and newly arrived camouflaged vehicles at supply base.

Remaining SS-25s being phased out.

Construction of SS-27 Mod 2 base (bottom); camouflaged vehicles at supply base (top left); upgrade to warhead storage (top right). Image: 2 Jun 2014

Nuclear Arsenals: Russia (ICBM)

Fifth SS-27 unit (28 Guards Missile Division).

Deployment of first regiment with 10 SS-27 Mod 2 (RS-24) underway. First 4 became operational in December 2014; first regiment done in 2015.

News media photos show upgrade of silos.

Planned numbers are unknown, but there were 60 SS-19s in 2006 and 60 SS-27s were deployed at Tatishchevo.

Previously with SS-19 (possibly all gone).

Upgrade to SS-27 Mod 2 at Kozelsk missile field in 2012 (bottom) and 2013 (top).

Nuclear Arsenals: Russia (SSBN)

Modernization from Delta to Borei:

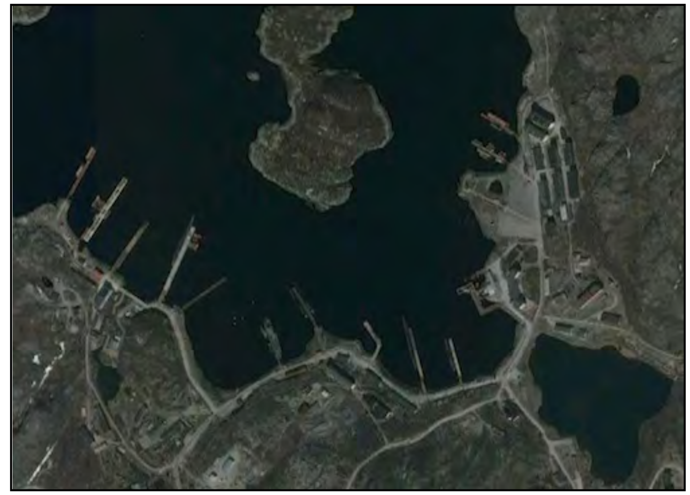
6 Delta IV, each with 16 SS-N-23 (Sineva modification)

Will likely be replaced by Borei SSBN in late-2020s

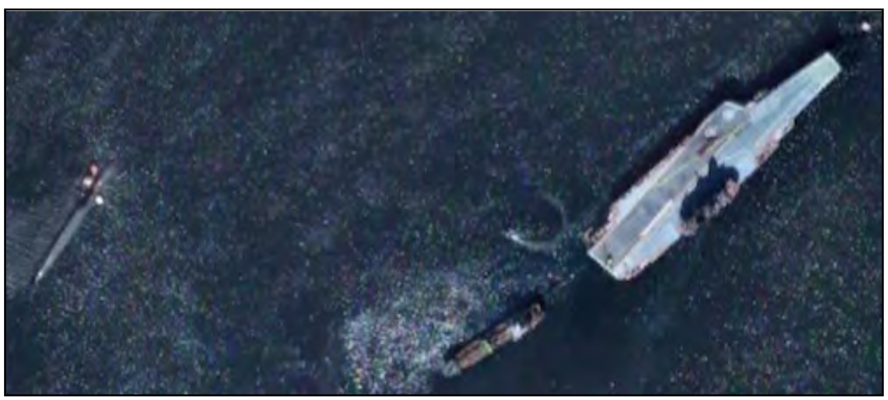
2-3 Delta III, each with 16 SS-N-18

Being replaced by Borei, starting in 2015

8 Borei (planned), each with 16 SS-N-32 (Bulava)



Russia's SSBN fleet is based at Yagelnaya (Gadzhiyevo) on the Kola Peninsula in the Barents Sea (top) and Rybachiy on the Kamchatka Peninsula in the Pacific.



A Borei SSBN captured in the Kola Bay on 20 July 2014 with the aircraft carrier Admiral Kuznetsov.

Nuclear Arsenals: Russia (SSBN)

Implications of modernization:

SSBN fleet will remain relatively stable around 8-10 operational SSBNs.

SLBMs stable at some 144 missiles.

Significant increase in warheads capacity from 528 to 800.

Weapons System	Missiles (2014)	Warheads (2014)	Missiles (2024)	Warheads (2024)
SS-N-18	48*	144	0	0
SS-N-23 (Sineva)	96**	384	32	128
SS-N-32 (Bulava)	-	-	112***	672
Total	**144**	**528**	**144**	**800**

* It is possible that only two Delta IIIs with 32 SS-N-18s are operational.
** Not all six Delta IVs are operational any given time; normally 1-2 boats are in overhaul.
*** Assume 7 of 8 planned Borei SSBNs have entered service.

Nuclear Arsenals: Russia (Bombers)

A new subsonic, low-observable long-range bomber (PAK-DA) is under development. A Tupolev design apparently was selected in 2013. Expected deployment in the mid-2020s to replace:

Tu-95MS (Bear): roughly 60 left of which perhaps 50 are operational. Carries AS-15B ALCM and bombs. Being upgraded to increase conventional capability.

Tu-160 (Blackjack): roughly 15 left of which perhaps 13 are operational. Carries AS-15A ALCM and bombs. Upgrade to increase conventional capability. Reproduction announced.

Su-22M3 (Backfire): Intermediate-range but sometimes considered strategic. Carries AS-4 ALCM and bombs. Being upgraded to increase conventional capability.

PAK-DA bomber
(subsonic, stealthy)

A new nuclear ALCM (Kh-102) has been under development for some time, possibly to replace the aging AS-15 on the Tu-95MS and Tu-160 bombers.

Nuclear Arsenals: Russia (Tactical)

- Widely dispersed forces in four Services: tactical air force, navy, defense, and army (see map)
- Warheads not on bases but in central storage
- Yet some upgrades of nuclear-storage sites at bases (Shaykovka Tu-22 base, bottom left; Kaliningrad bottom right)


May 2007


July 2007


October 2009

Nuclear Arsenals: Russia (Tactical)

Weapons System	Remarks
Air Force	
AS-4 ALCM	1967: 47 years old. For Tu-22M3
Bombs	For Tu-22M3, Su-24M, Su-34
Navy	
SS-N-9 (Malakhit)	1969: 45 years old. For ships.
SS-N-12 (Bazalt)	1976: 38 years old. For subs.
SS-N-15 (Vyuga)	1969: 47 years old. For subs/ships.
SS-N-16 (Vodopad)	1981: 33 years old. For subs.
SS-N-19 (Granit)	1980: 34 years old. For ships.
SS-N-21 (Granat)	1987: 27 years old. For subs.
SS-N-22 (Moskit)	1981: 22 years old. For ships.
SS-N-30 (Kalibr)	(2015). For subs. Replacing SS-N-21?
Torpedoes (550/650 mm)	For subs.
Depth Bombs	For ASW aircraft and helicopters.
Army	
SS-21 (Tochka)	1981: 33 years old.
SS-26 (Iskander-K)	2005: Replacing SS-21.
Defense	
S-300/A-135/coastal	Nuclear status of newer systems uncertain.

Large leftover warhead inventory of almost entirely Soviet-era weapons.

Reduced by at least 75% since 1991.

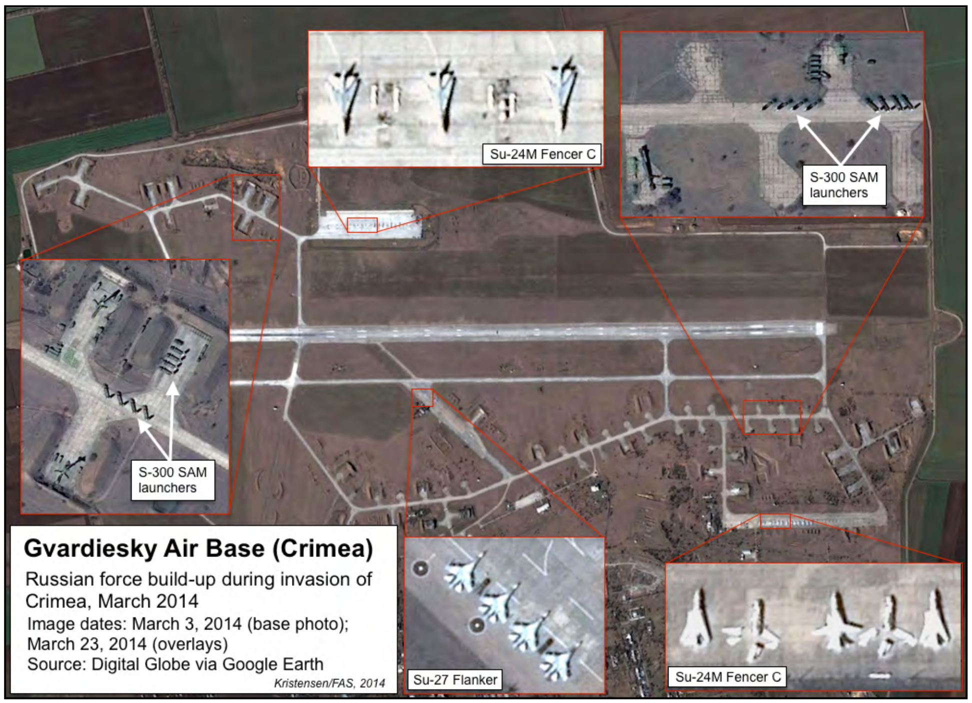
Most estimates vary from 1,800 to 2,000 warheads. DOD mentions unofficial estimates of 2,000-4,000.

All warheads in central storage; not with/on delivery vehicles.

Of current force, only three types are being modernized. Future plans are unknown.

> "The general purpose forces – to include dual-use nonstrategic nuclear forces – will continue to acquire new equipment for the near-term, but deliveries will be small and largely consist of modernized Soviet-era weapons."
>
> *US Defense Intelligence Agency, 2013*

Nuclear Arsenals: Russia (Tactical)



Because they are dual-capable, non-strategic nuclear forces are quickly drawn into conflicts: Russian deployment of S-300 air-defense and Su-24 bombers in Crimea (above); Russian Tu-22 bomber intercepted over Baltic Sea by French Mirage fighter (right).

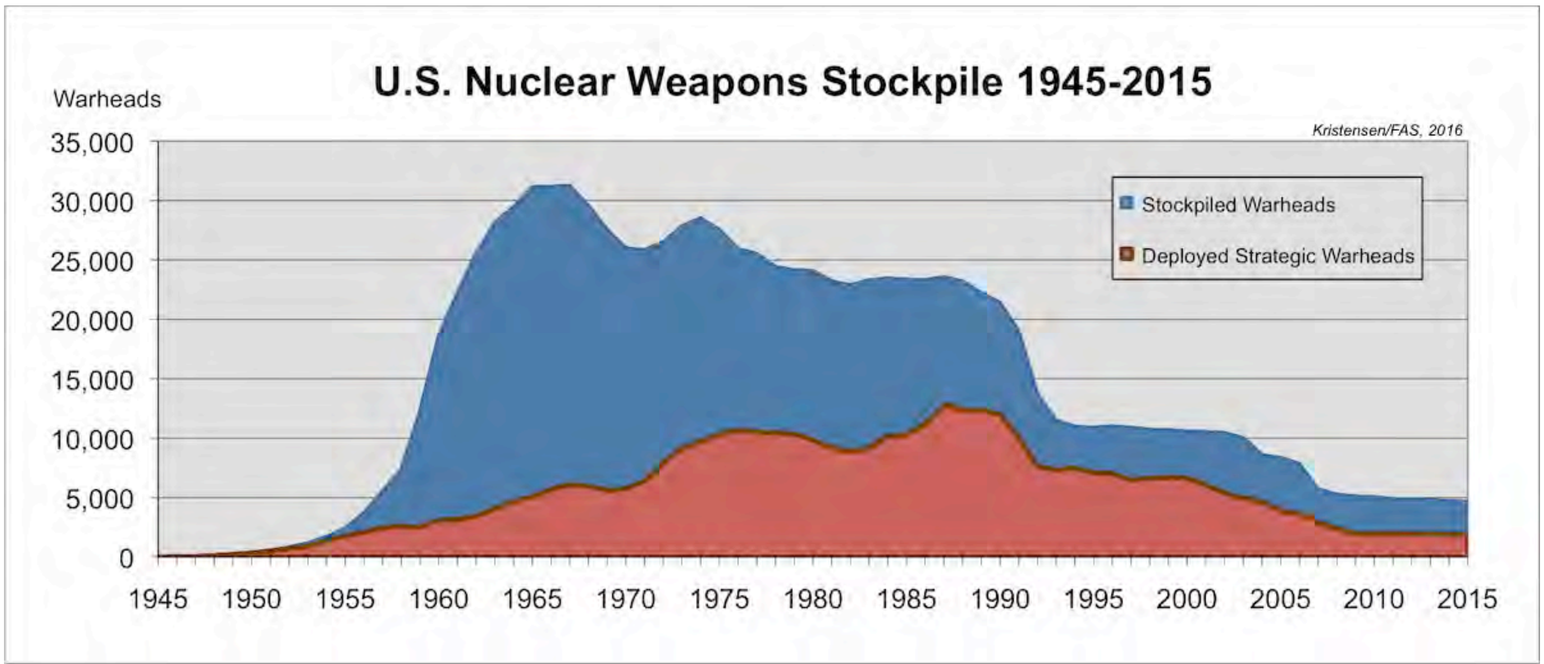
Over the past three years Russian exercises "include simulated nuclear attacks on NATO Allies (eg, ZAPAD) and on partners (eg, March 2013 simulated attacks on Sweden)…"

NATO Secretary General Annual Report 2015

Nuclear Arsenals: USA

Stockpile peaked in 1967; deployed strategic warheads peaked in 1986

Stockpile and deployed strategic warheads have not changed significantly since 2009



Nuclear Arsenals: USA

ICBM

- Minuteman III life-extension completing
- Warhead fuzes/interoperable warhead planned
- GBSD (ICBM replacement) in development

SSBN / SLBM

- Trident II D5 SLBM life-extension development
- SSBN replacement development (12 planned)
- W76-1 warhead life-extension deploying
- W88-1 warhead life-extension development

Bombers

- Upgrade of B-2 and B-52 underway
- LRS-B next-generation bomber in development
- B61-12 guided standoff bomb in development
- LRSO (ALCM) replacement in development

Tactical

- F-35A nuclear capability in development
- B61-12 guided standoff in development

Infrastructure

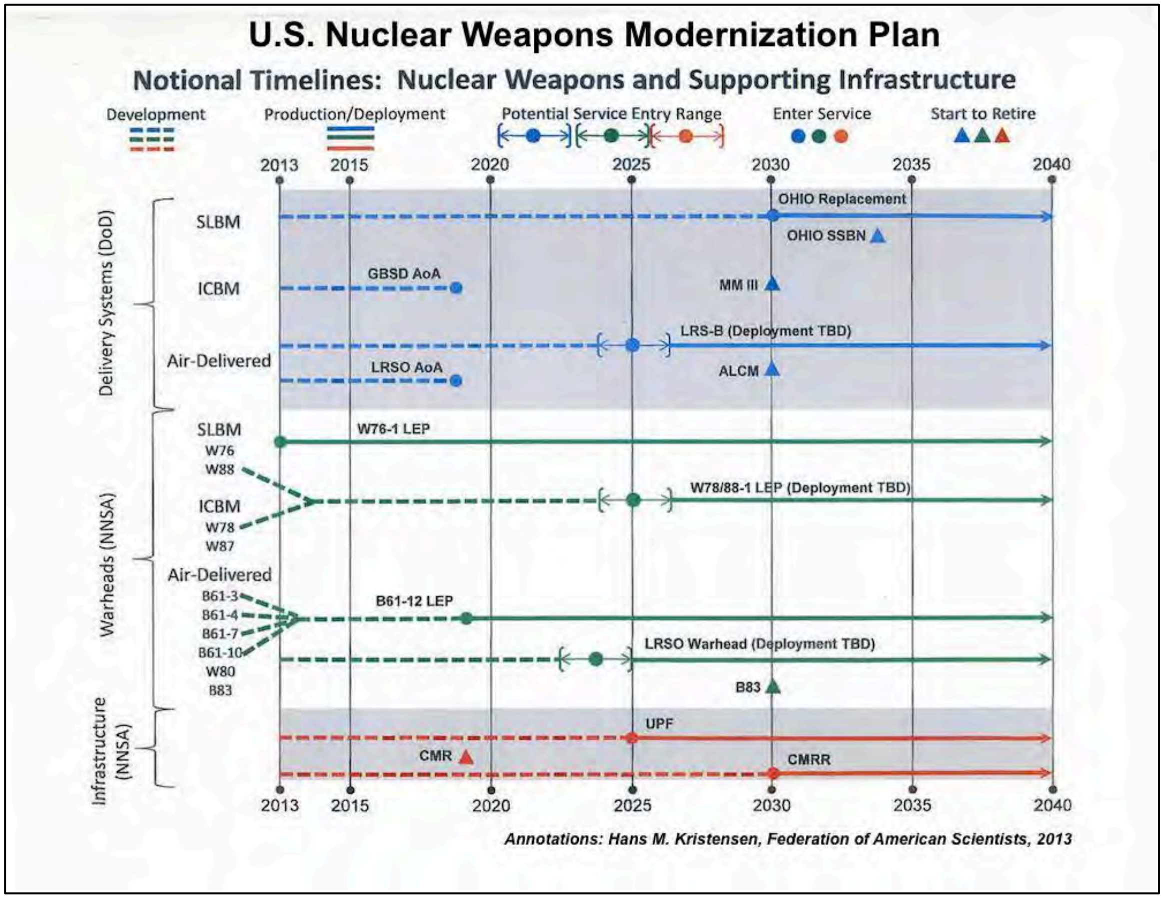
- Uranium Processing Facility (secondaries) construction
- Plutonium production facilities (primaries) construction
- Warhead surveillance/simulation facilities upgrade







Nuclear Arsenals: USA



Next 10 years:

$350 billion for maintaining and modernizing nuclear forces and infrastructure.

Comprehensive modernization:

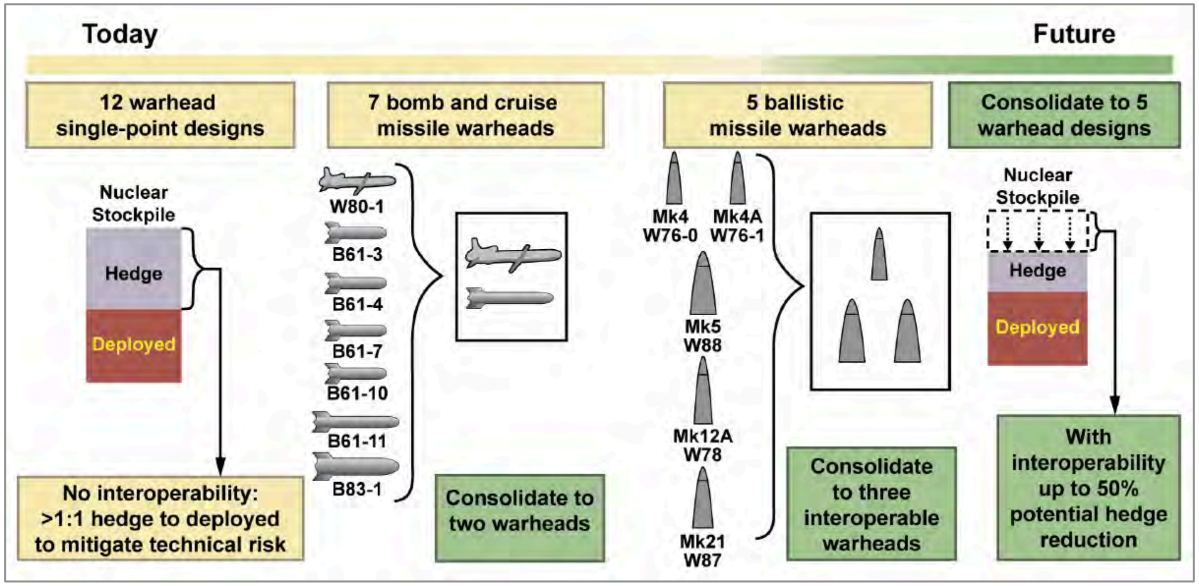
- All three legs of strategic triad
- Tactical dual-capable aircraft
- Warhead production complex

Consolidation and modification of warhead types.

Some delays happening; more expected.

Extending nuclear deterrent through 2080.

Nuclear Arsenals: USA



3+2 strategy: reduction from 12 warhead versions (8 basic designs) to 5 types:

3 "Interoperable" or "adaptable" warheads on ICBM and SLBM

IW-1 (W78/W88-1), IW-2 (W87/W88-1), IW-3 (W76-1)

2 non-interoperable warheads on bombers and fighters

ALCM (LRSO) with W80-1 or W84
B61-12 guided standoff bomb

Alleged advantages:

- Fewer warhead types permit reduction of hedge
- Modified warheads with increased safety, use control, and performance margin
- Fewer warheads will be cheaper to maintain and deploy

Possible risks:

- Modified warheads further from tested designs; reliability issues?
- Reduced stockpile diversity
- Complex and expensive programs prone to delays and cost overruns
- Modified warheads "new"?
- Costs highly uncertain and estimates probably underrated

Fundamental questions:

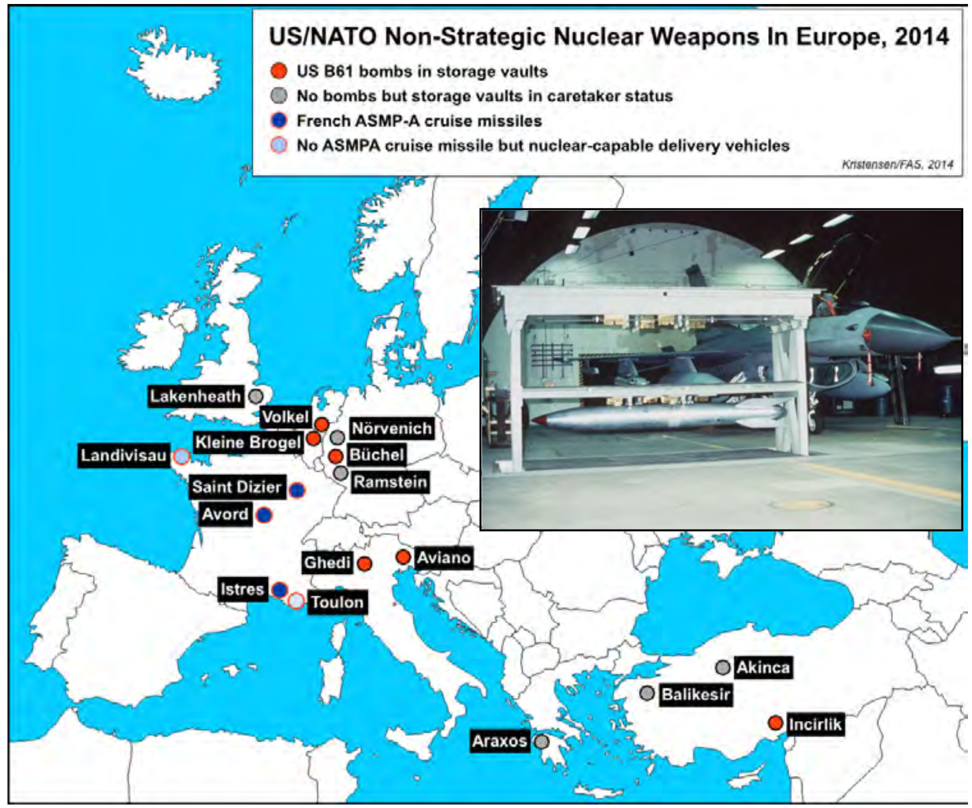
- Why is hedging necessary for missile warheads but not bomber weapons?
- Why must US hedge when Britain and France do not?
- Why is "deployed" warheads the same in the future?

Nuclear Arsenals: USA (Tactical)

- 180 U.S. B61 bombs scattered in 87 underground vaults underneath 87 aircraft shelters at six bases in five European countries:

US Nuclear Weapons In Europe 2014			
Country	**Base**	**Vaults**	**B61s**
Belgium	Kleine Brogel	11	20
Germany	Buchel	11	20
Italy	Aviano	18	50
	Ghedi Torre	11	20
Netherlands	Volkel	11	20
Turkey	Incirlik	25	50
Total		**87**	**180**

- Additional bombs in the United States for extended deterrence missions elsewhere.
- 50 French ASMPA cruise missiles at three bases for 3 squadrons (2 air and 1 naval).



Nuclear Arsenals: China

ICBM / MRBM

- DF-31A (CSS-10 Mod 2) fielding
- DF-5B (CSS-4 Mod 2) with MIRV
- DF-26 introduced
- New mobile ICBM test-launching
- Development of new mobile ICBM capable of delivering MIRV

SSBN / SLBM

- Jin (Type-094) SSBN fielding (4-5 expected)
- JL-2 (CSS-N-14) SLBM in development
- Type-096 SSBN possibly in development

Cruise Missiles:

- ALCM (CJ-20 on H-6 bomber) in development*
- GLCM (DH-10/CJ-10) fielding**

Note: China is the only of the P-5 (NPT declared) nuclear-armed states that is **increasing** its nuclear arsenal.

* Listed in 2013 AFGSC briefing.
** Listed by NASIC as "conventional or nuclear," the same designation as the Russian nuclear-capable AS-4 Kitchen ALCM.





Nuclear Arsenals: China (ICBM)

Nuclear Arsenals: China (MRBM)

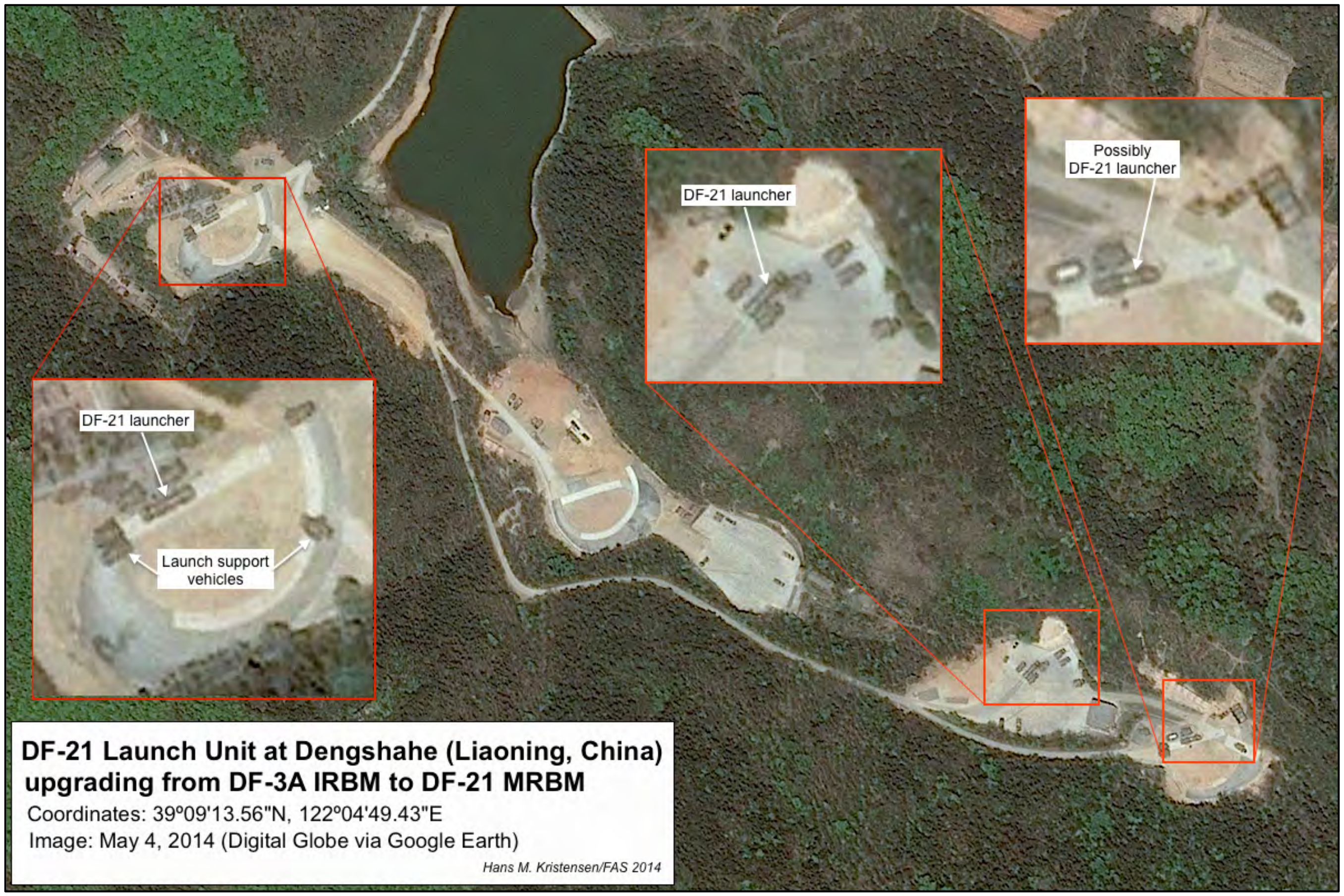
Approximately 80 nuclear (DF-21 and DF-21A).

Almost completely replaced DF-3A.

Vast training area in Delingha and Da Qaidam.

DF-21C and DF-21D conventional versions deploying.

Nuclear Arsenals: China (MRBM)



DF-21 Launch Unit at Dengshahe (Liaoning, China) upgrading from DF-3A IRBM to DF-21 MRBM
Coordinates: 39º09'13.56"N, 122º04'49.43"E
Image: May 4, 2014 (Digital Globe via Google Earth)
Hans M. Kristensen/FAS 2014

FAS

Nuclear Arsenals: China (MRBM)

Nuclear Arsenals: China (SSBN)

Building class of 4-5 Jin SSBNs
Each with 12 JL-2.

First seen in 2007 on commercial satellite photos.

4 in service, but JL-2 not yet fully operational.

All 4 said to be based at South Sea Fleet.

Big unknown: will China begin to deploy nuclear warheads on launchers in peacetime?

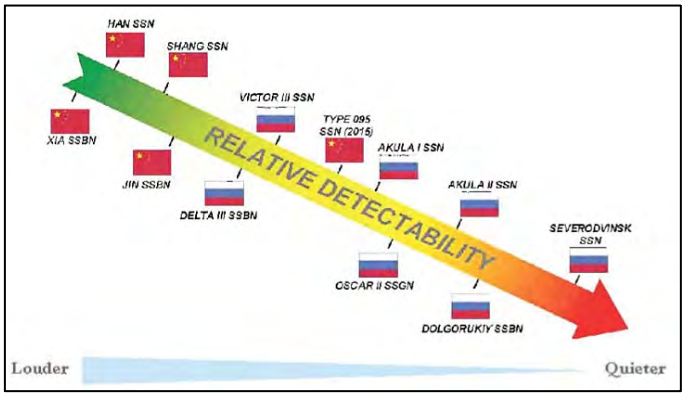
Nuclear Arsenals: China (SSBN)

Expansion of Hainan submarine base.

First Jin SSBN presence in 2008.

Base includes demagnetization facility, underground submarine pier, SLBM handling and transportation system.

Nuclear Arsenals: China (SSBN)

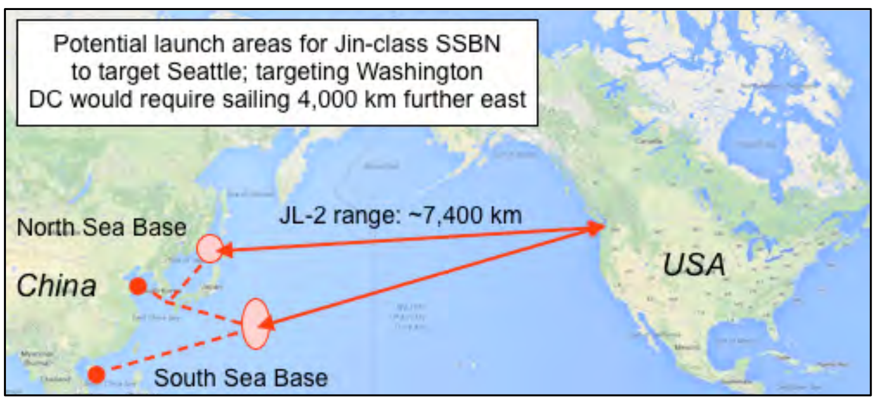


Important new capability, but…

Jin SSBN noisy compared with Russian SSBNs.

To target USA, a Jin SSBN would have to sail far into Pacific or Sea of Japan.

Command and control capability is limited.



Nuclear Arsenals: France

SSBN / SLBM

- TNO warhead on M51.2 SLBM.
- M51.3 SLBM development.

Bombers

- Rafale K3 to replace Mirage 2000N at Istres Air Base.
- Next-generation ALCM in development.

Infrastructure

- Megajoule at CESTA development.
- Airix/Epure hydrodynamic test center at Valduc development (partly Joint French-UK warhead surveillance testing center).

Nuclear Arsenals: Britain

SSBN / SLBM

- SSBN (Vanguard replacement) in development (3-4 planned).
- SLBM (Trident II D5LE) in development (USA).
- Mk4A/W76-1 type warhead fielding.

Infrastructure

- Joint UK-French warhead surveillance testing technology center development.

Nuclear Arsenals: Pakistan

MRBM / SRBM

- Shaheen III MRBM (Hatf-6) in development
- Shaheen II MRBM (Hatf-6) fielding
- NASR SRBM (Hatf-9) in development
- Abdali SRBM (Hatf-2) in development*

Cruise Missiles

- GLCM (Babur/Hatf-7) in development
- ALCM (Ra'ad/Hatf-8 on Mirage) in development
- SLCM (naval version of Babur) in development?

Infrastructure

- Khushab-IV reactor #4 construction
- Uranium enrichment facility upgrade

* Listed by Pakistani ISPR but not by 2013 NASIC report

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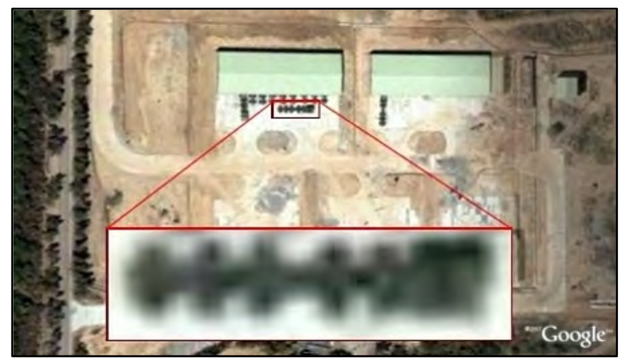
Nuclear Arsenals: Pakistan



Shaheen-II mobile launcher. Detected TELs fitting out at National Defense Complex. Not yet deployed in 2009, but probably now part of 110-130 warhead estimate. Extended-range Shaheen-III in development.

Nuclear Arsenals: India

ICBM / IRBM / MRBM

- Agni VI ICBM development (MIRV?)
- Agni V ICBM in development
- Agni IV IRBM in development
- Agni III IRBM fielding

SSBN / SLBM

- Arihant SSBN development (3+ expected).
- K-15/K-4 SLBM development.
- Dhanush SLBM fielding.

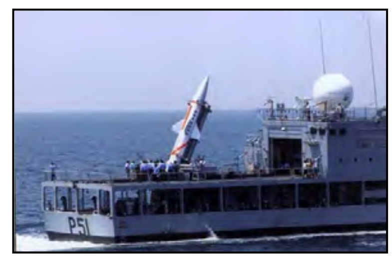
Cruise Missiles

- GLCM (Nirbhay) development*

Infrastructure

- One plutonium production reactor developing.
- Breeder reactors?

* Reported by news media but not listed in 2013 NASIC report.



Nuclear Arsenals: Israel

IRBM
- Jericho III IRBM development?

SSG / SLBM
- Dolphin SSG fielding
- SLCM (Popeye Turbo/Harpoon) rumored*

Bomber
- F-35A acquisition

* Reported by news media but denied by officials. US public intelligence reports omit references to Israeli nuclear forces

Nuclear Arsenals: North Korea

ICBM / IRBM / MRBM

- No Dong MRBM fielding
- Musudan IRBM in development
- Hwasong-13 (KN-08) ICBM in development (fielding?)
- Taepo Dong 2 SLV/ICBM in development

SSBN/SLBM

- SSBN/SLBM in early development
- Faked SLBM launch

Cruise Missiles

- KN-09 coastal defense cruise missile in development ?**

Infrastructure

- Yongbyon plutonium production reactor re-start
- Uranium enrichment production construction

Big unknown: Does North Korea have miniaturized and weaponized warhead that can be delivered by ballistic missile?

* Despite three underground nuclear tests, there is no known public evidence that North Korea has miniaturized its test devices sufficiently for delivery by ballistic missiles

** Listed by 2013 AFGSC briefing but not in 2013 NASIC report. 2014 update of AFGSC does not list KN-09

QUESTIONS?