

Sid Drell: Beyond the Blackboard

Physics of Nuclear Weapons

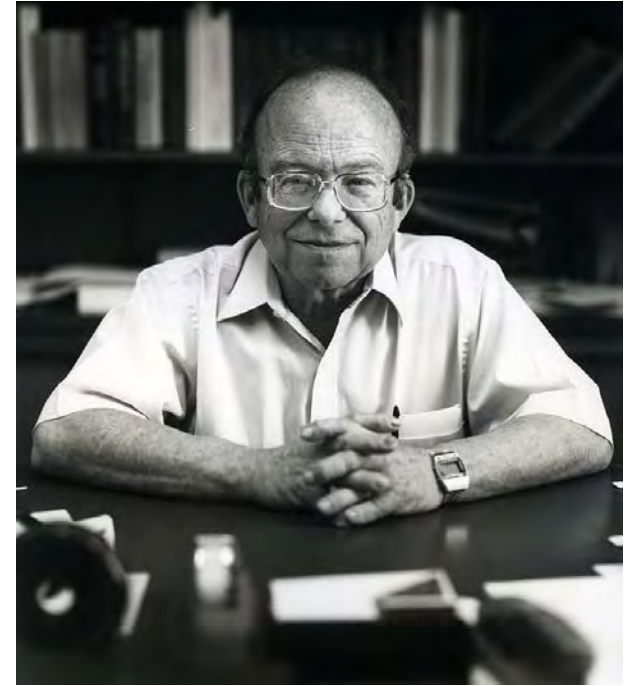
Raymond Jeanloz
University of California, Berkeley

Advisor to Presidents



... and more





The government needs independent experts, and we are fortunate that Sid is both...

Panofsky (1998)

Physics-Based Policy for Nuclear Weapons

- 1) Stockpile stewardship and nuclear-explosion ban
- 2) World without nuclear weapons “joint enterprise”
- 3) Nuclear-weapons safety & security

JASON

- Founding member – Townes call 1960

I personally think the biggest impact has been creating a generation of scientists... who have had an impact through their direct involvement, either because of the studies they did which then caused defense scientists or parts of the Defense Department to see things better, or because we've entered the public debate...

Drell (1986)

Science Based Stockpile Stewardship

S. Drell, Chairman

November 1994

JSR-94-345

Approved for public release; distribution unlimited

JASON
The MITRE Corporation
7525 Colshire Drive
McLean, Virginia 22102 USA
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NUCLEAR TESTING

Summary and Conclusions

Sidney Drell, Chair

JSR-95-320

August 3, 1995

(UNCLASSIFIED)
Cleared for release August 4, 1995

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“Stewardship” of US nuclear weapons
Objective: Provide technical basis for US adopting
Comprehensive Nuclear Test Ban Treaty (CTBT)

CTBT: Article I

1. Each State Party undertakes not to carry out any nuclear weapon test explosion or any other nuclear explosion, and to prohibit and prevent any such nuclear explosion at any place under its jurisdiction or control.
2. Each State Party undertakes, furthermore, to refrain from causing, encouraging, or in any way participating in the carrying out of any nuclear weapon test explosion or any other nuclear explosion.

Status of Stockpile Stewardship

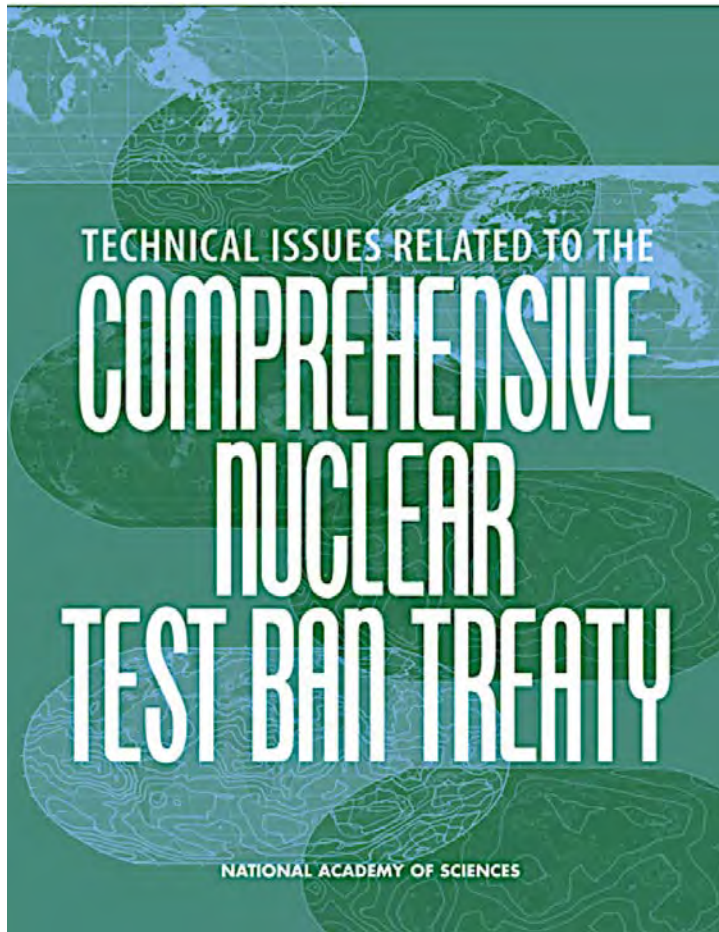
Successful annual assessments of stockpile

Successful life-extension programs

Re-establishment of pit production technology

Retention of core capabilities

- Advances in understanding weapon performance
- Advances in understanding materials
- Developments at experimental facilities



Study starts 2000
Publication: 2002



Study starts 2009
Publication: 2012

Available at National Academies Press
nap.edu

Summary of National Academy of Sciences Studies

Objectives

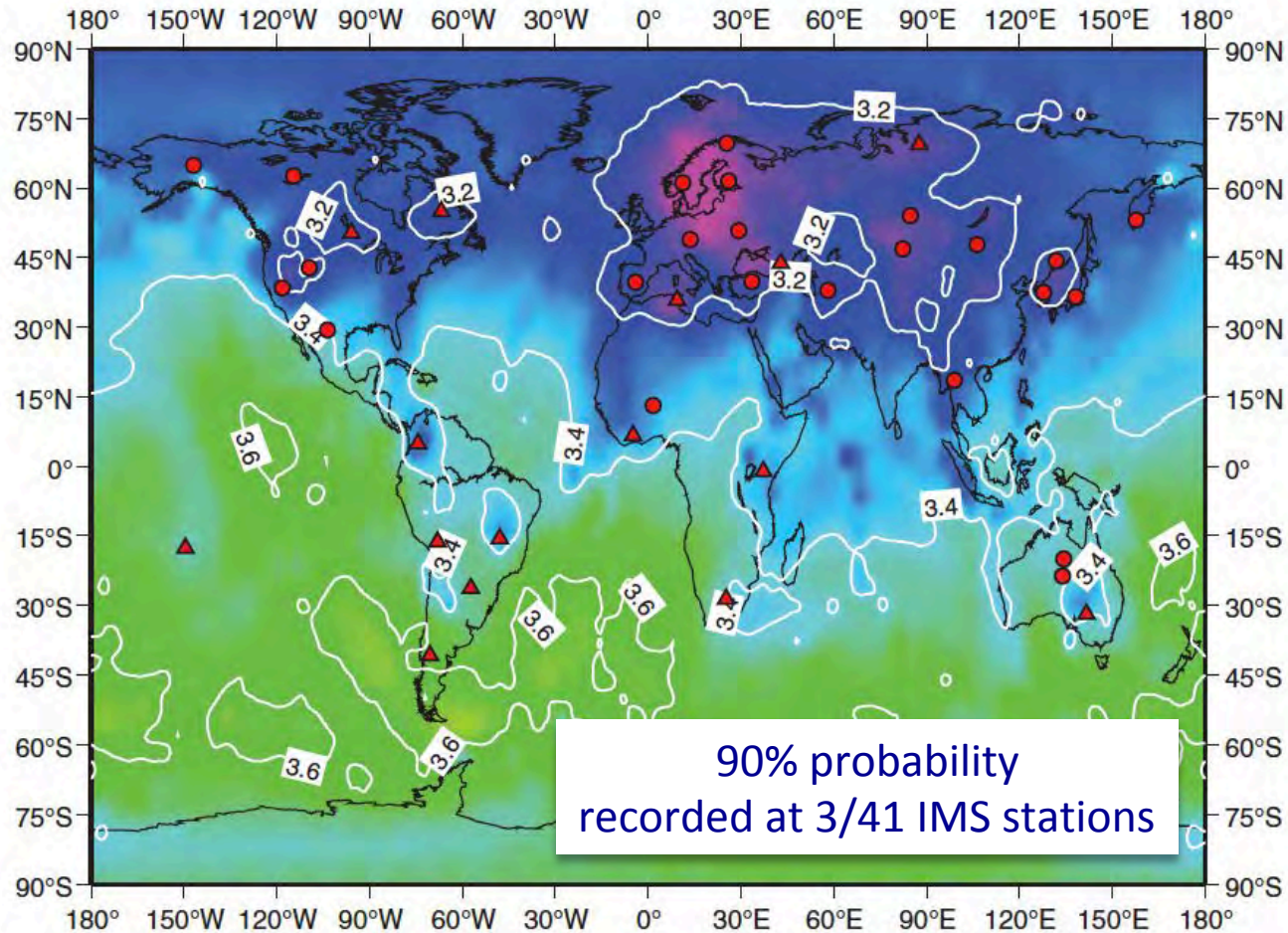
- 1) Assess maintaining US nuclear weapons capabilities
- 2) Assess nuclear-explosion monitoring
- 3) Assess constraints on nuclear proliferation

Conclusions of studies

2000: Adequate plan

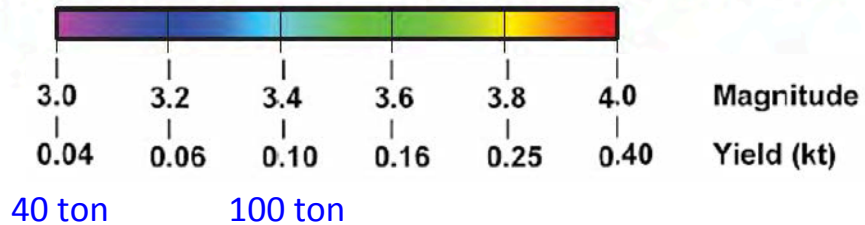
2009: Proven capabilities better than planned

Treaty Monitoring

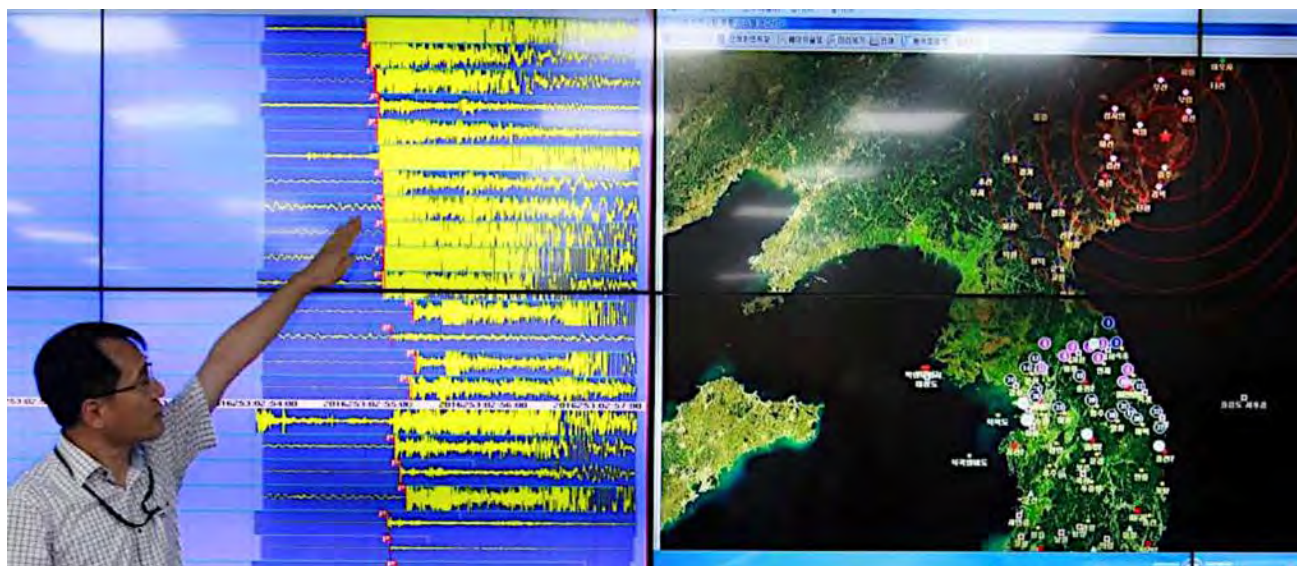


International Monitoring System (IMS)

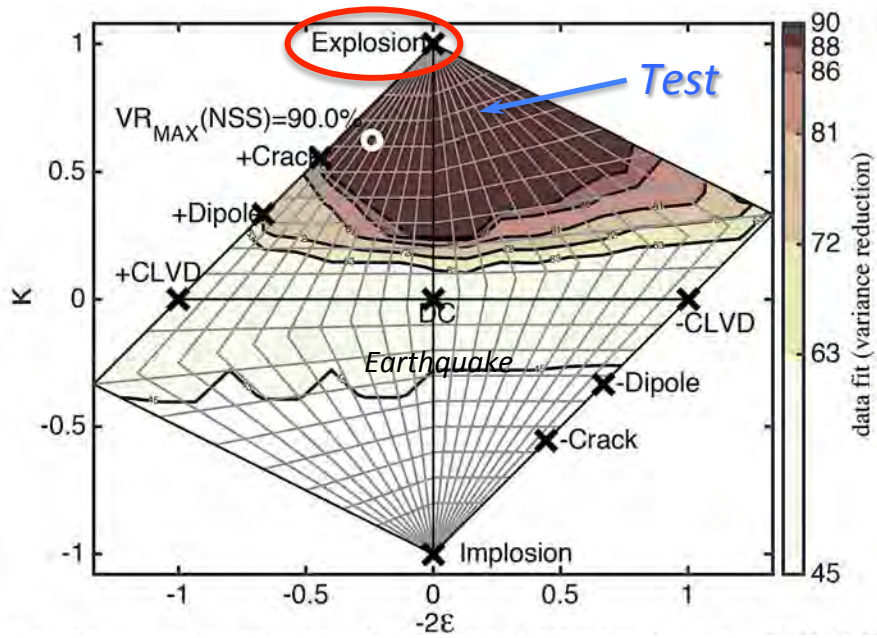
50 primary stations
120 auxiliary stations



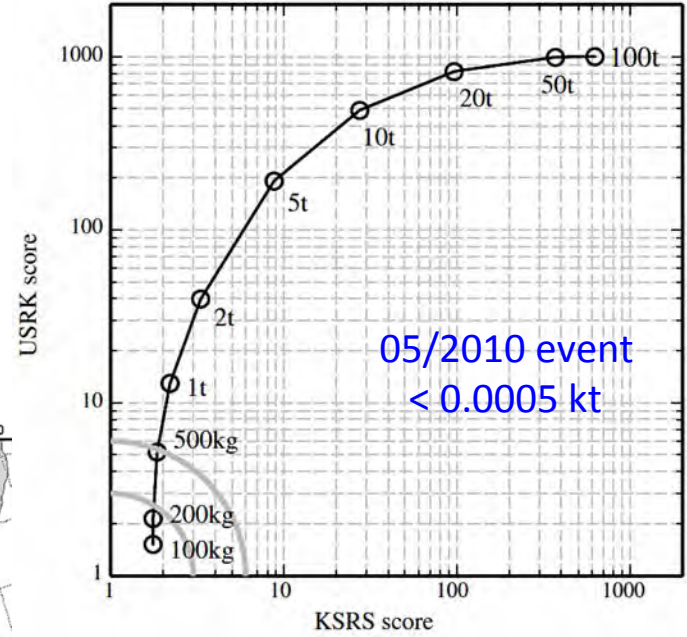
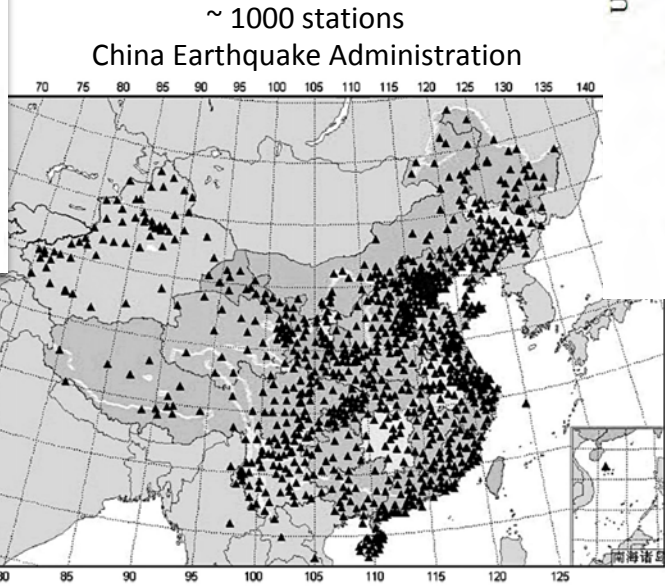
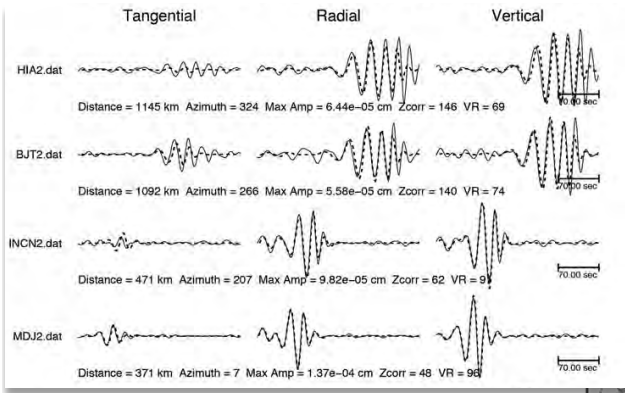
North Korea



| | |
|------------|----------|
| 10/09/2006 | ~ 0.5 kt |
| 05/25/2009 | ~ 2 |
| 02/12/2013 | ~ 10 |
| 01/06/2016 | ~ 5 |
| 09/09/2016 | ~ 12 |
| 09/03/2017 | ~ 250 |



| | |
|------------|----------|
| 10/09/2006 | ~ 0.5 kt |
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| 09/03/2017 | ~ 250 |



Dreger (2016)

Ford & Walter (2015)

Richards, 2017

2) World without nuclear weapons
“joint enterprise”

“Gang of Four”

COMMENTARY

A World Free of Nuclear Weapons

By George P. Shultz, William J. Perry, Henry A. Kissinger and Sam Nunn

Updated Jan. 4, 2007 12:01 a.m. ET



THE WALL STREET JOURNAL.



“Gang of Four”

COMMENTARY

A World Free of Nuclear Weapons

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Updated Jan. 4, 2007 12:01 a.m. ET



Deterrence in the Age of Nuclear Proliferation

The doctrine of mutual assured destruction is obsolete in the post-Cold War era.

By George P. Shultz, William J. Perry, Henry A. Kissinger And Sam Nunn

Updated March 7, 2011 12:01 a.m. ET

Next Steps in Reducing Nuclear Risks

The pace of nonproliferation work today doesn't match the urgency of the threat.

By George P. Shultz, William J. Perry, Henry A. Kissinger And Sam Nunn

March 5, 2013 8:20 p.m. ET

THE WALL STREET JOURNAL.

Toward a Nuclear-Free World

By George P. Shultz, William J. Perry, Henry A. Kissinger and Sam Nunn

Updated Jan. 15, 2008 11:59 p.m. ET



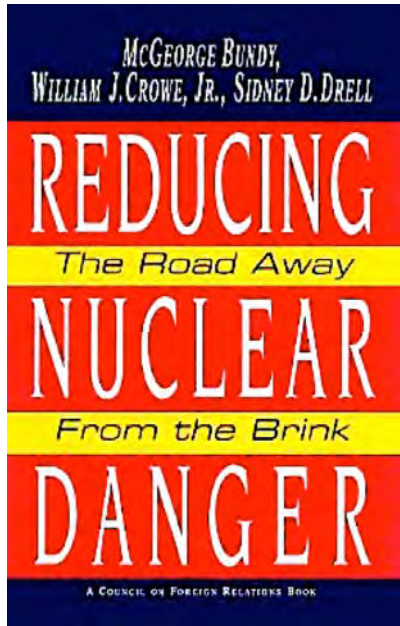
“Joint Enterprise”

- *Reassertion of the vision of a world free of nuclear weapons and practical measures toward achieving that goal... a bold initiative consistent with America's moral heritage.*
- *Without the bold vision, the actions will not be perceived as fair or urgent. Without the actions, the vision will not be perceived as realistic or possible.*
- *We endorse setting the goal of a world free of nuclear weapons and working energetically on the actions required to achieve that goal, beginning with the measures outlined above.*

Shultz, Perry, Kissinger & Nunn (2007)

Steps would include...

- *Changing the Cold War posture of deployed nuclear weapons to **increase warning time** and thereby reduce the danger of an accidental or unauthorized use of a nuclear weapon.*
- *Continuing to **reduce substantially** the size of nuclear forces in all states that possess them.*
- ***Eliminating short-range** nuclear weapons designed to be forward-deployed.*
- ***Initiating a bipartisan process** with the Senate, including understandings to increase confidence and provide for periodic review, to achieve ratification of the Comprehensive Test Ban Treaty, taking advantage of recent technical advances, and working to secure ratification by other key states.*
- ***Providing the highest possible standards** of security for all stocks of weapons, weapons-usable plutonium, and highly enriched uranium everywhere in the world.*
- *Getting **control of the uranium enrichment process**, combined with the guarantee that uranium for nuclear power reactors could be obtained at a reasonable price, first from the Nuclear Suppliers Group and then from the International Atomic Energy Agency (IAEA) or other controlled international reserves. It will also be necessary to deal with proliferation issues presented by spent fuel from reactors producing electricity.*
- ***Halting the production** of fissile material for weapons globally; phasing out the use of highly enriched uranium in civil commerce and removing weapons-usable uranium from research facilities around the world and rendering the materials safe.*
- *Redoubling our efforts to **resolve regional confrontations** and conflicts that give rise to new nuclear powers.*



Bundy, Crowe & Drell (1993)

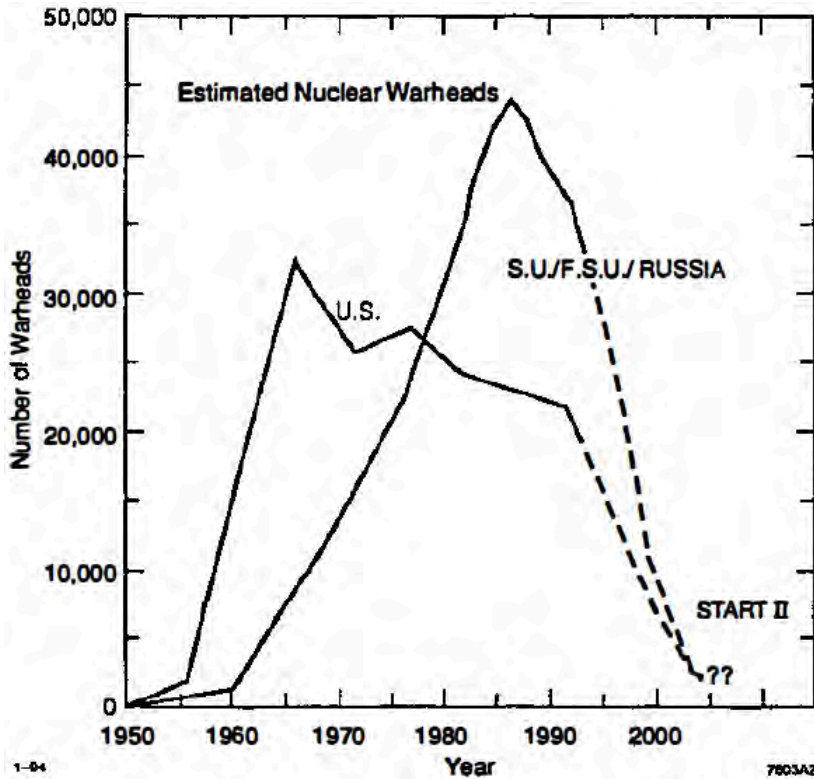


Drell & Goodby (2007)

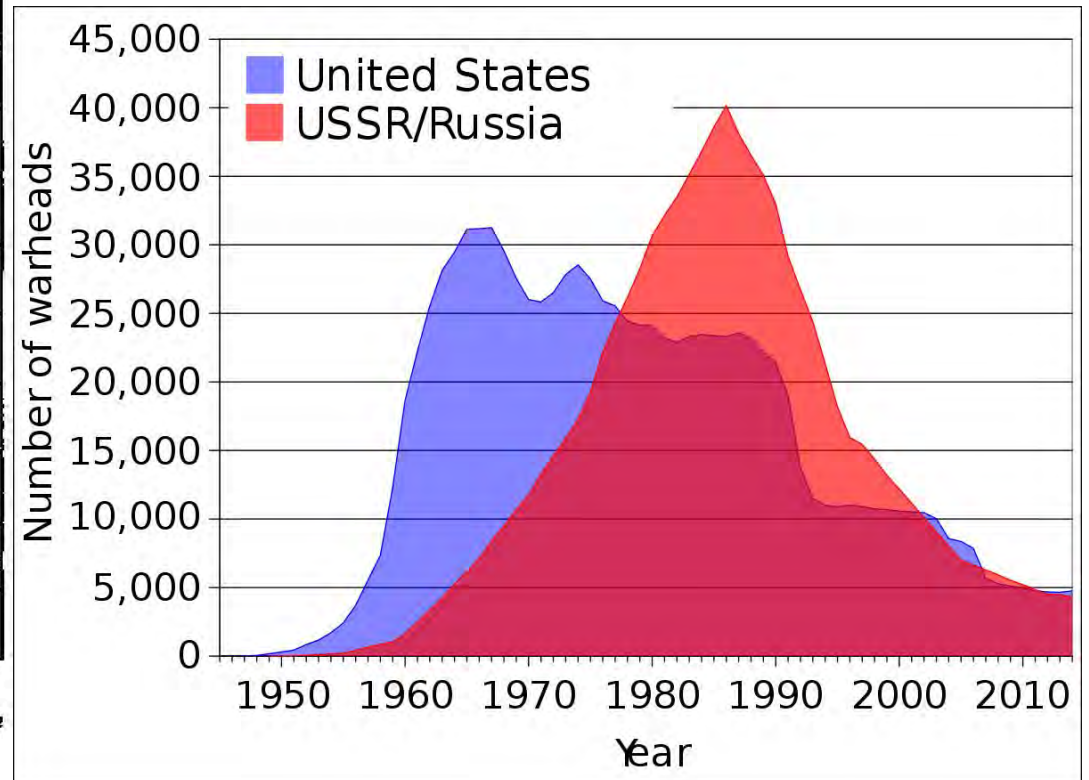


Drell & Goodby (2003)

Nuclear Arsenals



Drell & Peurifoy (1994)



Wikipedia

April 05, 2009

Remarks By President Barack Obama In Prague As Delivered

THE WHITE HOUSE



RELIGION 01/08/2018 06:34 am ET

Pope Francis Calls For Ban On Nuclear Weapons

He noted that the Holy See was among 122 states that last year agreed to a UN treaty to ban nuclear weapons.

REUTERS | By Philip Pullella

SEPTEMBER 20, 2017

Dozens of states sign nuclear weapons ban treaty at United Nations

Reuters



The Nobel Peace Prize 2017

International Campaign to Abolish Nuclear Weapons (ICAN)



3) Nuclear-weapons safety & security

Safety related technologies need to be robust – Goldsboro, NC Accident

Every safety mechanism had failed, except one: the ready/safe switch in the cockpit. The switch was in the SAFE position when the bomb dropped. Had the switch been set to GROUND or AIR, the X-unit would've charged, the detonators would've triggered, and a thermonuclear weapon would have exploded in a field near Faro, North Carolina. When Air Force personnel found the Mark 39 later that morning, the bomb was harmlessly stuck in the ground, nose first, its parachute draped in the branches of a tree.

“It would have been bad news—in spades,” Parker F. Jones, a safety engineer at Sandia, wrote in a memo about the accident. “One simple, dynamo-technology, low-voltage switch stood between the United States and a major catastrophe!”

Eric Schlosser, *Command and Control* (2013)

Jan. 23, 1961



Table 1A.1 Summary of Accidents Involving U.S. Nuclear Weapons^a

| Accident Number | Date | Location | Weapon Configuration ^b | | Type of Accident | Nuclear Weapon Response | | |
|-----------------|------------|--------------------------|-----------------------------------|---------------------|-----------------------------------|-------------------------|---------------|----------------------------|
| | | | Assembled Weapons | Unassembled Weapons | | HE Response | | Contamination ^c |
| | | | | | | HE Burn | HE Detonate | |
| 1 | 02/13/50 | Puget Sound, WA | — | X | Jettison, 8000' | — | X | — |
| 2 | 04/11/50 | Manzano Base, NM | — | X | Crash into mountain | X | — | — |
| 3 | 07/13/50 | Lebanon, OH | — | X | Crash in dive | — | X | — |
| 4 | 08/05/50 | Fairfield-Suisan AFB, CA | — | X | Emergency landing, fire | — | X | — |
| 5 | 11/10/50 | Over water, outside U.S. | — | X | Jettison | — | X | — |
| 6 | 03/10/56 | At sea (Mediterranean) | — | X | Aircraft lost | — | — | — |
| 7 | 07/27/56 | SAC Base | — | X | B-47 crashed into bunker | — | — | — |
| 8 | 05/22/57 | Kirtland AFB, NM | — | X | Inadvertent jettison | — | X | X |
| 9 | 07/28/57 | At sea (Atlantic) | — | X | Jettisons, 4500' & 2500' | — | — | — |
| 10 | 10/11/57 | Homestead AFB, FL | — | X | Crash on takeoff, fire | X | X (low order) | — |
| 11 | 01/31/58 | SAC base overseas | X | — | Taxi exercise, fire | X | — | X |
| 12 | 02/05/58 | Savannah, GA | — | X | Mid-air collision, jettison | — | — | — |
| 13 | 03/11/58 | Florence, SC | — | X | Accidental jettison | — | X | — |
| 14 | 11/06/58 | Dyess AFB, TX | X | — | Crash on takeoff | — | X | X |
| 15 | 11/26/58 | Chenault AFB, LA | X | — | Fire on ground | X | — | — |
| 16 | 01/08/59 | U.S. base, Pacific | — | X | Ground alert, fuel tanks on fire | — | — | — |
| 17 | 07/06/59 | Barksdale, AFB, LA | X | — | Crash on takeoff, fire | X (1/3) ^d | — | X (1/3) |
| 18 | 09/25/59 | Off Whidbey Is., WA | — | X | Navy aircraft ditched | — | — | — |
| 19 | 10/15/59 | Hardinsburg, KY | X | — | Mid-air collision, impact | X (2/2) | — | — |
| 20 | 06/07/60 | McGuire AFB, NJ | X | — | Missile fire | X | — | X |
| 21 | 01/24/61 | Goldboro, NC | X | — | Mid-air breakup | — | — | — |
| 22 | 03/14/61 | Yuba City, CA | X | — | Crash after abandonment | — | — | — |
| 23 | 11/13/63 | Medina Base, TX | — | X | Storage igloo at AEC plant | X | X | X |
| 24 | 01/11/64 | Cumberland, MD | X | — | Mid-air breakup, crash | — | — | — |
| 25 | 12/05/64 | Ellsworth AFB, SD | X | — | Missile reentry vehicle fell | — | — | — |
| 26 | 12/08/64 | Bunker Hill AFB, IN | X | — | Taxi crash, fire | X (3/5) | — | X (1/5) |
| 27 | 10/11/65 | Wright-Patterson AFB, OH | — | X | Transport aircraft fire on ground | — | — | X |
| 28 | 12/05/65 | At sea, Pacific | X | — | Aircraft rolled off elevator | — | — | — |
| 29 | 01/17/66 | Palomares, Spain | X | — | Mid-air collision, crash | — | X (2/4) | X (2/4) |
| 30 | 01/21/68 | Thule, Greenland | X | — | Crash after abandonment | — | X (4/4) | X (2/4) |
| 31 | Spring '68 | At sea, Atlantic | X | — | Lost weapons | — | — | — |
| 32 | 09/19/80 | Damascus, AK | X | — | Missile fuel explosion | — | — | — |

^a Source: DoD in coordination with DOE. 1981. *Narrative Summaries of Accidents Involving U.S. Nuclear Weapons 1950–1980*.

^b The term “assembled weapon” refers to either the separable nuclear capsule that was installed but was not in the bomb’s pit or a sealed-pit type of weapon with the nuclear material integral with the HE subsystem. “Unassembled weapons” means that the separable nuclear capsule was not installed in the weapon or that only weapon components were involved. (The USAF press release for accidents 1–13 used the term “assembled weapon” for the above plus where a capsule was on the aircraft).

^c Contamination from all accidents except 29 and 30 was low in radioactivity and highly localized in areas affected.

^d In the parentheses, the first number indicates the number of weapons that had the named response, and the second number gives the total involved in the accident.

NUCLEAR WEAPONS SAFETY

R E P O R T

OF THE

PANEL ON NUCLEAR WEAPONS SAFETY

OF THE

**COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES**

ONE HUNDRED FIRST CONGRESS

SECOND SESSION



DECEMBER 1990

**U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1990**

J. 36-661

REPORT

of

THE PANEL ON NUCLEAR WEAPONS SAFETY

of

The House Armed Services Committee

SIDNEY D. DRELL, *Chairman*

JOHN S. FOSTER, JR.

CHARLES H. TOWNES

DECEMBER 1990

(III)

1990 Drell, Foster, Townes Safety Panel findings reinforced previous studies of safety needs

Concerns about the safety of several of the nuclear weapons systems in the U.S. arsenal have led the government to take immediate steps to reduce the risk of unintended, accidental detonations that could result in dispersing plutonium into the environment in potentially dangerous amounts or even generate a nuclear yield. These steps include temporarily removing the short-range air-to ground attack missiles, SRAM-A, from the alert bombers of the Strategic Air Command and modifying some of the artillery-fired atomic projectiles (AFAPs) deployed with U.S. Forces.

Modernization and improvement programs gave priority to military requirements... Safety in general was not viewed with the same urgency.

Specifically, safety, security and use control should be treated together because of their critical importance and their interdependence.

Surety: Safety & Security

A major consequence of these results is a realization that unintended nuclear detonations present a greater risk than previously estimated (and believed) for some of the warheads in the stockpile.

Nuclear Weapon Design Safety

The following are safety criteria design requirements for all U.S. nuclear weapons:

- *Normal environment*—Prior to receipt of the enabling input signals and the arming signal, the probability of a premature nuclear detonation must not exceed one in a billion per nuclear weapon lifetime. $1:10^9$
- *Abnormal environment*—Prior to receipt of the enabling input signals, the probability of a premature nuclear detonation must not exceed one in a million per credible nuclear weapon accident or exposure to abnormal environments. $1:10^6$
- *One-point safety*—The probability of achieving a nuclear yield greater than four pounds of TNT equivalent, in the event of a one-point initiation of the weapon's high explosive, must not exceed one in a million. $1:10^6$

Public disclosures helped to focus government attention on addressing concerns

The Washington Post

DEFECTIVE NUCLEAR SHELLS RAISE SAFETY CONCERNS

By R. Jeffrey Smith May 23, 1990

The New York Times

May 24, 1990

Flawed Nuclear Arms Repaired Secretly

By KEITH SCHNEIDER, Special to The New York Times

WASHINGTON, May 23— Nuclear arms experts said today that more than 300 nuclear artillery shells deployed in Europe were brought back to this country and secretly repaired over the last 18 months because of design defects

May 28, 1990

Interest Rises in Studies of Atomic Shells

By KEITH SCHNEIDER, Special to The New York Times

WASHINGTON, May 27— The disclosure of a flaw in the design of nuclear artillery shells deployed in Europe has generated new interest in a number of Government studies that said 14 types of nuclear weapons had been temporarily withdrawn from the American arsenal since 1961 for repairs.

TECHNICAL ISSUES OF A NUCLEAR TEST BAN

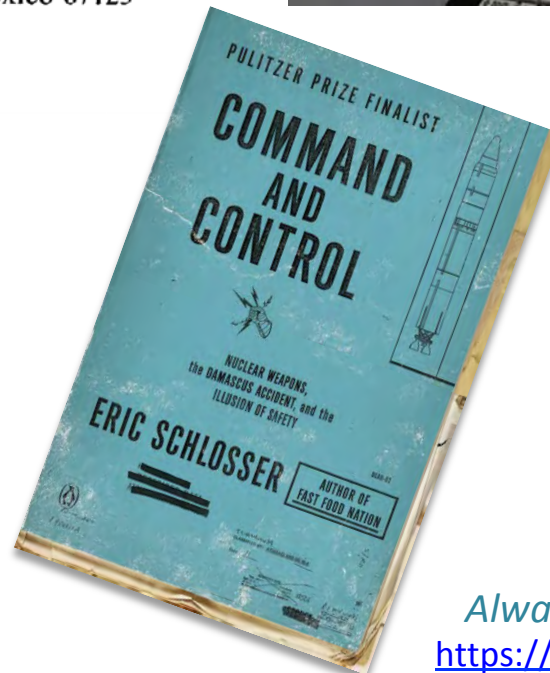
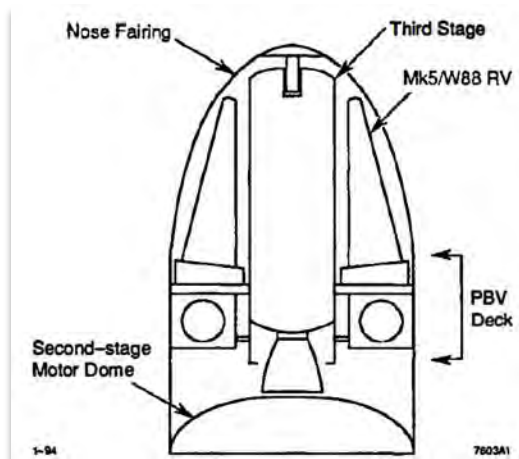
Sidney Drell

Stanford Linear Accelerator Center, P.O. Box 4349, Stanford, California
94309

Bob Peurifoy

909 Four Hills Road Southeast, Albuquerque, New Mexico 87123

KEY WORDS: testing, safety, reliability



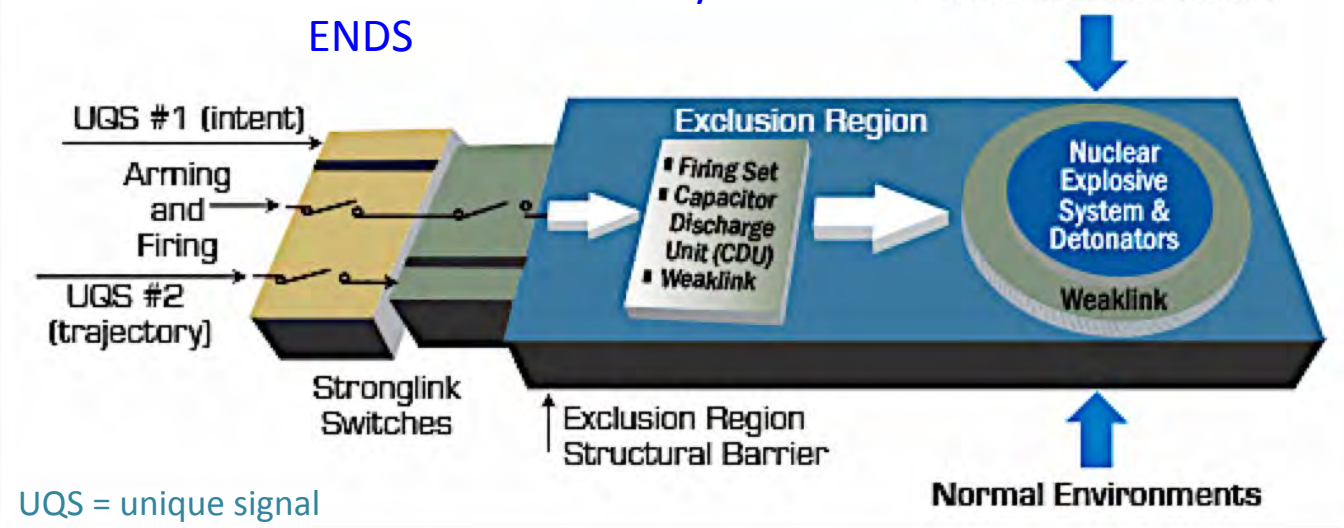
Always/Never (5 hour history)
<https://nsarchive2.gwu.edu/nukevault/ebb498/>



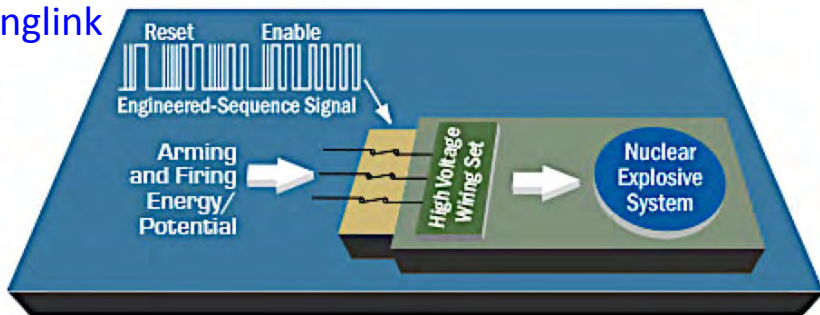
NUCLEAR MATTERS HANDBOOK 2016

OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR NUCLEAR MATTERS

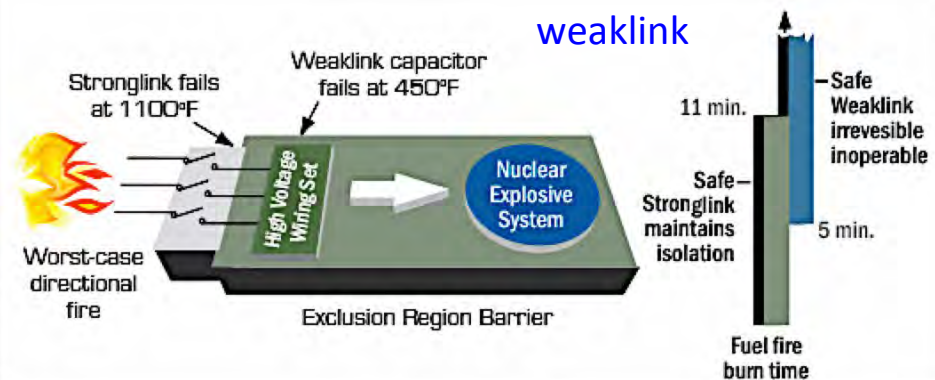
enhanced nuclear detonation safety



stronglink



weaklink



Nuclear Weapons Surety (Safety & Security)

- 1) Path to a catastrophic event
- 2) Potential for nuclear crisis
- 3) Difficult to discuss