HARVARD Kennedy School
BELFER CENTER
FOR SCIENCE AND INTERNATIONAL AFFAIRS

Cultures of nuclear security: How different countries decide to protect their nuclear facilities

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belfercenter.org/managingtheatom

The agenda

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- The problem, and problems of evidence
- Decisions deeply delegated
- Standard regulatory theories don't work
- Evidence 1: The U.S. case
- Evidence 2: A survey of international experts
- Evidence 3: The Canada-Belgium conundrum
- The punctuated equilibrium
- But different reactions to equilibrium challenges
- Building an institutional culture-outside pressures synthesis
- Understanding how to influence these decisions
- Remaining uncertainties and mysteries

3 types of nuclear terrorism

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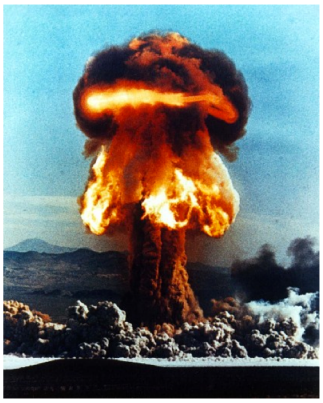
- Nuclear explosives
  - Incredibly catastrophic
  - Difficult for terrorists to accomplish (though not as implausible as some believe)
- Nuclear sabotage
  - Very catastrophic *if* highly successful (limited if not)
  - Could cause a Fukushima-scale accident, or worse
  - Also difficult to accomplish
- "Dirty Bomb"
  - "Weapons of mass disruption" – few if any deaths, but potentially $10s of billions in disruption, cleanup costs
  - Far easier to accomplish



Source: DOE

Each of these types of nuclear and radiological terrorism poses real dangers

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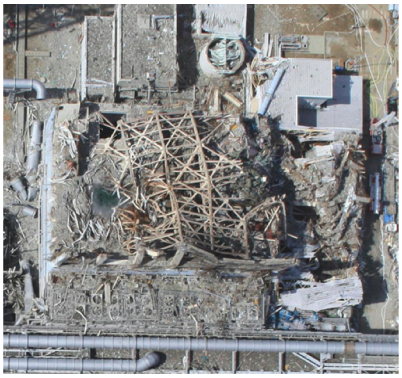
- Multiple government studies warn that a sophisticated terrorist group could potentially make a crude nuclear bomb if they got the material
  - al Qaeda, Aum Shinrikyo tried
- Multiple groups have planned or considered reactor sabotage
- Terrorists have also explored "dirty bombs"
- Terrorist plots suggest possible ongoing interest
  - E.g., ISIS monitoring of senior nuclear official in Belgium
- *Effective nuclear security is the key to reducing these dangers*



Source: Air Photo Service, Japan

Nuclear security is quite different from nuclear safety, in several dimensions

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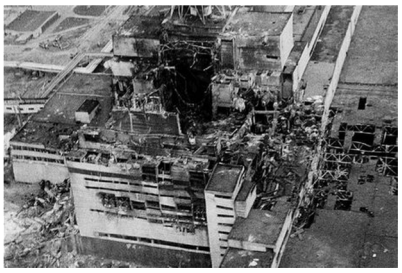
- Safety: preventing, preparing for *accidental* events
- Security: preventing, preparing for, *intentional* human actions
  - Changes the statistics – multiple failures no longer independent
- Many overlaps – some conflicts
- Nuclear security involves:
  - Lower, more controversial threat perception (no widely known incidents)
  - Lower public interest
  - More secrecy
  - Less organizational focus, resources
  - More separation from the rest of the operating organization



Source: The Millenium Report

Nuclear security: Why do countries decide to require more or less?

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- Nuclear security rules, approaches vary widely
  - Among countries
  - Within countries over time
  - Among facilities within a country
- How do these decisions get made?
- What key factors help explain the variations?
- How can this help us understand how to convince states to strengthen nuclear security?

The available evidence is problematic

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- There are no agreed measures to judge whether nuclear security in one place is "better" or "worse" than at another
  - Even "better" or "worse" is incorrect – imposes a one-dimensional spectrum on a multi-dimensional topic
  - Attempts at indices have not adequately captured the issues
- Most nuclear security measures are secret
  - Limits availability of data on current status
  - Limits availability of data on historical evolution
- Most nuclear security changes go largely unnoticed
  - Little if any public debate, reporting in the press
  - In most countries, there is little civil society engagement on nuclear security, so few non-government experts observing

3 main sources of evidence for this project

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- History of nuclear security decisions within the United States
  - Country with longest nuclear security history, probably most stringent nuclear security rules, 2nd largest nuclear complex
  - More publicly available discussions than any other country
  - Many individual decisions to examine
  - However, highly non-representative case
- Differences between otherwise similar countries' decisions
  - Case: Canada and Belgium after the 9/11 attacks
- Survey of nuclear security experts in majority of countries with HEU or separated plutonium
  - Each expert asked to rate the importance of different causes of nuclear security changes in his or her country
  - Subjective judgments – but better data not likely to be available

Standard theories of regulation are wrong

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- Realist: All states will provide high security for nuclear weapons and related materials, given their importance
- Economic: States will (and should) increase nuclear security until marginal benefit of reduced risk equals marginal cost
- Capture: Regulators will be dominated by the industries they regulate, and will act to serve those industries' interests
- Bureaucratic: Regulators' approach to regulation will mainly serve their own interests

The realist theory is wrong

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- Realist: All state[illegible]ovide h[illegible]urity for nuclear weapons and relate[illegible]given their importance

- Many states have manifestly failed to do so:
  - United States: *no rules at all* for security of privately-owned nuclear material until 1969; walls of material areas cut with tin snips
  - United States: exported tons of HEU to dozens of countries with *no requirements at all* that it have any security (until early 1970s)
  - Soviet Union: Soviet system had accounting only to monitor production, not to detect theft, no security cameras in key areas, no unique tamper-indicating devices…
  - Many countries: virtually no security at research reactors with HEU

The economic/rational theory is wrong

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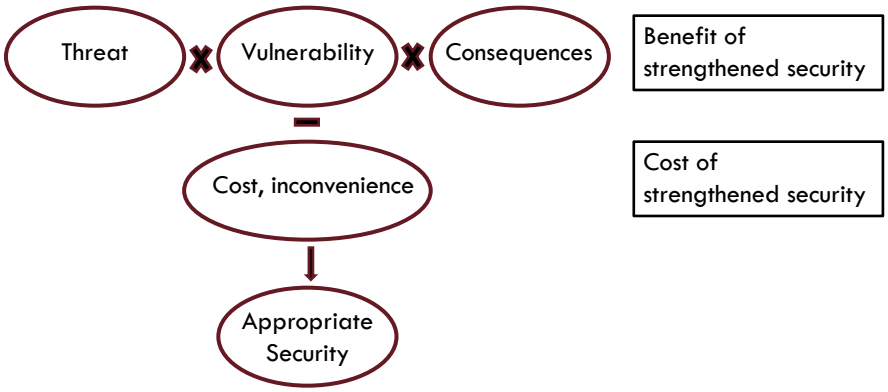
- Economic: States will (and should) increase nuclear security until marginal benefit of reduced risk equals marginal cost



The economic/rational theory is wrong

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- Economic: Stat[illegible]d sh[illegible]ease nuclear security until marginal bene[illegible] risk equals marginal cost

- Little rational logic to pattern of states' nuclear security rules
  - States facing similar threats have drastically different security rules
- Little to no evidence of attempts to perform such marginal risk estimates
  - None of the needed data is available – don't know probability of theft attempt, probability of different adversary capabilities and tactics, probabiiity of different levels of consequences….

The capture theory is only partly right

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- Capture: Regulators will be dominated by the industries they regulate, and will act to serve those industries' interests
- Nuclear security regulators *are* seriously influenced by the regulated industry – key source of personnel, expertise, feedback, political pressure, future jobs…
- *But,* nuclear security regulators often imposed rules industry opposes – *not* fully serving industry interestsences….

The bureaucratic theory is only partly right

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- Bureaucratic: Regulators' approach to regulation will mainly serve their own interests
- Few nuclear security rules, procedures, offer much benefit to the agencies that impose them
- *But,* nuclear security regulators often pick approaches that are convenient and unlikely to lead to serious criticism

The U.S. case: the 1960s-1970s

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Events

1960: JCAE team finds poor nuclear weapons control in Europe

Late 1960s: Commando attacks on U.S. bases in Vietnam; rise of int'l terrorism; Ted Taylor raises concerns on nuclear terrorism

Mid 1970s: Indian nuclear test, fear of "plutonium economy," Congressional hearings, *The Curve of Binding Energy*

1960

1965: Major loss of HEU at NUMEC

1970

1972: Munich Olympics attack

1980

1962: NSAM-160 orders PALs on NATO nuclear weapons

1966: AEC material accounting rules

1969: New AEC security rules

1973: AEC security rules toughened

1979: NRC "Strengthened Safeguards Rule"

1967: AEC Lumb report warns of nuclear terrorism risk

Decisions

1974: AEC split into NRC and ERDA/DOE

Appalling U.S. nuclear security in the 1960s-1970s

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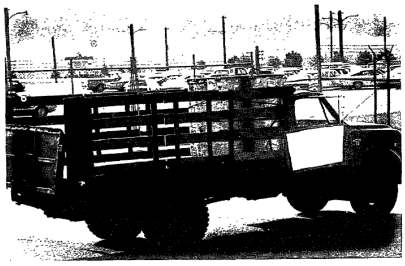
Wall protecting HEU cut with tin snips in 30 seconds. Source: GAO, *Improvements Needed in the Program for the Protection of Special Nuclear Material, 1973*



82 kg of HEU transported in open truck. Source: GAO, *Protecting Special Nuclear Material in Transit, 1974*

Selected later events in the U.S. case

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- 1980s:
  - Congressional investigations, failures in tests lead to White House attention, rapid upgrade program at DOE – "Operation Cerberus"
- After 9/11 attacks
  - Both DOE and NRC greatly ramp up security requirements
  - DOE later increases them further – then rolls back because of skyrocketing costs
  - Security costs drive DOE managers to seek to eliminate HEU and Pu
- Repeated episodes of industry push-back
  - E.g., got independent testing program canceled in early 80s – reinstated after outcry – then worked to weaken – post-9/11, got approval for same country that defends the sites to test the defenses
- Several incidents of civil society criticism (press, NGOs) driving Congressional concern, regulatory response

Lessons from the U.S. case

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- Incident-driven
- Path-dependent
  - Institutions, approaches, attitudes developed to cope with last incident shape reactions to the next one
  - Creating institutions for self-scrutiny (e.g., realistic testing programs) can offer "artificial incidents" that drive further improvement
- Pressures that mattered from
  - Industry
  - High levels of executive branch
  - Congress
  - Civil society
- *But,* little pressure (except to lower costs, inconvenience) when no incidents that are considered important occur

Why does the United States have more stringent nuclear security approaches?

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- Early incidents fostered security-focused institutions, culture
  - If NUMEC loss hadn't happened, reaction to later incidents, pressures would have been different
  - With many more nuclear facilities earlier than elsewhere (except USSR), incidents were more likely to occur
  - Incidents led to self-scrutiny approaches that drove further improvement
- 1970s "perfect storm" of concerns about nuclear power included major focus on security (not true elsewhere)
  - Driven by other factors in U.S. society – experience of Vietnam, domestic terrorism, rise of expert NGOs…
- Interventions from the White House, an empowered legislature, and civil society that did not occur elsewhere
  - Largely for reasons above

Drivers of nuclear security change: Survey of nuclear security experts

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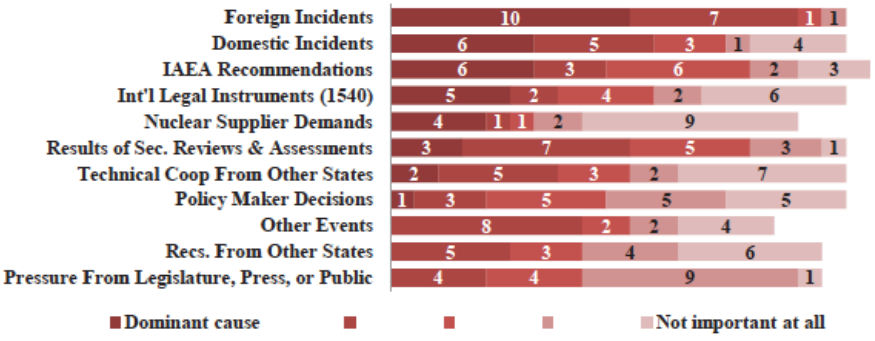
Figure 3: Causes of Nuclear Security Changes



Source: Bunn and Harrell, *Threat Perceptions and Drivers of Change in Nuclear Security: Results of a Survey, 2014*

The Belgium-Canada conundrum

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- Countries have important similarities
  - Stable, advanced democracies, U.S. NATO allies
  - Bi-national, bi-lingual
  - Serious but modest nuclear industries (some power reactors, one research facility handling HEU – Belgium also had a facility handling plutonium, Canada also had extensive uranium mining)
  - Weak pre-9/11 security requirements: no on-site armed guards (Belgium), no requirement they be able to defend against adversary threats (Canada)
- Countries had very different nuclear security reactions to the 9/11 attacks
  - Canada: transformation to fairly high-security approach
  - Belgium: very modest changes, ongoing resistance to U.S. pressure
- Why?

Explaining the Belgium-Canada differences

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- Factor I: Leadership
  - Canada: New CNSC head Linda Keen – not from nuclear industry – insisted on major nuclear security improvements
  - Canada: CNSC physical protection head John O'Dacre led a proactive team who reviewed every facility – Public Service Award
  - Belgium: No comparable leadership focus on nuclear security
- Factor II: Institutional culture
  - Canada: CNSC just created in May 2000, with mandate for tougher regulation, more independence, more enforcement power – little constraint from "escalation of commitment" to past approaches
  - Belgium: Also new regulator – but just came into existence 10 days before, after ~ decade of inaction, was still preparing approach to regulation

Explaining the Belgium-Canada differences (II)

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- Factor III: Pressures, connections
  - Canada was closer to the United States -- lost many citizens in 9/11
  - Canada: main international influences were from the United States
  - Belgium: U.S. pressure, but also major influences from Europe
  - Canada: NGOs chose to make security a major issue
  - Belgium: Little government, civil society pressure for more security
- Factor IV: National, industry culture
  - Canada: industry born in Manhattan project, early regulations focused on secrecy
  - Belgium: industry civilian, open, from early days
  - Vast difference in national attitudes toward guns, armed personnel

Account preliminary – more research needed

Decisions deeply delegated

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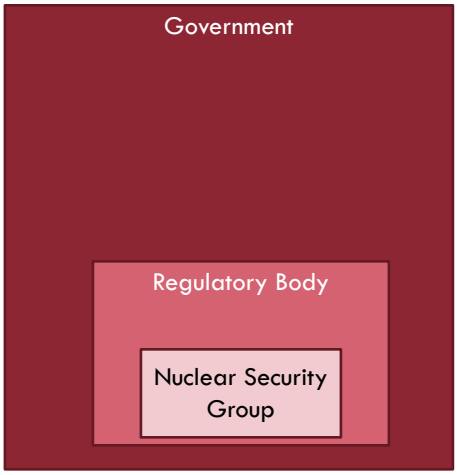
- Most countries do not consider nuclear security an important subject
  - Do not perceive serious threats to their nuclear facilities
  - Unlike nuclear safety, not a major focus of public concern
- Hence, decisions typically delegated to low-level officials within nuclear regulatory agency
  - Typically small groups
  - Often modest expertise
  - Individual personalities matter



Nuclear security is a punctuated equilibrium

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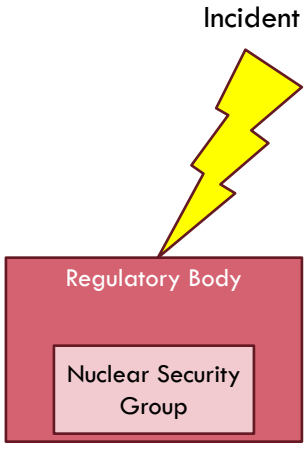
- Most of the time, regulators perceive that existing rules and approaches are good enough
  - Some loosening likely as complacency grows and industry presses for cost savings
- Major incidents may be seen as showing that existing approaches are inadequate, change is needed
  - Major changes without a substantial incident to drive them occur rarely
- But different regulators react to incidents in quite different ways



Reactions to incidents are modulated by institutional and national culture, pressures

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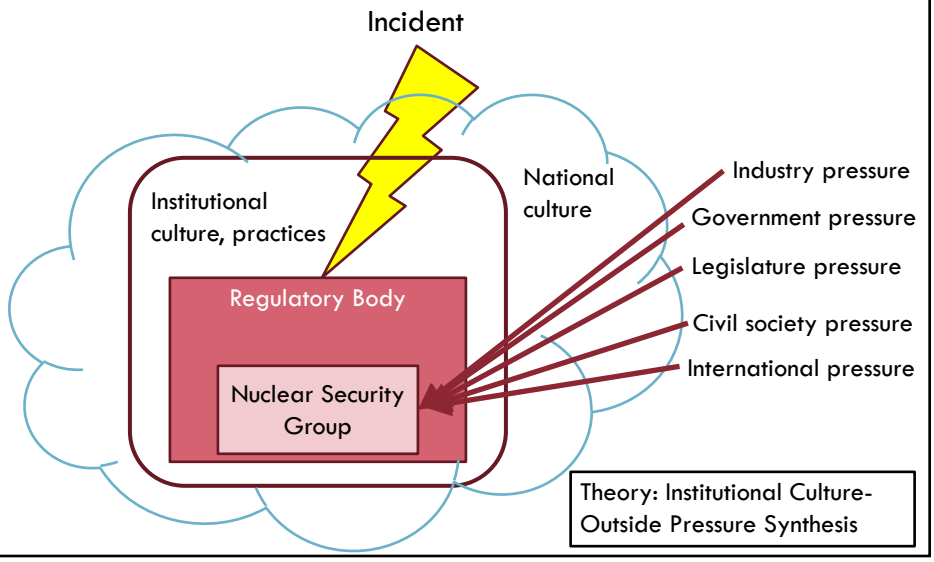

Regulator perceptions modulated by national, institutional cultures, outside pressures

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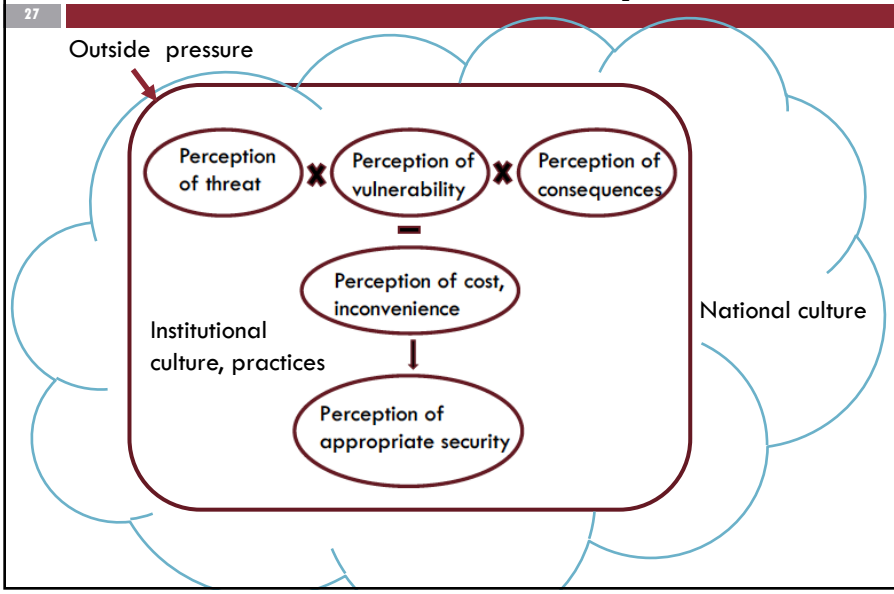

Options for influencing nuclear security decisions

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- Unlikely to be able to change institutional, national cultures – have to consider those contexts in choosing approaches
- Change perceptions of the threat
  - Briefings, reports, incident assessments
- Change perceptions of the vulnerabilities
  - Reviews, assessments, realistic tests
- Change perceptions of the consequences
  - Briefings, reports
- Change perceptions of the costs, inconveniences of improvements
  - Pay for all or part of the costs
  - Show low-cost options

Options for influencing nuclear security decisions (II)

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- Change perceptions of what security is appropriate
  - Identify, empower "security champions" within each system
  - Train decision-makers in state-of-the-art security approaches
  - Discuss, show good practices implemented elsewhere
  - International agreements
  - International recommendations, guidance
- Change outside pressures
  - Impose international pressure for better security
  - Institute independent reviews of security arrangements
  - Work with industry, legislatures, civil society – including "security champions" outside regulatory body

Prescription has to flow from diagnosis

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- If nuclear security is weak, why is that the case?
- Example: U.S.-Russia cooperation, 1990s-2000s
  - Theory I: Knowledge gap
  - Theory II: Short-term money gap
  - Theory III: Long-term money gap
  - Theory IV: Commitment gap
    - Need to change perceptions of the appropriate level of security
- Policy approaches to encouraging states to improve nuclear security need to be tailored to the circumstances of each case
  - Including national, institutional culture, pressures

Remaining mysteries, opportunities

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- How to get better data to confirm the theory?
  - Causes of important nuclear security decisions in each country
  - Opportunities for research: identifying, process-tracing these decisions
- How to better understand the national, institutional cultures and outside pressures in each national context?
  - Opportunities for research: in-depth organizational assessments
- How to better understand what tactics, policy tools, will be most effective in leading to sustained improvements in each context?
  - Opportunities for research: record of different approaches over time, what factors appear to have made the most difference in responses

Insider threats are the most dangerous nuclear security problem

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- The known HEU and Pu thefts, and most sabotages, involved insiders
- People don't want to believe their friends and colleagues could betray the organization
  - Leads to serious lapses in protection against insider threats
- Getting people to report suspicious behavior is *very* difficult
- Often even obvious "red flags" go unreported, unaddressed
- Bunn-Sagan book offers case studies, "Worst Practices Guide" on lessons learned from past mistakes

http://www.belfercenter.org/publication/insider-threats

Further Reading

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- *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline?* (2016): http://belfercenter.ksg.harvard.edu/files/PreventingNuclearTerrorism-Web.pdf
- *Insider Threats:* http://www.belfercenter.org/publication/insider-threats
- Video lecture on "Technologies and Institutions of Nuclear Security": https://www.youtube.com/watch?v=2GLZAKmCRRE
- Full text of Managing the Atom publications: http://belfercenter.org/managingtheatom
- Bunn materials, arranged by topic https://scholar.Harvard.edu/matthew_bunn

Backup slides if needed…

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Nuclear security: 3 layers of action

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- At facilities and transports
  - What security measures to prevent theft are actually implemented day-to-day?
  - How well are they implemented?
  - How are staff trained and motivated?
- National policy and regulation
  - What nuclear security measures are required?
  - What kinds of inspections and enforcement activities are carried out?
- International agreements and cooperation
  - What do treaties and international recommendations call for?
  - What are international initiatives motivating or helping countries to do?
  - What processes are there for dialogue, making commitments, and tracking progress?

Nuclear security: the conceptual structure

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- Can be thought of as global system with 100s of nodes
  - Only as strong as weakest link – failure at any one node could cause horrifying catastrophe
  - No central control over nodes
  - Minimal ability to find and fix the weakest nodes
- Key purpose of all the global agreements, initiatives, summits is to convince states to strengthen nodes within their borders
  - But very little understanding of the factors that motivate change within individual states

What affects nuclear security on the ground?

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- Rules & procedures
- Resources & other priorities
- Training
- Leadership
- Threat perceptions
- Vulnerability perceptions
- Knowledge of best practices
- Incentives
- Organizational and national culture

International discussions and agreements affect these factors importantly, but indirectly

Roles for global governance

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- Agenda setting and issue framing:
  - Starting a process, mobilizing actors and attention (Nuclear security summits, powerful states, civil society…)
- Capacity building
  - Resource mobilization, help in strengthening response (Bilateral technical cooperation, IAEA assistance, WINS and other training…)
- Norm creation and dissemination
  - Establishing common expectations as to appropriate conduct (CPPNM, IAEA recommendations, summit "gift baskets," WINS guidance, civil society groups…)
- Standard setting
  - More precise, often legally binding commitments (not much yet)
- Compliance and adjudication
  - Institutionalized mechanisms for resolving disputes and inducing compliance (not much yet)
- Coercive diplomacy and collective use of force (not much yet)

Global governance is more difficult when…

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- The threat to be addressed is disputed or downplayed
- There are no agreed measures of progress
- There is no verification and progress or backsliding takes place largely in secret
- There are no (or very limited) international fora for regular discussion of next steps
- International arrangements for handling the issue:
  - Do not exist, or are insufficient and difficult to change
- The needed changes in behavior are seen as expensive and opposed by the relevant industries
- There are no or few mechanisms for creating incentives for action by the actors who need to act
- States see further agreements as challenging their sovereignty, and there is resentment and political conflict on related issues

Assessing commitments: the 3Ms

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Commitments are most effective if they fulfill the "3Ms":

- *Meaningful* – significantly reduce the problem, if implemented ("you'd know if you'd done it")
- *Measurable* – you can count how much has been done
- *Monitorable* – you can confirm that it has been done
- Most nuclear security commitments do not meet these standards
  - Treaty ratifications: measurable, monitorable, not very meaningful
  - Security upgrades to protect against wide spectrum of adversary threats: highly meaningful, not usually measurable or monitorable
  - Material removals: measurable, monitorable, some are meaningful (only nuclear security measure that meets all three)
- Contrast to, for example, climate (all agreed that tons of greenhouse gases emitted is the right measure), strategic arms control (can measure number of missiles, bombers, etc.)
- *But,* some non-3M initiatives can still have major impact

Example of important impact without the 3Ms: IAEA nuclear security recommendations

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- For decades, experts from IAEA member states have drafted recommendations on physical protection of nuclear facilities
  - "INFCIRC/225"
  - Multiple revisions over the years
- These are:
  - Non-binding
  - Not (mostly) measurable or verified
  - Mostly somewhat vague (could fulfill recommendations, still have serious nuclear security vulnerabilities)
- *But,* they have substantially shaped national approaches:
  - Give regulators a convenient, hard-to-criticize approach to adopt
  - Give suppliers a benchmark to insist on (mainly United States)
  - Build norm – what states "should" do, not to be a "laggard"
  - Shape regulators' ideas about how nuclear security should be done
  - Provide "decision moments" domestic nuclear security advocates can take advantage of

Comparing governance: nuclear safety and nuclear security

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- International standards
  - Safety: IAEA safety standards and guides in wide range of areas, widely respected and used, fairly detailed (e.g., instructions on how to model potential tsunami threats)
  - Security: IAEA security series just beginning, not as detailed
- Sharing and learning from experience
  - Safety: Facilities report on incidents, root causes, lessons learned; IAEA/NEA and WANO maintain databases, analyze, and distribute
  - Security: no comparable mechanism
- Peer review
  - Safety: Several varieties of IAEA peer review services; all power reactors members of WANO, agree to accept peer reviews
  - Security: IAEA offers peer review, only a few HEU and Pu facilities have ever had one; no industry peer reviews

Comparing governance: nuclear safety and nuclear security (II)

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- Discussion, identifying next steps
  - Safety: Regular review meetings of the Nuclear Safety Convention; WANO meetings; many others
  - Security: Nuclear security summits – but no other comparable mechanism (IAEA ministerial meetings, future CPPNM reviews…)
- Sharing best practices
  - Safety: Extensive sharing through WANO, IAEA
  - Security: Limited sharing through World Institute for Nuclear Security
- Independent advice
  - Safety: International Nuclear Safety Group (INSAG) publishes annual letters on safety priorities, wide range of analyses and reports; many NGOs providing analysis and critique
  - Security: AdSec provides confidential advice to IAEA, does not publish reports; small number of NGOs involved

Need: a comprehensive program to reduce the risk of nuclear and radiological terrorism

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- A comprehensive, action-oriented plan
  - Going after the material – secure, minimize
  - Going after the smugglers – find, interdict, impede
  - Going after terrorist groups with nuclear potential
- Resources, authorities to implement the plan
- Someone in charge – with the right support, authorities
- Indicators to judge progress
- Process for learning, adapting, to optimize effectiveness

Today:

- Nuclear security efforts losing momentum after summits
- Intelligence effort focused on nuclear, biological, chemical terrorism small, largely reactive rather than proactive
- Only pieces of comprehensive program in place
- No clear progress indicators, means to learn and adapt

Going after the material

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- Goal:
  - Effective, sustainable security for all nuclear weapons and weapons-usable material worldwide – includes minimizing stocks, locations
  - Also need better security for nuclear facilities, radiological sources
- Current:
  - Dramatically improved nuclear security over past 25 years
  - But effort losing momentum 2 years after nuclear security summits
  - U.S. nuclear security programs shrinking, slowing
- Need to revitalize U.S. nuclear security programs
  - From paying for upgrades to convincing states to do more themselves
  - Equally applicable in rich countries and poor countries
  - Will be hard to convince countries to take steps we don't take in U.S.
  - Particularly important targets for cooperation
    - Russia
    - Pakistan
    - India

Going after the material (II)

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- Revitalized nuclear security programs should focus on genuinely effective implementation in 5 key areas
  - Protecting against the full spectrum of plausible adversaries
    - Are countries defending against everything they should be protecting against?
  - Multilayered defenses against insider threats
    - Insiders have been key to most real nuclear theft, sabotage incidents
  - Focused programs to assess, strengthen nuclear security culture
    - Need all security-relevant staff to be vigilant, aware
  - Realistic vulnerability assessment and performance testing
    - Do nuclear security systems really work, in the face of creative adversaries looking for weak points?
  - Consolidating to fewer sites
    - Can provide better security at lower cost protecting fewer places

U.S. nuclear security programs slowing

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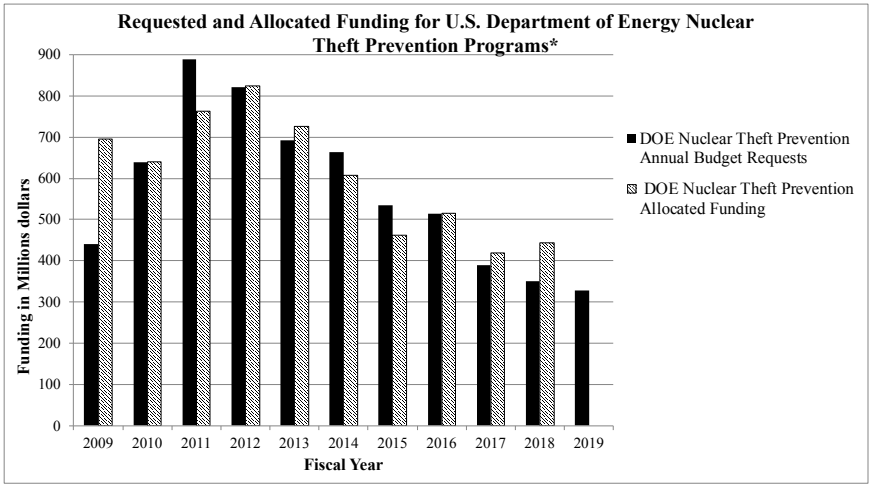

Even in secret areas, civil society can play a major role in pushing progress

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- In nuclear arms control:
  - Much of the most important progress over the decades was motivated in part by public pressure – people in the streets protesting
- In nuclear security, civil society groups provided
  - Awareness-raising: assessments of the threat, vulnerabilities
  - Ideas for action: Nunn-Lugar, HEU cleanout, the 4-year effort…
  - Accountability: public assessments of progress, commitments
  - Forums for dialogue: Track II, Track 1.5 discussions fleshed out ideas later pursued at the nuclear summits
  - Pressure for action:
    - "Naming and shaming" countries that weren't making sufficient progress
    - Independent assessments of gaps, how much progress summits and other talks had made

Careers: Choosing an international security specialization

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- Work in an area you believe is most central to international security, as it will:
  - Command your interest
  - Offer the greatest opportunity for material contribution
  - Likely be a growth area within government
  - Enjoy attention from senior officials
- Opportunities to:
  - Suggest an idea
  - Build support to get it adopted
  - See it make the world a safer place
  - Few things more satisfying!

Some opportunities in reducing nuclear dangers

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- To achieve success in:
  - Reducing nuclear weapons and stocks of fissile materials
  - Reducing the risk of nuclear war as technologies, politics change
  - Verifiably ending further production
  - Dealing with the hard proliferation cases (e.g., North Korea, Iran…)
  - Developing a new approach to the nuclear fuel cycle
  - Securing nuclear stockpiles worldwide
  - Stopping the next black-market nuclear network
  - Reducing demand for nuclear weapons
  - and more…
- The world will need a whole new generation of nuclear weapons, arms control, nonproliferation, safeguards, and nuclear security experts – exciting and critically important careers

A recent example: insider sabotage and a cleared terrorist at Doel-4

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- August 2014: An insider at Doel-4 reactor in Belgium drains lubricant, destroys reactor turbine
  - ~$200 million damage
  - Investigators unable to find culprit
  - Sabotage intended to cause economic damage, not radiation release
- Investigation finds that long before, contractor Ilyass Boughalab had access to vital area
  - Passed security clearance review in 2009
  - In late 2012, left to fight for terrorists in Syria (reportedly killed later)
  - Later convicted as part of "Sharia4Belgium" terrorist group

Source: Kristof Pieters

Insider threats are the most dangerous nuclear security problem

52

- The known HEU and Pu thefts, and most sabotages, involved insiders
- People don't want to believe their friends and colleagues could betray the organization
  - Leads to serious lapses in protection against insider threats
- Getting people to report suspicious behavior is *very* difficult
- Often even obvious "red flags" go unreported, unaddressed
- Bunn-Sagan book offers case studies, "Worst Practices Guide" on lessons learned from past mistakes

http://www.belfercenter.org/publication/insider-threats

July 2012: Protester intrusion at Y-12

53

Graffiti from Y-12 Break-In

- 2012: 82-year-old nun and two other protestors enter Y-12 facility
  - Passed through 3 alarmed fences, setting off multiple alarms – no one responded for extended period
  - New intrusion detection system setting off 10x as many false alarms
  - Cameras to allow guards to see cause of alarm had been broken for months
  - Major breakdown in security culture

Factors changing the risk

54

- Nuclear security around the world dramatically better than 25 years ago (reduces risk)
- Core al Qaeda dramatically degraded (reduces risk)
- ISIS geographic caliphate largely eliminated (reduces risk)
- India-Pakistan ongoing arms race, Pakistani shift to tactical nuclear weapons, powerful terrorist groups continue (increases risk)
- Global spread of committed jihadists (increases risk)
- North Korea continuing to produce more nuclear material (increases risk)
- US-Russia nuclear terrorism cooperation cut off (increases risk)
- Some modest spread of nuclear power (slightly increases sabotage risk, does not increase terrorist nuclear bomb risk)

But the risk should not be exaggerated

55

- No convincing evidence any terrorist group has ever gotten the nuclear material needed to make a bomb
- Neither al Qaeda nor Aum Shinrikyo, two especially large and sophisticated terrorist groups, appears to have come very close to nuclear weapons capability
  - Suggests barriers are significant
- No publicly available evidence of current al Qaeda nuclear plots (including from Abbotabad papers)
- No publicly available evidence of sustained ISIS nuclear program (as opposed to hints of possible interest)

But what could be happening that we don't know? How rapidly could things change in the future?

Nuclear security: the global picture

56

- Global stockpiles include:
  - ~14,000 nuclear weapons
  - > 500 tons of separated plutonium
  - >1300 tons of HEU (+/- 125 tons)
  - <1/3 of plutonium and HEU is physically in nuclear weapons
- Stocks located in 100s of buildings, bunkers, in >20 countries
- Widely varying security
- No global rules specify how secure stocks should be

W-48 nuclear artillery shell, one of many thousands of tactical nuclear weapons that have been dismantled

Source: U.S. Department of Energy

Theft of 0.01% of world stockpile could cause a global catastrophe

Nuclear security: 3 particular issues

57

- Russia
  - World's largest stocks of nuclear weapons and materials, largest number of buildings and bunkers
  - Dramatically improved security – but still some significant weaknesses (and may erode in the face of major budget cuts)
  - U.S.-Russian cooperation largely suspended
  - Widespread corruption, spreading Islamic extremism
- Pakistan and India
  - Small but growing nuclear arsenals, moving to tactical weapons
  - Some of the world's most capable terrorists – and insider issues
- HEU-fueled research reactors
  - Small (often not enough for a bomb at one site), but often minimal security

Since the nuclear security summits: some continued progress, but momentum slowing

58

- At the national level, some progress is continuing:
  - Several states have strengthened nuclear security regulations
  - Some states have established armed guards for nuclear facilities for the first time (or strengthened their guard forces)
  - Some states have established new requirements for cyber security for nuclear facilities
  - Some regulators are requiring operators to have security culture programs
  - Progress on minimizing civil HEU use continuing
- But substantial gaps remain
  - Some facilities not protected against the full spectrum of plausible threats
  - Limited protection against insider threats in particular
  - Few focused security culture programs in place
  - Few creative, effective, assessment and testing programs in place

Since the nuclear security summits: some continued progress, but momentum slowing (II)

59

- At the global level, little progress:
  - 5 "Action Plans" have led to little action
  - Summit "gift baskets" have gained few additional members, little additional action
  - U.S.-Russia cooperation in deep freeze, Russia not participating in most global nuclear security initiatives
  - IAEA global meeting made no progress on further action (though useful technical exchanges)
  - IAEA nuclear security efforts remain tightly constrained by member states with other priorities
  - Industry nuclear security grouping has made little progress
  - Most civil society interest focused on other nuclear dangers (e.g., North Korea, U.S.-Russian arms control, disarmament, Iran…)

We need more effective global governance of nuclear security

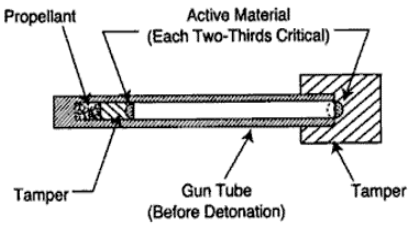
60

- Currently we have:
  - No international standards that specify what levels of security nuclear weapons, plutonium, or HEU (or major power facilities) should have
  - No regular international mechanism to build confidence that states are putting effective nuclear security in place
  - No forum for continuing high-level discussion of nuclear security now that the summit process has ended
- Current patchwork of nuclear security agreements, initiatives is clearly insufficient
  - But efforts to negotiate new treaties are unlikely to succeed in a timely way
  - More likely to succeed with political commitments among groups of like-minded states, and building on existing commitments

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

61

- With HEU, gun-type bomb – as obliterated Hiroshima – very plausibly within capabilities of sophisticated terrorist group
- Implosion bomb (required for plutonium) more difficult, still conceivable (especially if they got help)
  - Doesn't need to be as complex as Nagasaki bomb



Source: NATO

Doesn't take a Manhattan Project -- >90% of the effort was focused on producing nuclear material. And making a crude terrorist bomb is *far* easier than making a safe, reliable weapon

Key core al Qaeda nuclear operatives still at large

62

Ayman al Zawahiri  Source: FBI	Now head of the group. Nuclear project reported directly to him.
Abdul Aziz al-Masri  Source: NCTC *aka* Ali Sayyid Muhamed Mustafa al-Bakri	CEO of al Qaeda's nuclear program, oversaw explosives experiments in Afghanistan.

Sayf al-Adel  Source: FBI	Senior al Qaeda operational planner, reportedly personally approved attempted purchase of 3 nuclear bombs in 2003; released from Iran.
"Pakistani Nuclear Expert" ?	2003 communications from al Qaeda leaders reportedly approved purchase of nuclear devices if the Pakistani expert confirms they are real – U.S. Government has never identified or found this expert.

Nuclear terrorism anywhere would be a global catastrophe

63

- Not just a risk to the United States
- Economic, political, military consequences would reverberate worldwide
  - Likely shut-down of much of world trade, for a period

"Were such an attack to occur, it would not only cause widespread death and destruction, but would stagger the world economy and thrust tens of millions of people into dire poverty…. [A]ny nuclear terrorist attack would have a second death toll throughout the developing world."

– Kofi Annan, "A Global Strategy for Fighting Terrorism," March 10, 2005

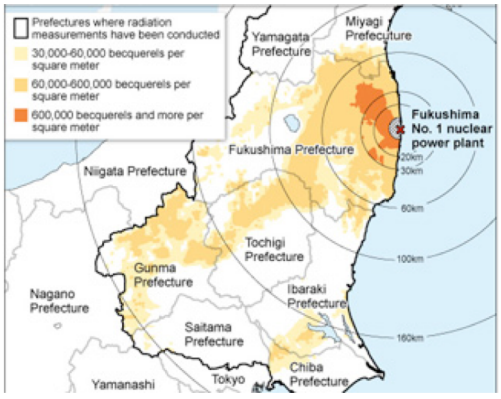
- Political consequences would doom prospects for large-scale nuclear growth, putting nuclear industry at risk
- Even a small probability is enough to justify risk-reduction action

Insecure nuclear material anywhere is a threat to everyone, everywhere

Terrorists might also be able to cause a Fukushima-scale nuclear accident

64

- Sabotage could cause a major radioactive release
  - Cutting off both off-site and on-site power could cause cooling to fail, reactor to melt
  - Under some circumstances, draining water from a spent fuel pool could cause a spent fuel fire, massive radiation release
- Challenging, but not impossible, to accomplish
- Could force widespread evacuation, fear, cost $10s of billions or more



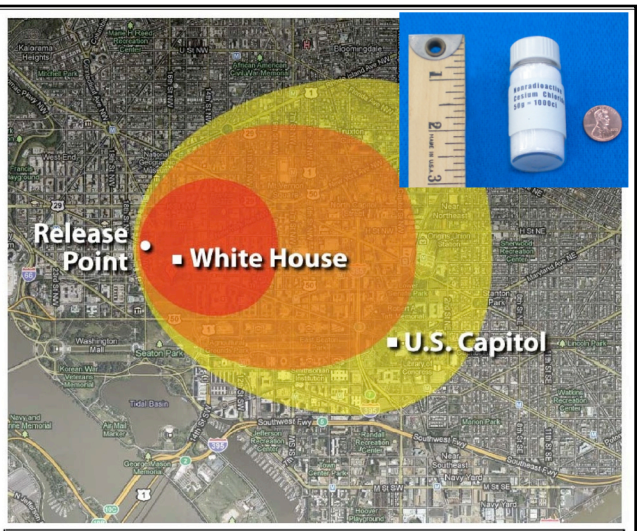
Source: Asahi Shimbun, from MEXT

Cs-137 "dirty bomb"

65

- Potentially dangerous sources used in hospitals, industry, in almost every country
- Al Qaeda, Chechens have repeatedly considered dirty bomb attacks

Source: Congressional Research Service, modeling by Sandia National Laboratories, 2010



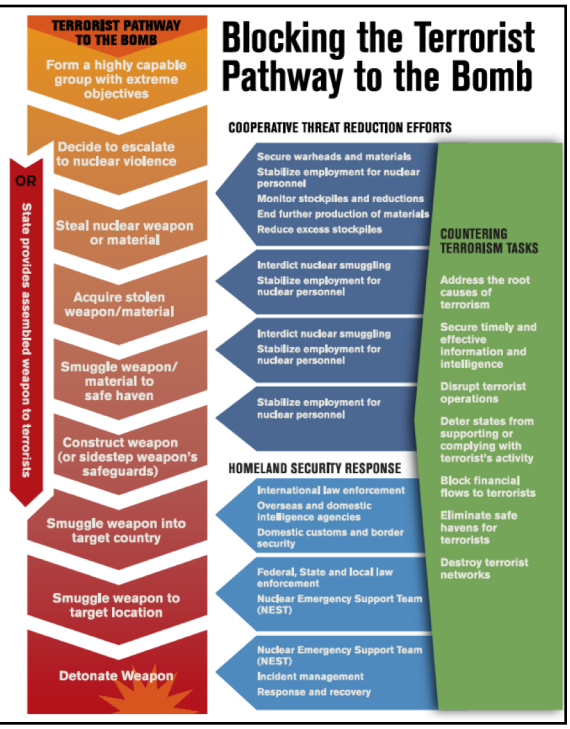
Effects and Actions

Area km²	Area mi	Equivalent Dose (rem)	Exceeds relocation PAG for which year:	Population	All Cancers	Fatal Cancers
2.10	0.81	>2.00	First year only	38,000	233	159
7.60	2.93	>0.500	Any subsequent year	94,700	278	189
13.2	5.10	>5.00	50 years (cumulative)	125,000	461	314

Areas and counts are cumulative. RDD detonated at 38.9 N, 77.0 W. PAG: Protective Action Guide


PM
PM

Blocking the terrorist pathway to the bomb



Source: Bunn, Securing the Bomb 2010: Securing All Nuclear Materials in Four Years (2010)

69

Attack at Pelindaba, Nov. 8, 2007

70

- Site with 100s of kgs of highly enriched uranium (HEU)
- Attack by 2 teams of armed, well-trained men, from opposite sides
- One team:
  - Penetrated 10,000-volt security fence
  - Disabled intrusion detectors
  - Went to emergency control center, shot a worker there, who raised first alarm
  - Spent 45 minutes inside guarded perimeter – never engaged by site security forces
  - Left through same spot in fence – never caught or identified
- Strong indications of insider help
- South Africa has since undertaken major nuclear security upgrades, established a regulatory design basis threat

The 4th and final nuclear security summit

71

- Outcomes:
  - Communiqué reaffirming the threat, need for continued action
  - 5 "action plans" – IAEA, UN, GICNT, GP, Interpol
  - ~ 15 group commitments – "gift baskets"
  - Actions by individual states
- Industry and civil society summits just before
- Question: what will fill the gap now that the summit process is over?

The nuclear security summit process: what it did and didn't do

72

- The up side
  - Brought together leaders from 50+ countries and organizations
  - Elevated issue from technical experts to political leaders
  - Transformed international debate – greatly increased international attention, decision moments to drive commitments
  - Created deadlines to get actions done
  - Created ongoing discussion among senior officials ("sherpas), interagency discussions within countries
- The down side
  - Consensus process has led to vague communiqués that may do little to drive decisions to beef up on-the-ground security
  - Have not agreed on any nuclear security standards or any new nuclear security architecture
  - What happens when the summits come to an end?

The nuclear security summit process: some accomplishments

73

- Many removals of HEU and plutonium
  - Several countries eliminated all the weapons-usable material on their soil (30 countries have now eliminated – more than half of all those who ever had such material)
  - All HEU out of Ukraine before the fighting started
- 2014 "Strengthening Nuclear Security Implementation" initiative
  - Commitment to meet objectives of IAEA recommendations, accept regular reviews
- Increased ratifications of key treaties
  - 2005 amendment to the physical protection convention finally likely to come into force this year
- Strengthening support for IAEA, other existing elements of international nuclear security framework

The nuclear security summit process: some gaps

74

- No agreement on any standards for nuclear security
- No agreement on any verification or common-format reporting
- No agreement on any new instruments or organizations – nuclear security framework remains a patchwork
- Less progress on plutonium, military stocks, sabotage, or radiological sources than on civil HEU
- Likely little to no effect on security measures as actually implemented in Russia, Pakistan, India…
- Russia – with world's largest stocks of nuclear weapons and materials – no longer participating

Nuclear security summits: reasons for success

75

- Relatively fertile, unplowed ground
  - No previous high-level forum on nuclear security
- Nuclear security does not threaten any state's interests
- Stayed focused on this area of common interest
  - Arab and Israeli leaders; Pakistani and Indian leaders; NWS and NNWS; developed and developing states, all able to work together without rancor
- Innovations: "house gifts" (national commitments), "gift baskets" (group commitments)

Source: Associated Press

Nuclear security summits: constraints on progress

76

- Difficult to define, measure, verify progress
  - Nuclear security measures complex and generally secret
- Widespread complacency about the threat
- Consensus process for communiqués
- Summit "sherpas" often knew little about nuclear security
- By end: summit fatigue

Source: Associated Press

The international nuclear security framework

77

- Key purpose of *international* and *national* frameworks is to ensure effective *local* nuclear security
  - Focus should never be on ratifying agreements for their own sake, but on ways to strengthen security on the ground
- International framework includes many elements – a "regime complex," not a single regime
  - Binding agreements
  - International recommendations
  - Technical cooperation
  - Summits and other high-level discussions
  - IAEA guidance, reviews, services
  - Requirements of supply agreements
  - Best practice exchanges
- Constrained by complacency, sovereignty, secrecy, politics…

Drivers of nuclear security: the data problem

78

- No agreed measure of nuclear security
  - NTI Index assesses answers to yes/no questions about whether rules of particular types exist
  - Effective nuclear security also depends on *quality* of the rules, and effectiveness of their implementation
  - Experts disagree on the importance of different factors
- Nuclear security measures are largely secret
  - Can get only partial data from published regulations, national reports, conference papers, interviews, site visits…
- Data on change over time is usually unavailable
  - Makes it far more difficult to assess what factors lead to change

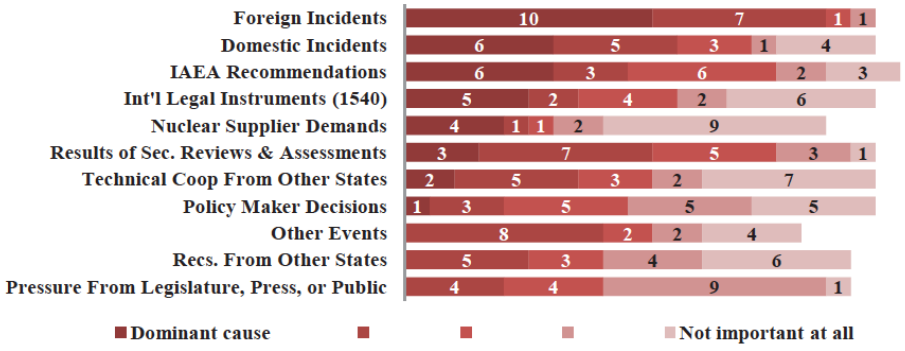
Drivers of nuclear security: Incorrect theories

79

- The realist approach: states will protect nuclear stocks because they are central to their security (e.g., Waltz)
  - Many states transparently failed to do so
- The rational actor approach: states will be provide security at the optimum balance of cost and risk
  - Transparently not the case for much of the nuclear age
  - Most regulators do not attempt to make cost/risk judgments
- Regulation fills public demands, driven by politics
  - Little public interest in or attention to nuclear security
- Full capture: regulation will only serve industry interests
  - Many nuclear security regulations imposed over industry objections
  - But nuclear industry does have outsize influence

Drivers of nuclear security change

80



Source: Bunn and Harrell, *Threat Perceptions and Drivers of Change in Nuclear Security Around the World: Results of a Survey* (2014)

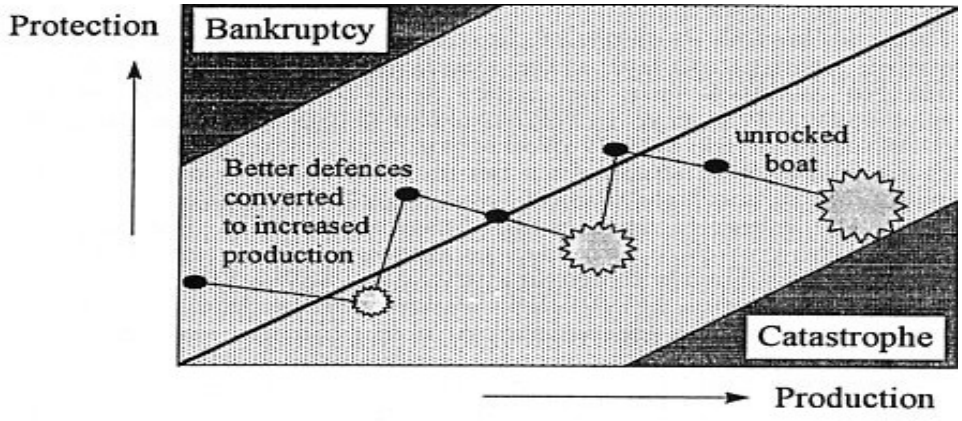
Nuclear security: an incident-driven punctuated equilibrium

81

- Normal state:
  - Regulators, operators believe existing security arrangements are sufficient, until there is overwhelming contrary evidence
- Major incidents drive change – but how much varies
  - Political, institutional, cultural factors affect how incidents are interpreted, responded to
  - Does a near-miss mean "the system worked" or "we need to fix things so that doesn't happen again"?
- Policy-makers do not have to wait for incidents
  - Poor results on inspections, failures in realistic tests can also be "incidents" that drive change
  - International recommendations and reviews are influential
  - In U.S. case, congressional investigations, embarrassing media stories, expert NGOs have played important roles

Navigating the punctuated equilibrium

82



From James Reason, Managing the Risks of Organizational Accidents *(Ashgate, 1997)*

The role of the IAEA

83

- IAEA develops guidance, offers advice, provides services – but only when states request them
  - Broad range of guidance documents
  - >100 member states now have "Integrated Nuclear Security Plans" agreed or in development
  - IAEA offers nuclear security reviews – especially International Phsical Protection Advisory Service (IPPAS)
  - IAEA provides countless training programs
  - Manages database of illicit trafficking incidents
  - Helps with HEU removals, recovery of orphan sources
  - Provides limited hardware assistance in some cases

Nuclear security: policy tools

84

- Bilateral cooperation or assistance
  - E.g., U.S.-Russia, U.S.-Pakistan, many other countries
- Consolidating material to fewer sites
  - E.g., converting HEU research reactors, removing HEU
- Legally binding international instruments
  - E.g., Physical Protection Convention and amendment
  - UNSCR 1540
- International recommendations
  - E.g., INFCIRC/225/Rev. 5
- Supply requirements
  - Nuclear cooperation agreements, U.S. review visits
- Best practice exchanges
  - E.g., World Institute for Nuclear Security
- Nuclear security summits

National regulation and policy

85

- Various questions countries must answer:
  - What threats should nuclear weapons, HEU, and plutonium be protected against?
  - What specific security measures should be required?
  - How should these vary with the type of material, and how hard it would be for terrorists to use to produce a nuclear blast?
  - How much will it cost, and who should pay?
  - How do we strengthen security culture?
  - Who's in charge in the event of a real incident, and how do we ensure different parties involved are properly coordinated?
- Many of these are answered in regulations. Key questions:
  - Are the regulations strong enough that, if followed, effective nuclear security would result?
  - How well are the rules implemented and enforced?

National regulation and policy (II)

86

- Strong regulation is crucial to effective, sustainable nuclear security
  - Most nuclear managers will not invest in expensive nuclear security systems unless governments tell them they have to – and back that up with inspection and enforcement
  - A critical element: the design basis threat (DBT) – the threat nuclear security systems must be designed to protect against
- *But,* a culture only focused on following the rules will not achieve excellence in nuclear security
  - Need a culture focused on continual improvement of security, as in nuclear safety – always looking for ways to find and fix vulnerabilities, do things better, adapt to new realities
  - Requires convincing key managers and staff that the threat is real and effective security is part of their mission (not so easy to do)
  - *Incentives* are a crucial part of the story – how to structure?

Legally binding international instruments on nuclear security

87

- *Not* the NPT or IAEA safeguards
  - NPT does not require any security for nuclear material
  - "Safeguards" are not about either safety or guarding – inspections to confirm material has not been diverted
- 1980 Physical Protection Convention
  - U.S. originally hoped would be effective, binding global standard
  - Least common denominator: covers ONLY security for material in international transport – and only civilian material (~15% of total)
  - Minimal, vague security requirements
  - Includes extensive legal provisions, requiring all parties to pass laws making nuclear theft a crime and giving them authority to arrest and prosecute or extradite nuclear thieves from elsewhere

Legally binding international instruments on nuclear security (II)

88

- 2005 Amendment
  - Covers civilian material in domestic use
  - Extends criminal law provisions to sabotage, other acts related to nuclear theft and terrorism
  - Parties must have a rule on nuclear security and an agency charged with implementing it – but what should it say?
- 2005 Nuclear Terrorism Convention
  - All parties to take "appropriate" nuclear security measures – unspecified
  - Mostly focused on legal response
- UNSC Resolution 1540
  - All states must provide "appropriate effective" nuclear security and accounting – but no one has specified what this means

International nuclear security recommendations and initiatives

89

- International recommendations
  - IAEA "Nuclear Security Series," especially INFCIRC/225/Rev. 5
    - More specific, but still quite general – should have a fence with intrusion detectors, but how hard should they be to defeat?
    - Compliance voluntary (though most countries do)
- Technical cooperation and funding
  - Nunn-Lugar, comparable programs
  - Global Partnership
  - Substantial progress – but varies greatly from site to site, country to country; many security elements can't be much influenced from outside; new measures may not be sustained
- Best practice exchanges
  - WINS
  - U.S.-Russia-UK, others
  - Little data on implementation, some countries do not participate

International nuclear security recommendations and initiatives (II)

90

- Global Initiative to Combat Nuclear Terrorism
  - 85 nations participating
  - Helps to convince countries of reality of threat
  - Sharing of experience, best practices, capacity-building
  - Mostly focused on emergency response, forensics, smuggling… modest focus on upgrading nuclear security
- Proliferation Security Initiative
  - > 70 countries participating
  - Focused on interdiction of proliferation-sensitive shipments
  - Also information sharing, excercises
  - Unlikely to stop smuggling of nuclear material that would fit in a suitcase

What are the underlying drivers of inadequate nuclear security?

91

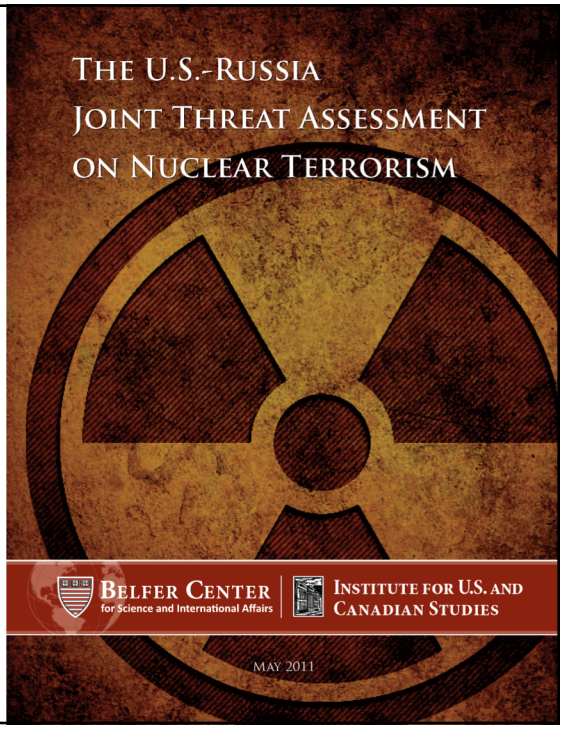
- Diagnosis drives prescription
- Is this mainly driven by lack of:
  - Knowledge of modern security approaches? → Provide training
  - Resources for security? → Provide financial + technical assistance
  - State capacity? → Provide help to build up regulator, other state functions
  - State commitment to action? → Tools of statecraft to try to change minds, change incentives
- Complacency is the biggest obstacle. Beliefs that:
  - There's little threat of nuclear terrorism
  - If it happens it's the United States' problem, not my problem
  - My security measures are already good enough
  - I've got other priorities that are more important
- Other important obstacles
  - Sovereignty, secrecy, political disputes, pride, bureaucracy

Not just a U.S. view

- First ever U.S.-Russian joint threat assessment
- Concludes the danger is real, urgent action is needed to reduce it
- Endorsed by broad range of retired military, intelligence experts

http://belfercenter.ksg.harvard.edu/publication/21087/

92



International assessments of the danger of nuclear terrorism

93

"Nuclear terrorism is one of the most serious threats of our time. Even one such attack could inflict mass casualties and create immense suffering and unwanted change in the world forever. This prospect should compel all of us to act to prevent such a catastrophe."

– U.N. Secretary-General Ban-Ki Moon, 13 June 2007

"The gravest threat faced by the world is of an extremist group getting hold of nuclear weapons or materials."

– then-IAEA Director-General Mohammed ElBaradei, 14 September 2009

"We have firm knowledge, which is based on evidence and facts, of steady interest and tasks assigned to terrorists to acquire in any form what is called nuclear weapons, nuclear components."

– Anatoly Safonov, then counter-terrorism representative of the Russian president, former head of the FSB, 27 September 2007

Nuclear security is the foundation for the three pillars of the NPT

94

- Disarmament:
  - Nuclear weapon states will not disarm if insecure nuclear material could allow other states or terrorist to rapidly get nuclear weapons
- Peaceful uses:
  - Nuclear energy will not gain needed support unless people are confident that it is safe and secure
- Nonproliferation:
  - Efforts to stop the spread of nuclear weapons will not work if Insecure nuclear material offers states or terrorist groups a rapid path to the bomb

In all these areas, nuclear security is important to the security of all countries around the world

The scale of the catastrophe

95

- Tens of thousands killed; tens of thousands more burned, injured, irradiated
  - Radioactive fallout would require large-scale evacuation
- Terrorists may claim they had more bombs hidden in cities, threaten to detonate them unless their demands were met
  - Potential for widespread panic, flight from major cities, resulting economic and social chaos
- Huge pressure on leaders of attacked state to take any action necessary to prevent further attacks – and to retaliate
  - Effects on international affairs likely far larger than 9/11

Notions of sovereignty and civil liberties may be radically altered – every state's behavior affects every other

Did you know? Real incidents related to nuclear terrorism

96

- Events that have genuinely occurred:
  - A large-scale terrorist attack on a U.S. nuclear weapons base
  - Terrorist teams carrying out reconnaissance at Russian nuclear weapons storage facilities
  - An attack on the Pelindaba site in S. Africa (100s of kgs of HEU) by two armed teams
    - One team penetrated 10,000-volt security fence, disabled intrusion detectors, went to emergency control center, shot worker there
    - 45 minutes inside guarded perimeter, never engaged by site security forces
  - A terrorist attack on a nuclear facility (not yet operational) in which armed guard force was overwhelmed, terrorists were in control of facility for an extended period
  - More than a dozen real acts of sabotage at nuclear facilities
    - None apparently intended to cause large radioactive release
    - One involved firing a rocket-propelled grenade at a nuclear facility
  - Russian businessman offering $750,000 for stolen weapon-grade plutonium, for sale to a foreign client

Did you know? Real incidents related to nuclear terrorism (II)

97

- Events that have genuinely occurred:
  - Preliminary explosive tests in al Qaeda's nuclear program
  - Repeated al Qaeda efforts to get stolen nuclear material or nuclear weapons (most recently in 2003)
  - Repeated al Qaeda attempts to recruit nuclear expertise
    - Including bin Laden and Zawahiri meeting with senior Pakistani scientists
  - al Qaeda seeking and receiving religious ruling authorizing nuclear attack on American civilians (2003)
  - Several incidents of al Qaeda considering (but not pursuing) attacks on nuclear power plants
- Good news on nuclear terrorism (*as far as we know*):
  - No convincing evidence terrorists have yet succeeded in getting either materials or expertise needed
  - Risk has likely declined, because of improved nuclear security, large disruptions to "al Qaeda central"
  - Both al Qaeda and Aum Shinrikyo found nuclear to be difficult

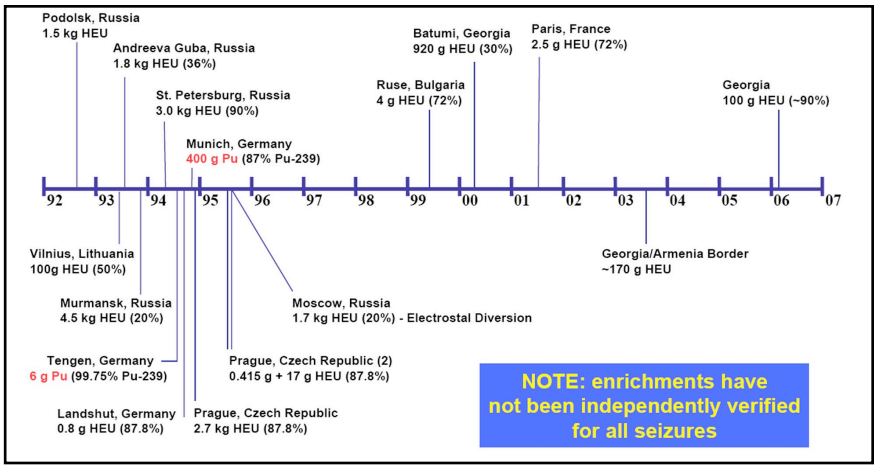
Some (sometimes misleading) terms to remember

98

- *Highly enriched uranium (HEU)*
  - Uranium with at least 20% U-235
  - As opposed to *natural uranium* (0.7% U-235), *low-enriched uranium* (LEU, typically 4-5% U-235), or *depleted uranium* (<0.7% U-235)
- *Weapons-grade uranium*
  - Uranium with ~90% U-235
  - But bombs can be made with material far below weapons-grade
- *Weapons-grade plutonium*
  - Plutonium with ~ 90% Pu-239
  - As opposed to *reactor-grade* plutonium (much less Pu-239) – contained in spent fuel from typical nuclear power reactors
  - Weapons-makers prefer weapons-grade plutonium, but reliable, effective weapons can also be made with reactor-grade plutonium (once reprocessed from spent fuel)

Documented seizures, 1992-2006 (more seizures in 2010, 2011)

99



Source: Los Alamos National Laboratory, Tom Bielefeld

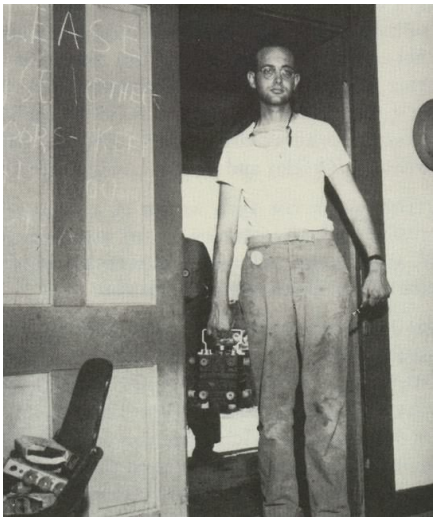
Some recent anecdotes of insecurity

100

- Russia: Gen-Major Victor Gaidukov, commander of a nuclear weapon storage site, arrested for accepting >$300,000 in bribes (2011)
- Pakistan: Brig.-Gen. Ali Khan arrested for ties to Islamic extremists (2011)
- S. Africa: Two armed teams attack Pelindaba site where 100s of kilograms of HEU is stored, one penetrates 10,000 volt fence, disables intrusion detectors, shoots worker in emergency control center – never caught (2007)
- Belgium: Peace activists break into nuclear weapon storage base, spend >1 hour there before being detected and stopped (2010)
- United States: Bomber flies across the country with 6 nuclear weapons on board, no one knows – checks failed (2007)

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

101



Source: Los Alamos

The amounts of material required are small

102

- For simple "gun-type" bomb (with reflector): ~ 50-60 kg of HEU (Hiroshima bomb was 60 kg of 80% enriched material)
  - Fits in two 2-liter bottles
- For 1st-generation implosion bomb:
  - ~6 kg plutonium (Nagasaki)
  - ~ 3x that amount of HEU

The size of the plutonium core for the Nagasaki bomb
Source: Robert del Tredici

North Korea and Iran are likely small parts of the nuclear terrorism problem

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- Nuclear security:
  - North Korea has only a few bombs' worth of plutonium in a tightly controlled garrison state – theft very unlikely
  - Iran has not begun to produce weapons-usable material – has only a small amount of HEU research reactor fuel
- Conscious state transfer:
  - Regimes bent on maintaining power unlikely to take the immense risk of providing nuclear bomb material to terrorist groups who might use it in a way that would provoke overwhelming retaliation
  - Transfers to other *states* – who are likely to be deterred from using nuclear weapons – a very different act
- High-level "rogues" within states
  - If stocks of weapons-usable material grew, could an "A.Q. Kim" sell without detection?
- State collapse could lead to "loose nukes" scenario

Spread of nuclear power need not increase terrorist nuclear bomb risks

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- Most nuclear reactors do not use nuclear material that can readily be used in nuclear bombs:
  - Low-enriched uranium fuel cannot be used to make a nuclear bomb without technologically demanding further enrichment
  - Plutonium in spent fuel is 1% by weight in massive, intensely radioactive fuel assemblies
- Reprocessing (separating plutonium from spent fuel) could increase risks, requires intensive security and accounting
  - Poor economics, few additional countries pursuing – South Korea and China only countries currently considering shift
  - Reprocessing does not solve the nuclear waste problem – still need a nuclear waste repository
- Power reactors do pose potential targets for sabotage
  - Sabotage would mainly affect countries in region, global nuclear industry
  - As with nuclear theft, strong security measures can reduce the risk

Belief in the threat – the key to success

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- Effective and lasting nuclear security worldwide will not be achieved unless key policymakers and nuclear managers around the world come to believe nuclear terrorism is a real threat to *their* countries' security, worthy of investing their time and resources to address it
- Steps to convince states this is a real and urgent threat:
  - Intelligence-agency discussions – most states rely on their intelligence agencies to assess key security threats
  - Joint threat briefings – by their experts and our experts, together
  - Nuclear terrorism exercises and simulations
  - "Red team" tests of nuclear security effectiveness
  - Fast-paced nuclear security reviews – by teams trusted by the leadership of each country
  - Shared databases of real incidents related to nuclear security, capabilities and tactics thieves and terrorists have used, lessons learned

What's true? Reasons for skepticism about the nuclear terrorism threat

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- States have had great difficulty getting nuclear weapons, surely it would be harder for terrorists
  - Hardest part for states is making the nuclear material – 90% of Manhattan Project
  - Making safe, reliable weapons that can be delivered by missile or aircraft is *far* harder than making crude terrorist bomb
- Terrorist attacks are mostly not very sophisticated
  - But there is a spectrum – some terrorist groups *have* used sophisticated explosive designs
  - Significant numbers of well-trained engineers and scientists have worked with terrorist groups
- Greatly weakened al Qaeda could not organize a nuclear bomb effort
  - Killing, capture, disruption of much of top leadership *does* reduce the risk – but modest cell far from the drone strikes could still be pursuing a nuclear effort

What's true? Reasons for skepticism about the nuclear terrorism threat (II)

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- U.S. intelligence has exaggerated terrorist threats – including in the lead-up to war in Iraq
  - Absolutely correct – skepticism justified. *But* notable that *both* George W. Bush and Barack Obama identify nuclear terrorism as greatest threat to U.S. national security
  - Wide range of other countries (both nuclear weapon states and non-nuclear-weapon states) have reached similar conclusions
- Terrorists could not plausibly get nuclear material
  - Ongoing seizures suggest danger still exists
  - For most seizures, material was never noticed to be missing --how many other thefts have *not* been detected?
- Terrorists not likely to get state support
  - Probably true – states unlikely to hand such power over to terrorist groups they cannot control
  - But state support helpful, not essential, to terrorist nuclear effort

Nuclear terrorism: the good news

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- No convincing evidence any terrorist group has yet obtained a nuclear weapon or the materials and expertise needed to make one
  - Despite many claims
- No evidence any state has helped terrorists with nuclear weapons
- Making a nuclear bomb is clearly not "easy"
  - Al Qaeda and Aum, both sophisticated, well-funded groups, appear to have faced major hurdles
- Overall, threat is probably lower than 20 years ago
  - Many nuclear sites have much better security, or all nuclear material removed
  - Al Qaeda substantially disrupted
  - *But what may be happening without being detected?*

The threat of nuclear sabotage

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- Most nuclear power plants protected by security forces, containment vessels, and redundant safety systems
- *But,* levels of security vary widely:
  - Some reactors have no (or few) on-site armed guards
  - Few civilian facilities are designed to cope with 9/11 threat -- multiple, coordinated teams, suicidal, well-trained, from a group with substantial combat and explosives experience
  - Some reactors do not have Western-style containments, few redundant safety systems
- *If* attackers could successfully destroy multiple safety systems, reactor could melt down, breach containment, spread radioactive material – as at Fukushima
- Similarly, *if* attackers could successfully drain the water from a spent fuel pool, real risk that fuel could get hot enough to catch fire -- potential Chernobyl-scale disaster

The threat of "dirty bombs"

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- Dirty bomb could be very simple -- dynamite and radioactive material together in a box
  - Other simple means to disperse radioactive material more effective
- Dangerous radioactive sources in use for valuable civilian purposes in hospitals, industry, agriculture
  - Even large sources often have minimal security
- "Weapons of mass disruption" – not mass destruction
  - Would cause zero to a few near-term radiation deaths, potentially a few hundred long-term cancer deaths (undetectable against natural cancer background)
  - *But,* fear of anything "radioactive" could create panic
  - Expensive, disruptive – potentially many blocks would have to be evacuated, cleaned up (possibly 10s of billions in costs)

Dealing with the "dirty bomb" threat

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- Better control, accounting, security for radioactive sources:
  - All high-priority sources worldwide should be accounted for, regulated, and have basic security measures (strong locks, alarms, etc.) throughout their life-cycle – IAEA "Code of Conduct"
  - Improved transport security especially needed
  - Retrieve, safely dispose of disused sources
  - >100 countries worldwide have inadequate controls
- Radiation detection at ports, borders
- Improved capacity to detect, assess, respond to attack
  - Need training, regular exercises, for first responders
  - Develop improved urban decontamination technologies
- Most important: communication strategy to limit panic, tell public how to respond – complicated by past gov't lies

What would nuclear security success look like?

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- Number of sites with nuclear weapons, HEU, or separated plutonium greatly reduced
- All countries with HEU, Pu, or major nuclear facilities put in place *at least* a "baseline" level of nuclear security
  - Protection against a well-placed insider, a modest group of well-trained and well-armed outsiders (able to operate as more than one team), or both outsiders and an insider together
  - Countries facing higher adversary threats put higher levels of security in place
- Strong security cultures in place, focused on continual improvement, search for sustainable excellence
- Measures in place to confirm strong security performance
  - Effective regulation, inspection, enforcement
  - Regular, realistic performance tests – including "red teams"
  - Independent, international review – becoming the norm

Essential elements of an "appropriate effective" physical protection system

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- A *design basis threat* reflecting today's threats
- Effective *regulation* requiring all facilities with potential bomb material or posing a catastrophic sabotage risk to have security capable of defeating the DBT
  - Backed up by inspections, and enforcement
  - Ideally including *realistic tests* of the system's ability to defeat outsider and insider threats
  - Effective *control and accounting* of nuclear material
- A strong *security culture*, to ensure that all relevant staff understand the threat and the importance of security
- *Police and intelligence* efforts focused on ensuring that nuclear conspiracies will be detected
- *Regular review and adaptation* to ensure the system adapts to changing threats and opportunities

Reactor-grade plutonium is weapons-usable

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- Higher neutron emission rate:
  - For Nagasaki-type design, even if neutron starts reaction at worst possible moment, "fizzle yield" is ~ 1kt – roughly 1/3 destruct radius of Hiroshima bomb – more neutrons won't reduce this
  - Some advanced designs are "pre-initiation proof"
- Higher heat emission:
  - Various ways to deal with – for example, plutonium component can be inserted into weapon just before use (as in early U.S. designs)
- Higher radiation:
  - Can be addressed with greater shielding for fabrication facility
  - Last-minute insertion of plutonium component again

Reactor-grade plutonium is <u>not</u> the <u>preferred</u> material for weapons, but any state or group that can make a bomb from weapon-grade plutonium can make one from reactor-grade