

CONFRONTING THE PERPETUAL MENACE CAN WE HAVE NUCLEAR DISARMAMENT WITHOUT NUCLEAR TRANSPARENCY?

Alex Glaser Princeton University

Copenhagen, December 11, 2020

Painting by Helen Audrey Schrayer, Acrylic on Canvas, 2017 Revision 4b

OUTLINE

BACKGROUND

(How we got here)

DEALING WITH SECRETS

(Nuclear weapons and arms control)

WHAT SCIENTISTS & ENGINEERS CAN DO

(Elements of a research agenda)

OUTLOOK

(Next steps for nuclear arms control & verification)

BACKGROUND (How we got here)

200 kt

(47.8 square miles) Area destroyed by mass fire

200 kt (5.7 square miles) Area destroyed by air blast

> **16 kt** Hiroshima-sized explosion (1.1 square miles)

A modern nuclear weapon has a destructive power tens to hundreds of times greater than the Hiroshima bomb

New York City

A 200-kt nuclear explosion would immediately kill more than 1,300,000 million people in New York City and the surrounding areas. Fallout effects would significantly increase this number.

Credit: S. Glasstone and Philip Dolan, The Effects of Nuclear Weapons, 3rd Edition, Washington, DC, 1977 and nuclearsecrecy.com/nukemap

Even a "limited" nuclear war would have global environmental consequences Smoke from a regional nuclear war between India and Pakistan



Alan Robock and Luke Oman, <u>climate.envsci.rutgers.edu/nuclear</u> and <u>www.atmos-chem-phys.net/7/2003/2007</u>; see also, Toon et al., Science Advances, October 2019



Hans Kristensen and Robert Norris, Nuclear Notebook, Federation of American Scientists and thebulletin.org/nuclear-notebook-multimedia



www.youtube.com/watch?v=2jy3JU-ORpo

There never has been a moment's justification for having the capability to destroy humanity.

Daniel Ellsberg

75 YEARS OF NUCLEAR WEAPONS (CAN YOU SPOT THE DIFFERENCES IN THESE PICTURES?)



U.S. W80-4 cruise missile warhead Source: NNSA/Sandia National Laboratory



North Korean two-stage weapon Source: KCNA

The H-Bomb, the Progressive Case and National Security

Bor

A. DeVolpi G.E. Marsh T.A. Postol G.S. Stanford



ALEX WELLERSTEIN



BOHR ON THE NUCLEAR CHALLENGE "A PERPETUAL MENACE TO HUMAN SECURITY"



FROM THE 1944 MEMORANDUM TO PRESIDENT ROOSEVELT

"Unless ... some agreement about the control of the use of the new active materials can be obtained in due time, any temporary advantage, however great, may be outweighed by a perpetual menace to human security."

www.atomicarchive.com/resources/documents/manhattan-project/bohr-memo.html



FROM THE 1950 OPEN LETTER TO THE UNITED NATIONS

"Free access to information and unhampered opportunity for exchange of ideas must be granted everywhere. [...] It must be realized that full mutual openness, only, can effectively promote confidence and guarantee common security."

www.atomicarchive.com/resources/documents/deterrence/bohr-un-letter.html

THE TURNING POINT (1989/1990)



U.S. OPENNESS INITIATIVE, 1993

NEWS



FOR IMMEDIATE RELEASE

December 7, 1993



NEW MEDIA CONTACT: Sam Grizzle, 202/586-5806

ENERGY SECRETARY UNVEILS OPENNESS INITIATIVE

Secretary of Energy Hazel R. O'Leary today launched a comprehensive initiative to lift the veil of Cold War secrecy and move the Department of Energy (DOE) into a new era of government openness. As a beginning to the process, O'Leary released information about the nation's nuclear weapons program that has been kept secret for 50 years. "Secretary O'Leary's bold new initiative will allow a more informed group of stakeholders to work with the Department of Energy to solve the problems that face our Nation," said President Bill Clinton, who has directed federal agencies to dramatically increase the public's access to information about its government. "This new policy will ensure maximum disclosure of information and technologies critical to the Nation's economic and global Examples of previously classified information being disclosed for the first time include:

were kept secret; some

RESTRICTED DATA DECLASSIFICATION DECISIONS (RDD-8), 1994–2002



"A New Approach. The breakup of the former Soviet Union, the end of the Cold War, and other national and international events of recent history have enabled our national leadership to reconsider the constraints placed on both classified and unclassified Government information. The Department of Energy (DOE) remains committed to a policy of responsible openness, and will continue ... to declassify and release information to the public consistent with the requirements of national security" (p. i).

u. Hypothetically, a mass of 4 kilograms of plutonium or uranium-233 is sufficient for one nuclear explosive device. (94-1)

x. Fact that all U.S. weapon pits that contain plutonium have at least 500 grams of plutonium, no elaboration. (99-4)

Restricted Data Declassification Decisions: 1946 to the Present (RDD-8), U.S. Department of Energy, Washington, DC, January 2002 <u>www.osti.gov/includes/opennet/od/RDD-8%203-16-04%20reprint-Lined%20out.pdf</u>

U.S. FISSILE MATERIAL DECLARATIONS (1996, 2001/2005)



Plutonium: The First 50 Years, U.S. Department of Energy, Washington, DC, 1996, <u>ipfmlibrary.org/doe96.pdf</u> *Highly Enriched Uranium: Striking a Balance,* U.S. Department of Energy, Washington, DC, 2001, <u>ipfmlibrary.org/doe01.pdf</u>

There is enough nuclear explosive material worldwide to make over 200,000 nuclear weapons

1340 tons of highly enriched uranium (HEU)



Each block corresponds to 12 kg of HEU, the amount necessary to make a fission bomb; about 111,670 bombs-worth total

Each block corresponds to 4 kg of plutonium, the amount necessary to make a fission bomb; about 130,000 bombs-worth total

TRANSPARENCY SCORECARD 2020

INFORMATION ON NUCLEAR WARHEAD & FISSILE MATERIAL INVENTORIES AND STATUS

	United States	Russia	Britain	France	China
Number of total warheads	Approximate	No	Yes (upper limit)	Yes (upper limit)	Relative (out of date)
Number of deployed warheads	Yes (strategic only)	Yes (strategic only)	Yes (planned)	Yes	No
Dismantlements	Yes	No	Yes (no details)	Yes (no details)	Νο
Verification	Partial	Partial	Νο	Νο	Νο
Fissile material stockpiles	Yes	Νο	Yes (no details)	No	Νο
Production histories	Yes	No	No	No	No
Excess/Disposal	Yes (nothing new)	Yes (nothing new)	Yes (nothing new)	No	No
Verification	Partial	Partial (but no longer)	Partial (some plutonium)	No	No

DEALING WITH SECRETS How do you regulate & eliminate nuclear weapons (when you cannot "talk about" them?)

(Why does this matter now?)

GLOBAL NUCLEAR WEAPON STOCKPILE



Based on the Nuclear Notebook, maintained by Hans M. Kristensen and Matt Korda, thebulletin.org/nuclear-notebook/

BEYOND NEW START



OBAMA/BIDEN ADMINISTRATION (2009–2016)

"I've determined that we can ensure the security of America and our allies, and maintain a strong and credible strategic deterrent, while reducing our deployed strategic nuclear weapons by up to one-third."

Remarks by President Obama at the Brandenburg Gate, Berlin, June 19, 2013



Source: DPA (top) and NNSA (bottom)

TRUMP ADMINISTRATION (2017–2020)

U.S. Special Presidential Envoy for Arms Control (Marshall S. Billingslea) has threatened to increase the U.S. nuclear arsenal if Russia does not agree to U.S. conditions for New START extension, i.e., to begin negotiations on a multilateral "all-warhead" agreement with strengthened verification provisions

fas.org/blogs/security/2020/10/new-start-2020_aggregate-data/

PROJECT CLOUD GAP, 1963–1969 (WITH FIELD TEST 34 IN SUMMER/FALL 1967)



fas.org/nuke/guide/usa/cloudgap

FIELD TEST 34

TAKE AWAYS BY THE U.S. ATOMIC ENERGY COMMISSION

"Permitting the inspectors a degree of access to the weapons which included x-ray photography did not always result in their correctly identifying real and fake weapons. Thus, even though a great deal of weapon design information was revealed through x-ray photography, it did not provide assurance that actual weapons were being examined."

Allan M. Labowitz (Special Assistant for Disarmament), *Project Cloud Gap and CG-34: Demonstrated Destruction of Nuclear Weapons,* Memorandum for Chairman Seaborg, U.S. Atomic Energy Commission, Washington, DC, November 1967

NUCLEAR WEAPONS HAVE UNIQUE SIGNATURES BUT THEY ARE SENSITIVE AND CANNOT BE REVEALED TO INSPECTORS



U.S. Scientists on a Soviet Cruiser in the Black Sea, 1989

NUCLEAR WARHEAD VERIFICATION KEY CONCEPTS OF (PROPOSED) INSPECTION SYSTEMS

ATTRIBUTE APPROACH

Confirming selected characteristics of an object in classified form (for example, the presence/mass of plutonium)

TEMPLATE APPROACH

Comparing the radiation signature from the inspected item with a reference item ("golden warhead") of the same type

INFORMATION BARRIERS

Technologies (and procedures) that prevent the release of sensitive nuclear information

EARLY INFORMATION BARRIERS

(RESEMBLED RUBE-GOLDBERG MACHINES)



David Spears (ed.), *Technology R&D for Arms Control,* U.S. Department of Energy, Washington, DC, 2001 Fissile Material Transparency Technology Demonstration (FMTTD), Los Alamos, August 2000

"All I see is a green LED with a battery connected to it."

Russian nuclear weapons expert during technology demonstration at a U.S. national laboratory in the early 2000s

HOW INSPECTIONS MAY LOOK LIKE (NO REAL PRECEDENTS EXIST)



Source: U.S. Department of Energy (left) and <u>ukni.info</u> (right)

HOW NOT TO GIVE AWAY A SECRET



CONTINUE IMPROVING TECHNOLOGIES AND APPROACHES

Work on information barriers with a particular focus on certification and authentication; in particular, identify joint hardware and software development platforms



REINVENT THE PROBLEM: NEVER ACQUIRE SENSITIVE INFORMATION TO BEGIN WITH

Explore radically different verification approaches; for example, consider non-electronic measurements or develop alternatives to direct inspections of nuclear weapons altogether



REVEAL THE SECRET

Requirement to protect sensitive information is typically the main reason for complexity of verification approaches; for example, mass of fissile material in a nuclear weapon

Source: Author (top and bottom), altave.com.br (middle)

REINVENTING THE PROBLEM (Some examples)

TAKING ELECTRONICS OUT OF THE PICTURE (WHERE IT MATTERS MOST, FOR DETECTION AND DATA STORAGE)



ZERO-KNOWLEDGE NEUTRON RADIOGRAPHY WITH PRELOADED, NON-ELECTRONIC (BUBBLE) DETECTORS



A. Glaser, B. Barak, and R. Goldston, A Zero-knowledge Protocol for Nuclear Warhead Verification, Nature, 510, June 2014 S. Philippe, R. J. Goldston, A. Glaser, F. d'Errico, Nature Communications, 7, September 2016 M. Hepler, Zero-knowledge Isotopic Discrimination for Nuclear Warhead Verification, PhD Thesis, Princeton University, May 2020

Perhaps we shouldn't even bother about directly accessing nuclear warheads (at least, for now)

SEPARATING THE "ITEM" AND ITS "TAG" (BUDDY-TAG INSPECTIONS WITHOUT DIRECT ACCESS TO WARHEADS)



A. Glaser and Yan Jie, Minimally Intrusive Approaches to Nuclear Warhead Verification, Irmgard Niemeyer, Mona Dreicer, Gotthard Stein (eds.), Nuclear Non-proliferation and Arms Control Verification, Springer, 2020 A. Glaser and M. Kütt, IEEE Sensors Journal, June 2020, <u>ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9025267</u>

CONFIRMING WARHEAD LIMITS WITH ABSENCE MEASUREMENTS

Building on the experience with New START, confirming compliance with all-warhead agreements could primarily rely on absence measurements with minimum access to treaty accountable items

> H1514 MODEL

> > Source: Sandia National Laboratories, Randy Montoya

INSPECTIONS FROM A DISTANCE THAT DO NOT REQUIRE TRUSTED SENSORS

Apparatus with RF antennas/receivers and 20 independently movable mirrors ("Death Star")



Joint project with U. Rührmair (LMU Munich) J. Tobisch, C. Paar, C. Zenger (Ruhr University Bochum) S. Philippe, A. Glaser (Princeton University) B. Barak (Harvard University) Using Virtual Reality to develop and demonstrate new verification approaches

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CAN WE HAVE NUCLEAR DISARMAMENT WITHOUT NUCLEAR TRANSPARENCY?

CAN WE HAVE NUCLEAR DISARMAMENT WITHOUT NUCLEAR TRANSPARENCY



NO NEED FOR REVEALING NUCLEAR SECRETS

Inspection protocols and measurement equipment for non-intrusive approaches for confirming numerical limits and for monitoring nuclear warheads in long-term storage could be developed quickly

Focus initially on basic approaches that can accommodate "upgrades" later on



Source: U.S. DOE (top and bottom)

MEANWHILE

Dismantlements continue to be unverified, and almost 90% of all nuclear weapons do no longer exist today

Weapon states ought to begin now to document dismantlements in ways that international inspectors will find credible at a later time

The Washington Po

Democracy Dies in Darkness

National Security Foreign Policy Justice Military

National Security

Georgetown students shed light on China's tunnel system for nuclear weapons



Phillip A. Karber, right, meets with his Asian Arms Control Project students, from left, William Kim, and Nick Iacono. (Ricky Carioti/WASHINGTON POST)

The Washington Times

Reliable Reporting. The Right Opinion.



By Bill Gertz - The Washington Times - Thursday, November 12, 2020

China is rapidly building up its nuclear forces, including the expansion of plutonium and uranium plants as part of a secretive, crash program to add warheads to its growing missile and bomber forces, according to declassified U.S. briefing slides obtained by The Washington Times.

The four slides were part of a recent briefing for NATO allies in the past month on Chinese nuclear forces and show three facilities that appear to have sharply increased in size since 2010.

Articles by William Wan, Washington Post, November 2011; and Bill Gertz, Washington Times, November 2020

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U.S. plutonium production reactor at the Savannah River Site, *i.imgur.com/CPrBoCK.jpg*



A U.S. delegation led by State Department official Sung Kim crosses the military demarcation line between North and South Korea on May 10, 2008. North Korea shared 18,000 pages of operating records to confirm the correctness of its declared plutonium stockpile. Credit: Chung Sung-Jun

REFOCUSSING TRANSPARENCY ON FISSILE MATERIALS & THE HISTORY OF THEIR PRODUCTION



ESTABLISHING THE BASELINES

- Confirming the end of fissile material production for military purposes
- Declaring historic production to establish baselines

These efforts could be followed by declarations of excess materials, international safeguards on these materials, and their disposition/elimination



CONFIRMING WHAT'S THERE: NUCLEAR ARCHAEOLOGY

- Preserving operating records
- Developing relevant (nuclear forensic) techniques

Joint exercises could envision data exchanges (e.g. sharing of operating records) and measurement campaigns at selected "test beds"

Source: U.S. DOE (top) and <u>www.francetnp.gouv.fr</u>

THE BAN TREATY WILL ENTER INTO FORCE IN JANUARY 2021



Tim Wright and Ray Acheson with Ban Treaty

Setsuko Thurlow and Beatrice Fihn with Berit Reiss-Andersen

Nuclear Weapons We built them. We can take them apart.

@NuclearAnthro