Nuclear Terrorism: How Can Intelligence Best Contribute to Reducing the Risk?

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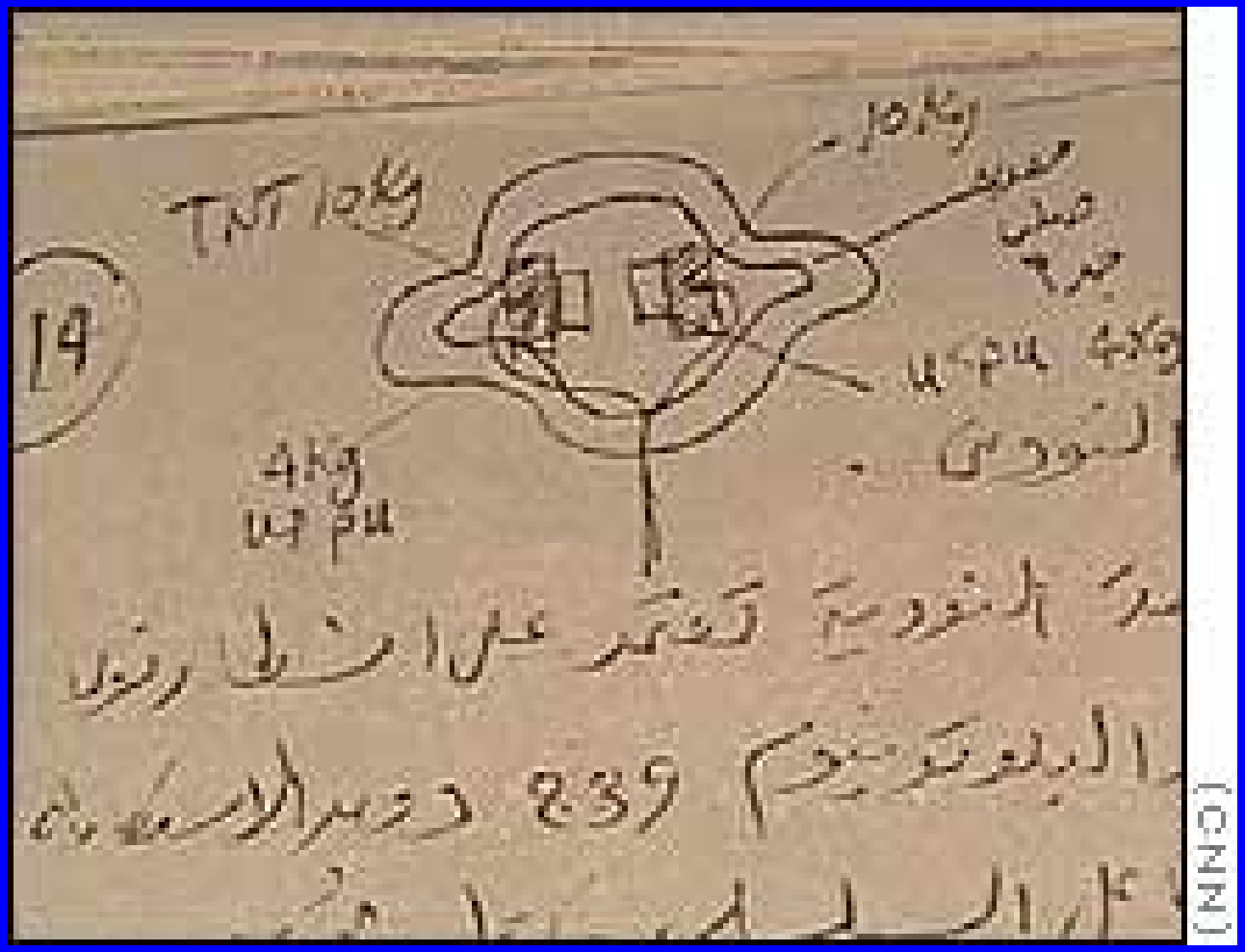
http://www.managingtheatom.org
http://www.nti.org/securingthebomb

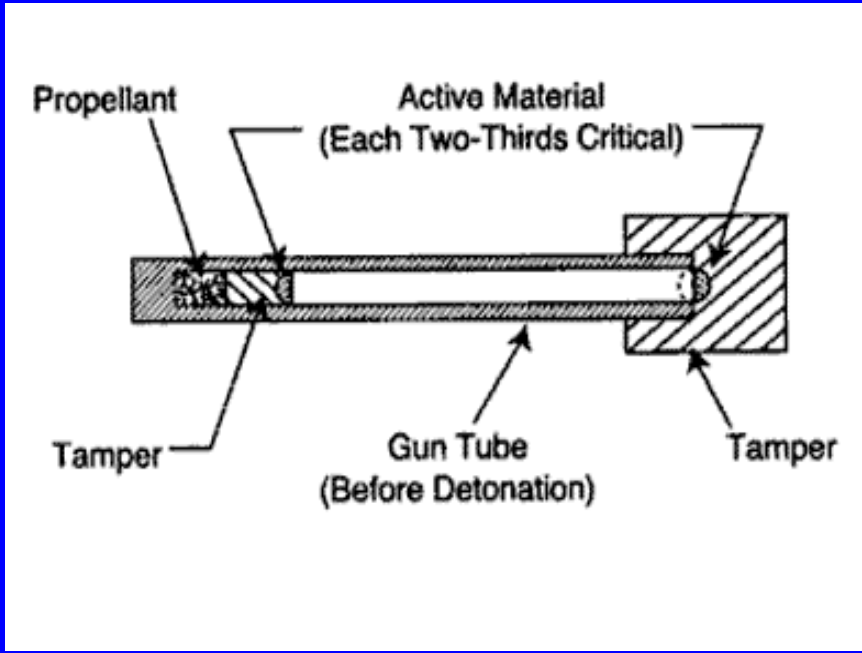
Al Qaeda nuclear bomb sketch



Source: CNN

With nuclear material, terrorists may be able to make crude nuclear bombs

- With HEU, gun-type bomb – as obliterated Hiroshima – very plausibly within capabilities of sophisticated terrorist group
- Implosion bomb (required for Pu) more difficult, still conceivable (especially if they got help)



Source: NATO

Some overall judgments

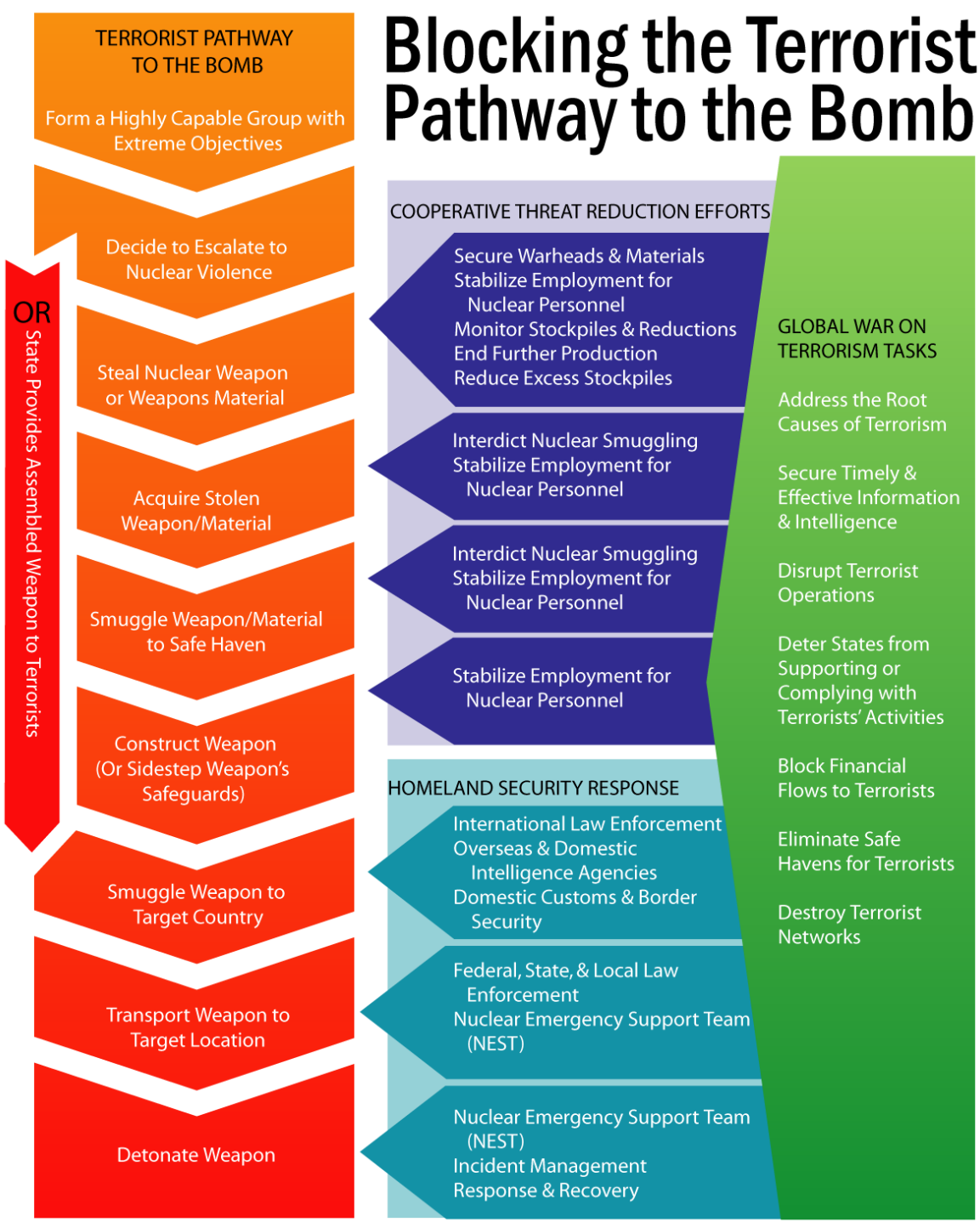
- Focusing on groups is important, but very hard target
  - Many potential indicators of nuclear terrorist activity, all difficult to detect – traditional police and counterintelligence likely key
  - Footprint of nuclear effort could be small
- Chasing every radioactive seizure is a distraction
  - But it is important to go into important cases in-depth, to understand incentives, obstacles to transactions, nascent networks
- Highest-leverage approach to preventing nuclear terrorism is to secure material at its source
  - Urgent need for comprehensive global assessment of risk of theft at all sites + transport legs for nuclear weapons, HEU, plutonium, identification of most urgent risks
  - Also strong need for intelligence assessments of opportunities for convincing foreign countries + institutions to take action to reduce risk

Multi-layer defense – focusing on key adversary choke points

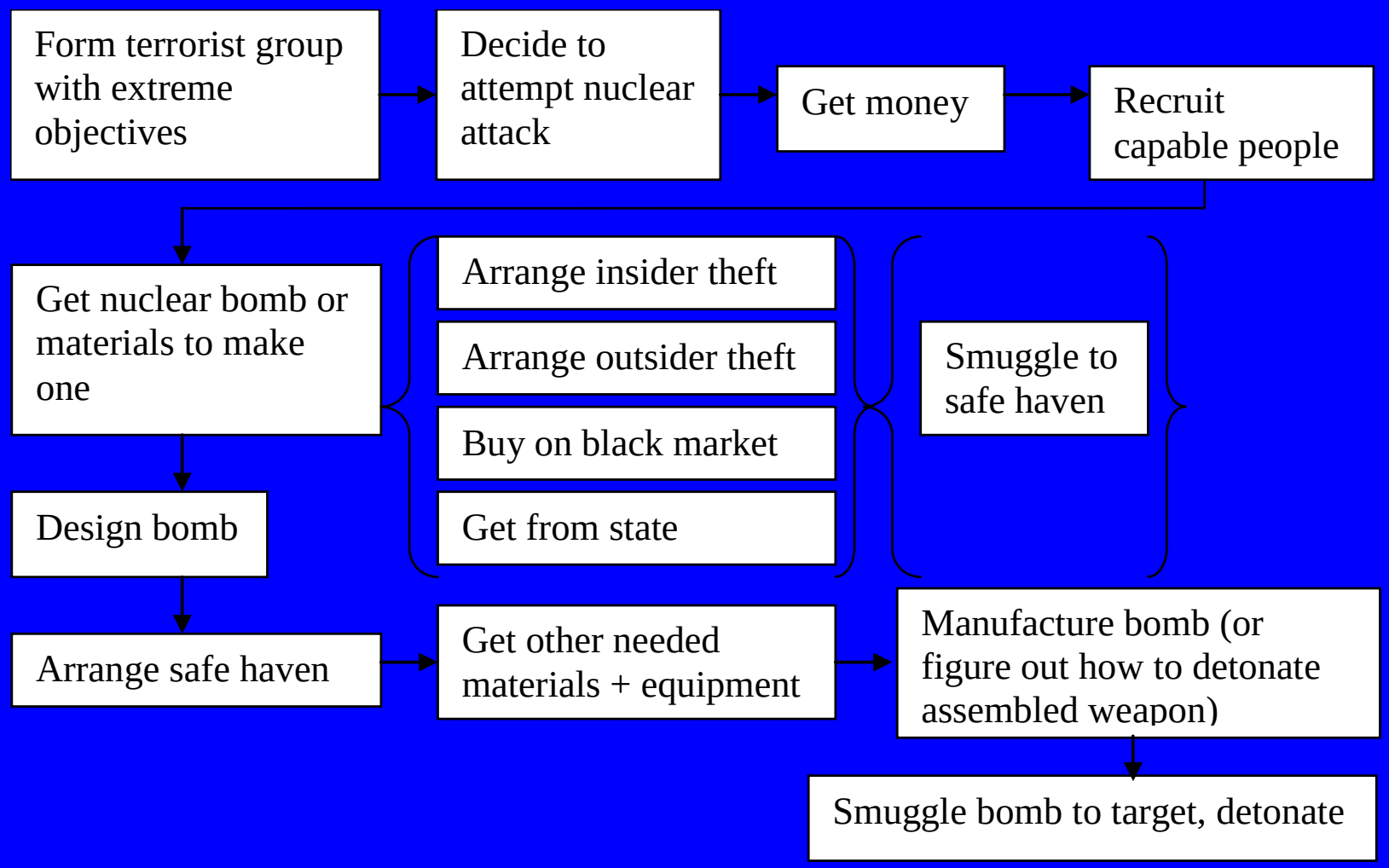
- #1 priority: prevent theft of potential nuclear bomb material
  - Once the material has left the facility where it is supposed to be, it could be anywhere, challenge multiplies a thousandfold
  - Preventing theft is a large but do-able mission – potential bomb material exists in hundreds of buildings around the world (not tens of thousands or millions)
- #2 priority: information/incentive warfare to encourage adversaries to inform, weaken adversary "market"
- #3 priority (because so difficult): detect, break up nuclear terrorist conspiracies in their early stages
- Traditional counter-terrorism, intelligence, police efforts likely to be more important than high technology (e.g., radiation detection or hyper-spectral imagery)

Blocking the Terrorist Pathway to the Bomb

Source: Bunn, Wier, Holdren, Controlling Nuclear Warheads and Materials: A Report Card and Action Plan (2003)



Another look at the terrorist pathway



Focusing on groups: a hard problem

- Nuclear terrorist effort <u>might</u> have quite small footprint
  - Group of 6-20 capable people might be sufficient
  - No need for large fixed facilities
  - Other than HEU or Pu, can use commercially available equipment, materials (though should watch for, e.g., vacuum induction furnaces)
- Recruitment an indicator to watch for
  - Zawahiri: waste of time to try to make CW from scratch, need to hire experts
  - Not just nuclear physics – uranium or plutonium machining, etc.
- Look for signs of increasing technical sophistication
  - Improved understanding of key nuclear technical issues
  - Sophistication in analogous areas – e.g., chemical processing for drug manufacture, BW efforts, shaped charge explosives…

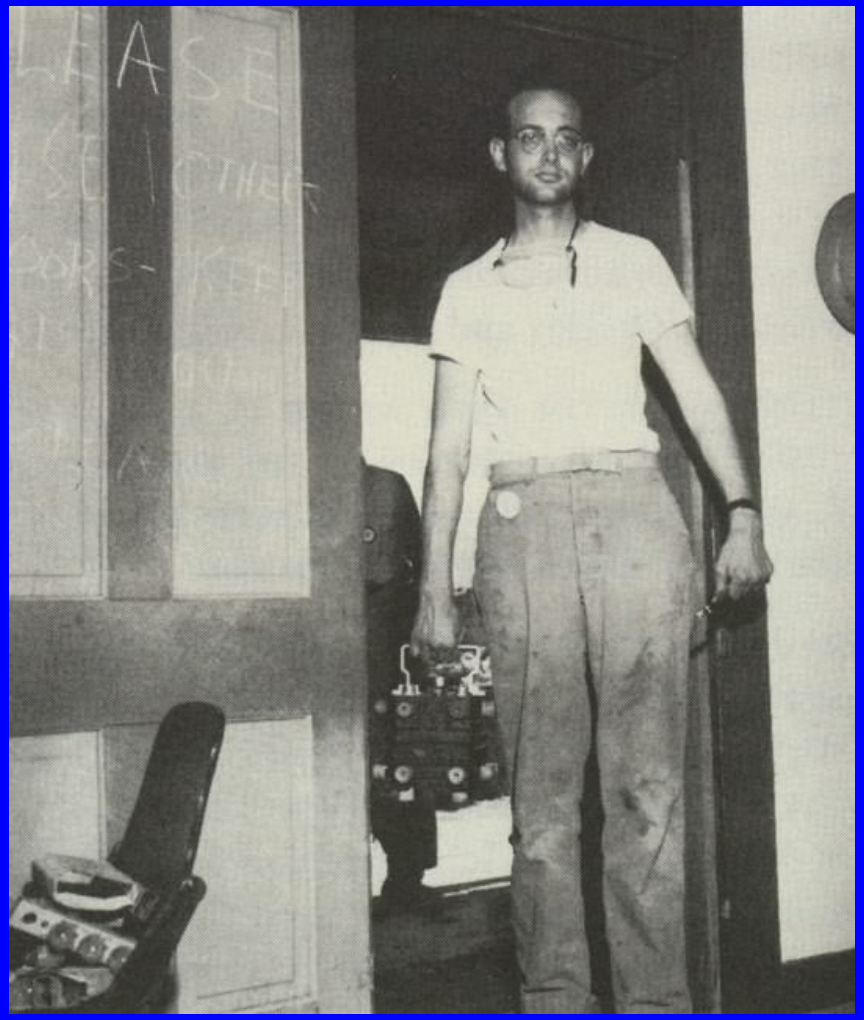
Focusing on groups (II)

- Slaughter of innocents on a nuclear scale clearly forbidden in Islamic law -- may be able to affect internal debates, potential for recruiting key experts
  - Some clerics who approved 9/11 apparently declined to sign nuclear *fatwa*
  - Need to understand this debate among jihadis
  - Can seek to engage this debate with broader Islamic community, potentially reduce chances that deeply religious experts would cooperate with nuclear bomb effort
- International intelligence, police cooperation essential
  - E.g., Pakistani, Egyptian monitoring of key nuclear experts
- Need to watch for other groups that might cooperate with al Qaeda, or launch such an effort on their own

Focusing on seizures: Sometimes a distraction

- With every radioactive seizure, pressure to drop everything and rapidly confirm whether important/unimportant
  - Huge quantities of noise in the signal – radioactive incidents that have no malevolent aspect, misinterpretations of material types, etc.
  - Example: recent Slovak case originally reported as 96.8% HEU
- But the real data from important cases needs to be explored in depth, for incentives, obstacles, possible networks
  - In-depth interviews with captured nuclear thieves and smugglers, exploration of their networks, may be very valuable
  - E.g.: 2003 case of Russian businessman offering $750,000 for stolen weapon-grade plutonium for sale to a foreign client
  - E.g.: 1998 case of insider conspiracy to steal 18.5 kg of HEU at facility in Chelyabinsk oblast

Nuclear material is not hard to smuggle – plutonium box for first-ever bomb



Source: Los Alamos

Encouraging adversaries to inform

- Known successes in seizing stolen HEU or Pu predominantly *not* from border detectors, but some one informing – often as thieves are trying to find a buyer. "Human factor" – individual who proves unreliable – is the weakest link, both for the good guys and the bad guys
- Hence highest-leverage post-theft point is strengthening the good guys' human factor, weakening the bad guys':
  - Adequate pay for nuclear workers, guards, and effective training (including on dangers of nuclear theft and terror)
  - Toughen penalties for nuclear theft and collaborating with thieves – and widely publicize those penalties
  - Create easy means for anonymous reporting, make sure everyone knows about them – global "WMD 911"
  - Offer substantial, well-publicized rewards for information leading to preventing a nuclear theft, recovering stolen material

Intelligence and police operations to smash nuclear smuggling rings

- Making reliable connections between those who want nuclear bomb material and those in a position to steal it has proved difficult in the past – "market" is weak
  - Difficult to find each other
  - Both buyers and sellers fear stings and scams – difficult to establish *bona fides*, even once initial contact made
- A good defense should seek to make this connection more difficult, catch those exploring this market
  - Demand stings (posing as potential nuclear material buyers)
    - » May also help to round up already-stolen material
    - » <u>But</u>, risk of creating demand that leads to additional thefts -- problematic
  - Supply stings (posing as potential nuclear material sellers)
  - Expertise stings (posing as providers and seekers of nuclear expertise)

Expanded police capabilities, int'l police + intelligence cooperation

- Programs should be put in place to ensure that every relevant country has:
  - 1 unit of national police trained and equipped to deal with nuclear smuggling cases
  - All local and other police/intelligence forces informed as to who to call in such a case
  - Access to high-quality nuclear forensics facility to send seized material to
- *Substantial* increase in international police and intelligence cooperation needed on nuclear theft and smuggling – to at least the level of in-depth cooperation now present on counter-terrorism – as threat is transnational
  - In-depth cooperation with Russian FSB, Pakistani ISI, in particular, is difficult but essential to success

Focusing on preventing nuclear theft: Sometimes low-hanging fruit

- 100s of tons of HEU + Pu in dozens of countries around the world is not yet secure enough to reliably defeat the threats terrorists and criminals have shown they can pose
- Rapid global effort needed to beef up security, remove material entirely from most vulnerable sites
- To support this effort requires comprehensive global assessment of theft risks at each site or transport leg with nuclear weapons, HEU, or Pu, including estimates of:
  - Quantity and quality of material or weapons that could be stolen
  - Security measures in place – what insider or outsider threats could they defeat?
  - Plausible adversary capabilities those security measures must cope with (insider and outsider)
- *Informing policy steps to prevent nuclear theft is <u>the</u> area where intelligence can make the biggest difference*

Methodology for identifying the highest-risk nuclear facilities or transport legs

- Each stock's contribution to the global probability of terrorists getting a nuclear bomb:

$$R = P_{attempt} P_{success} P_{bomb\text{-}making}$$

- Where:
  - $P_{attempt}$ is the probability of a theft attempt at that site
  - $P_{success}$ is the probability the attempt would be successful
  - $P_{bomb\text{-}making}$ is the probability that adversaries would succeed in making a usable bomb from the stolen items
- $P_{success}$ is determined mainly by balance between security measures and adversary capabilities they must protect against
- $P_{bomb\text{-}making}$ is determined by the quantity and quality of the material
- $P_{attempt}$ is presumably determined by the other two variables

Key risk variables

- Most important variables are:
  - Distribution of adversary capabilities (varies significantly by country)
  - Adversary capabilities security system can defeat
    - » Determined not only be security system, but by facility environment (for example, hands-on bulk-processing facility may find covert insider thefts more difficult to prevent than facility with rarely-accessed material stored in a vault)
  - Quantity and quality of nuclear material available to steal
- Difference from standard DOE “risk equation”
  - Not a single DBT – takes into account that threat may be different in different countries and regions
  - Does not take probability of attempt as 100%

Securing nuclear stockpiles -- a global problem

- Thousands of tons of weapons-usable nuclear material exist in hundreds of buildings in more than 40 countries worldwide
- Security ranges from excellent to appalling -- no binding global standards in place
- ~140 operational research reactors fueled with HEU in dozens of countries – most with modest security
- Pakistan: small nuclear stockpile, heavily guarded – but huge threats, outsider and insider
- Russia has world's largest stocks, largest number of buildings and bunkers, substantially improved security (but still significant weaknesses) – but large outsider and insider threats

Implementing the method: example risk assessments in a few countries

Country Risk Estimates With a Rating-Based Approach

Country	Threat Level	Sec. Level	Att. Prob.	Theft Prob.	Discount Factor	Risk Rating
Russia	4-5	3	0.45	0.55	1.0	0.25
Pakistan	5	3-4	0.5	0.55	1.0	0.27
United States	3	4-5	0.3	0.16	1.0	0.049
U.S. res. reactors	3	1-2	0.3	0.55	0.4	0.066
Japan	2	2-3	0.2	0.25	1.0	0.050
Canada	2	3	0.2	0.2	1.0	0.040
Uzbekistan	4-5	2-3	0.45	0.65	0.2	0.058
Unnamed Country	3-4	2	0.35	0.55	1.0	0.19

Source: Author's estimates

Assessing security measures in place

- What kinds of adversary capabilities (insiders, outsiders) is this facility or transport leg required to be defended against?
- Do they have armed guards? How many, what training, armament, equipment, motivation?
- What barriers, detectors, access control, material control, material accounting, and other measures are used?
- How are employees screened and monitored for trustworthiness?
- Is the security system regularly inspected, tested? How effective are those tests and inspections?
- What steps are taken to ensure that all key staff understand the threat and take security seriously?
- *Key information can be collected easily by talking to people who have been to these sites, and from public documents*

Nuclear security regulation: A key item to watch

- Every dollar a nuclear manager spends on security is a dollar not spent on his organization's principal missions – most will only invest in nuclear security when gov't says they have to
- Hence, effective regulations, effectively enforced, are fundamental to achieving and sustaining good nuclear security
- Large quantity of information on regulations available from open sources
- Additional information available from policy agencies interacting with foreign regulators
- Key elements:
  - Robust design basis threat (outsider and insider)
  - Realistic vulnerability assessments
  - Regular inspection, testing

Security culture matters: Propped-open security door

Source: GAO, Nuclear Nonproliferation: Security of Russia's Nuclear Material Improving, More Enhancements Needed *(GAO, 2001)*

Assessing threats security systems must defend against

- *Insider threats:*
  - Are staff with access to nuclear material desperate and underpaid?
  - Are they corrupt and prone to theft?
  - Do they have extremist sympathies?
  - How effective are the state's efforts to monitor them?
- *Outsider threats:*
  - What is the level of terrorist activity near a site?
  - What is the level of organized crime activity, thefts from guarded facilities or transports (e.g., bank robberies)?
  - What capabilities (numbers, armament, training) have terrorists or criminals demonstrated in that country or region?
- *Key information can be gleaned from wide range of sources*
  - E.g., insurance companies' premiums for insuring against insider theft or armed robbery from guarded facilities and transports

An example: the Ozersk case study

- Study done by 2 researchers at American University
  - Made contact with residents of Ozersk, location of the Mayak Production Association, many tens of tons of Pu, HEU
- Findings:
  - Estimate of bribe required to enter the closed city
  - Estimate of bribes required for various jobs at Mayak
  - Extensive organized crime penetration of town
  - 100s of Central Asians brought in for construction work at facility, isolated, worshipping at Saudi-sponsored Wahabbi mosques
- Was anyone in U.S. government previously aware of these conditions?
- *Need to assess such conditions for key facilities worldwide*

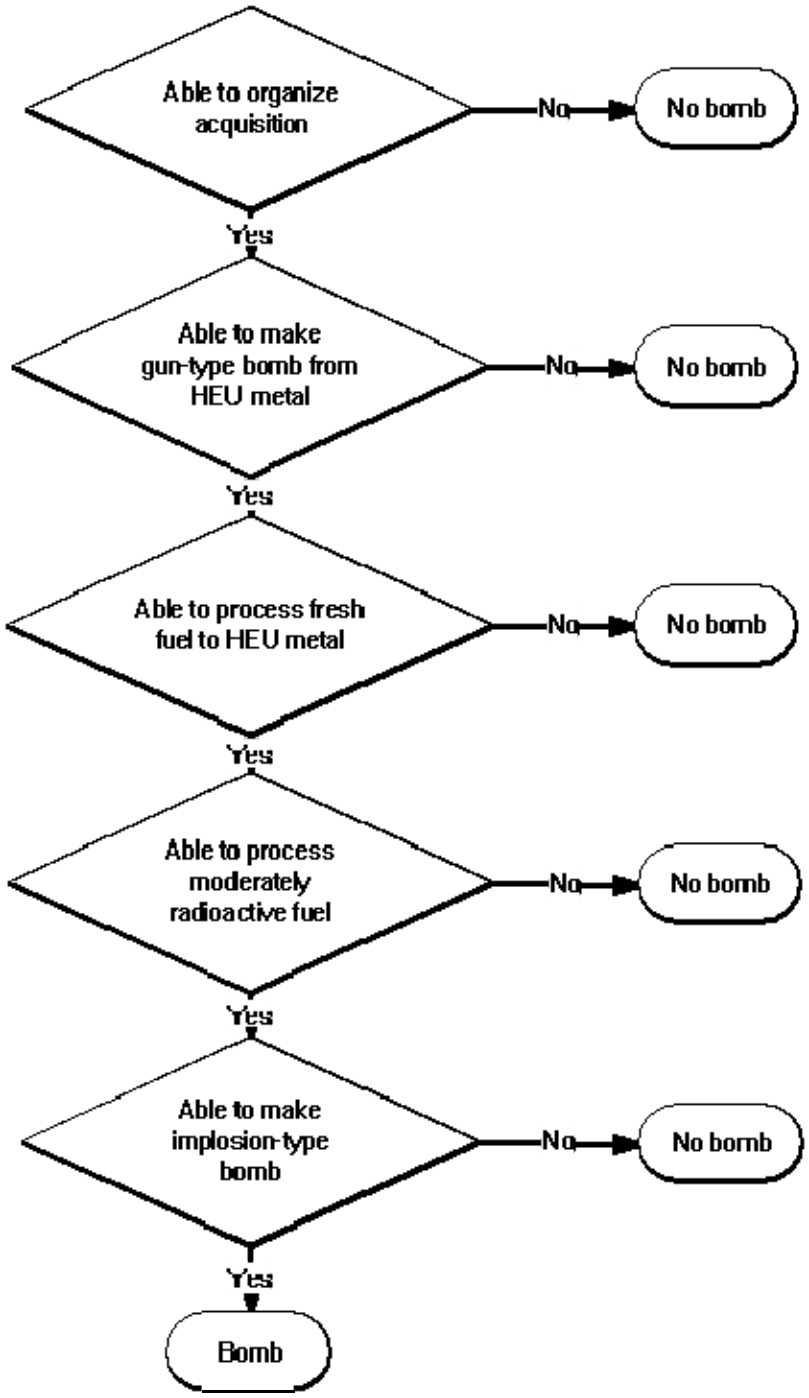
The Pelindaba incident: a case study

- Major intrusion at facility with 100s of kilograms of weapon-grade HEU, November 2007 – virtually unreported outside S. Africa
- Coordinated attack by 2 teams of armed gunmen
- 1 team of 4 people:
  - Defeated the perimeter security system, entered without detection
  - Spent 45 minutes on-site without being engaged by site security forces
  - Went to the emergency control room, shot an officer there, who raised an alarm
  - Exited by the same route
  - 3 people later arrested – little public information
  - Motive unclear, links to known groups unclear

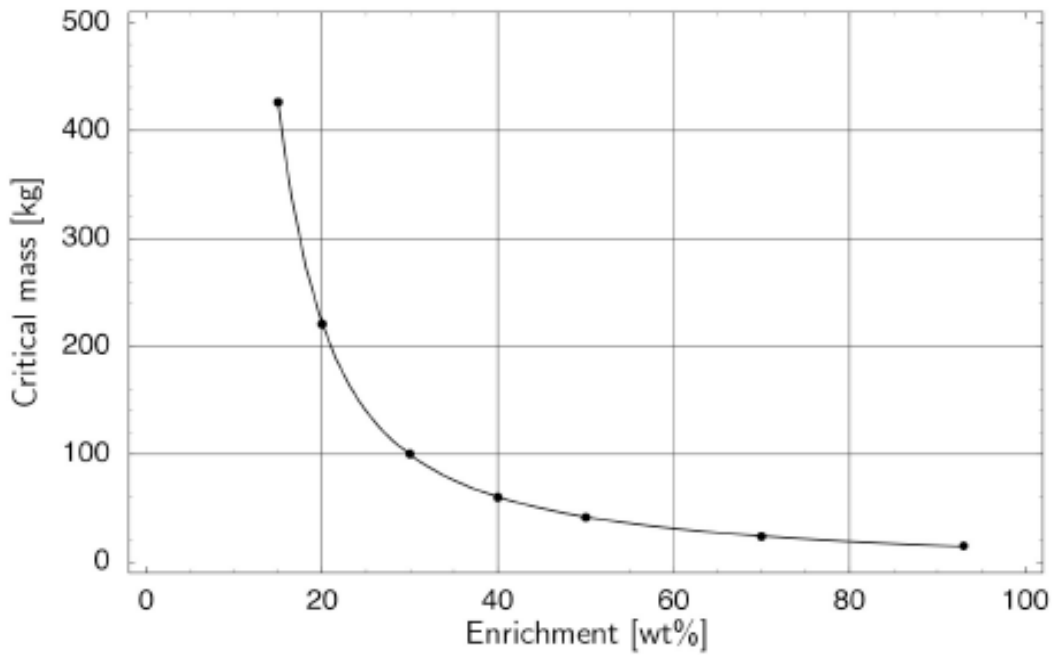
The Pelindaba incident: a case study (II)

- Before this occurred, did U.S. intelligence know:
  - That security at this site was so poor that a team of 4 could penetrate undetected, spend 45 minutes on-site, and never be engaged?
  - That there had been a previous penetration by one person two years earlier?
  - That a senior facility official had been assassinated in June?
  - That there were groups in South Africa with the capability to mount a coordinated attack by 2 teams of well-trained gunmen, possibly with insider help?
  - That the process of requiring the site to be able to defend against a specified design basis threat (DBT) had been stalled for years?
  - Anything about the factors that might convince South African officials to cooperate in beefing up security, removing the HEU at this site (both of which U.S. officials had unsuccessfully proposed)?

Example of how material quality and quantity affects risk: capabilities needed to make a bomb from 20 kg of HEU in irradiated research reactor fuel



Isotopics: Uranium and critical mass



Critical mass of a uranium sphere with a 10 centimeter thick beryllium reflector. MCNP 4B calculations at 300 degrees K. Assumed uranium density 19 g/cm^3.

Source: Alexander Glaser, "On the Proliferation Potential of Uranium Fuel for Research Reactors at Various Enrichment Levels," *Science and Global Security* 14, 2006, pp. 1-24.

*Should use "effective kilograms" (kgHEU*fU235^2) rather than kg U235 to assess quantity – provides better estimate of risk*

Isotopics: plutonium

Key Properties of Different Grades of Plutonium

Grade	Critical Mass (kg)	Neutrons /g-sec	Heat (W/kg)
Super-grade	n.a.	18	2.0
Weapon-grade	11.5	53	2.5
Fuel-grade	13.2	202	14.1
Reactor-grade (33 GWd/t)	14.6	338	14.4
Reactor-grade (50 GWd/t)	n.a.	457	25.1
MOX-grade	n.a.	471	22.2
FBR blanket	n.a.	36	2.1

Source: Neutron and heat generation are calculated from the isotopic properties and the contents of the different grades presented in the text. Critical masses are for bare spheres of alpha-phase plutonium with a density of 19 g/cc, presented in Alexander Glaser, "On the Proliferation Potential of Uranium Fuel for Research Reactors at Various Enrichment Levels," *Science and Global Security* 14, 2006, pp. 1-24.

Reactor-grade plutonium is weapons-usable

- "Virtually any combination of plutonium isotopes -- the different forms of an element having different numbers of neutrons in their nuclei -- can be used to make a nuclear weapon... At the lowest level of sophistication, a potential proliferating state or subnational group using designs and technologies no more sophisticated than those used in first-generation nuclear weapons could build a nuclear weapon from reactor-grade plutonium that would have an assured, reliable yield of one or a few kilotons (and a probable yield significantly higher than that). At the other end of the spectrum, advanced nuclear weapon states such as the United States and Russia, using modern designs, could produce weapons from reactor-grade plutonium having reliable explosive yields, weight, and other characteristics generally comparable to those of weapons made from weapons-grade plutonium.... Proliferating states using designs of intermediate sophistication could produce weapons with assured yields substantially higher than the kiloton-range possible with a simple, first-generation nuclear device."
  - *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives* (Washington, DC: DOE, January 1997)

Proposed categorization of nuclear materials: quality

Attractiveness Level	Material Type	Discount Factor
A: Weapons and Gun-Type Bomb Materials	Weapons, ≥50 eff. kg HEU metal (>40% enrichment)	1.0
B: Implosion-Type Bomb Materials	Pu metal, < 50 eff. kg HEU metal (>40% enrichment), HEU metal ≤ 40% enrichment	0.6
C: Compounds and Mixes Not Requiring Chemical Separation	Oxides, carbides, nitrates, other direct-use compounds, alloys and mixtures	0.8
D: Compounds and Mixes Requiring Chemical Separation	Alloys and mixes requiring chemical separation; fuel elements and assemblies; solutions	0.5
E: Lightly Irradiated Material	Emitting ~20-400 rad/hr at 1 m	0.8
F: Irradiated Material Requiring Remote Handling	Emitting ~400-10,000 rad/hr at 1 m	0.2
G: Highly Irradiated Material Imposing Disabling Doses During Theft	Emitting >10,000 rad/hr at 1 m.	0.001

How can we motivate foreign leaders to lock down stockpiles?

- Single most critical element of success in securing stockpiles worldwide is convincing political leaders and nuclear managers worldwide that nuclear theft and terrorism is a real threat to their security, worthy of their time and investment
  - Key to agreements to cooperate on security upgrades
  - Key to providing funds necessary to sustain effective security
  - Key to building security culture
  - Key to getting effective nuclear security rules in place and effectively enforced
  - Key to gaining agreement on stringent global security standards
- Intelligence can help understand who foreign leaders will listen to, what arguments will be most effective
  - Cooperation with foreign intelligence agencies can make the case directly

How can we improve intelligence/policy connections?

- Intelligence agencies need policy agencies' information to improve assessment
  - Long-standing problems with getting full data from site visits, discussions, etc.
- Policy agencies need more integral support from intelligence for their efforts to reduce the risk
  - Operating with little intelligence input on prioritization of sites, transport legs posing highest theft risks
  - Operating with little intelligence input on sustainability, nuclear security budgets, nuclear security regulation
- Both need to be more fully informed by information and analysis available from open sources – academia, NGOs can contribute

The challenge

- Lugar Doctrine: war on terrorism will not be won until every nuclear bomb and cache of bomb material everywhere in the world is secure and accounted for to stringent and demonstrable standards

On the day after a nuclear terrorist attack, what would we wish we had done to prevent it?

Why aren't we doing it now?

For further reading…

- A major web section we maintain for the Nuclear Threat Initiative, *Securing the Bomb:*
  - http://www.nti.org/securingthebomb
- Includes hundreds of pages of analysis, links, and databases, and our most recent reports:
  - *Securing the Bomb 2007* (September 2007)
  - *Funding for U.S. Efforts to Improve Controls Over Nuclear Weapons, Materials, and Expertise Overseas: Recent Developments and Trends* (February 2007)
  - *Securing the Bomb 2006* (July 2006)
- For regular e-mail updates from Managing the Atom, write to atom@harvard.edu

Backup slides if needed…

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Widely varying nuclear security

- No specific and binding global standards for nuclear security in place:
  - Physical Protection Convention amendment useful, but does not specify what levels of security are needed
  - Nuclear Terrorism Convention also useful but sets no standards
  - UNSC 1540 requires all states to provide “appropriate effective” security for any nuclear stockpiles they have – no definition of what the essential elements of an “appropriate effective” system are
  - IAEA recommendations (INFCIRC/225 Rev. 4) are more detailed, but still not very specific, and not binding (e.g., Cat. I material should have a fence with intrusion detectors, and guards – but how many guards, how strong a fence, how good intrusion detectors, able to defeat what?)
- Stanford survey: some respondents did not have required protections against insiders, some did not include sabotage

Widely varying nuclear security (II): Moscow HEU building, 1994

Source: DOE

Widely varying nuclear security (III): The threat in Russia today

- Russia is a different place today than 10 years ago – economy has stabilized; government in firmer control; nuclear workers paid a living wage, on time
- Nuclear security at most facilities dramatically improved – 1990s incidents of one insider or outsider stealing without detection would generally not be possible now
- But:
  - Resources devoted to nuclear security remain far below what is needed
  - "Security culture" issues – e.g., guards patrolling without ammo
  - Massive corruption, sophisticated insider theft conspiracies
  - Huge terrorist attacks (30-100 heavily armed attackers)
  - Confirmed terrorist reconnaissance on nuclear warhead sites
  - Businessman offering $750,000 for stolen plutonium

Widely varying nuclear security (IV): A global issue

- > 40 countries with weapons-usable material – few with security measures that can provide high probability of defeating all demonstrated terrorist and criminal threats
- Pakistan: small stockpile, heavily guarded – but huge threats (insiders, outsiders)
- HEU-fueled research reactors – some have enough HEU for a bomb on-site, usually very modest security measures (in some cases, night watchman and chain-link fence)
- Transport of nuclear material especially difficult to protect, carried out under wide range of security levels