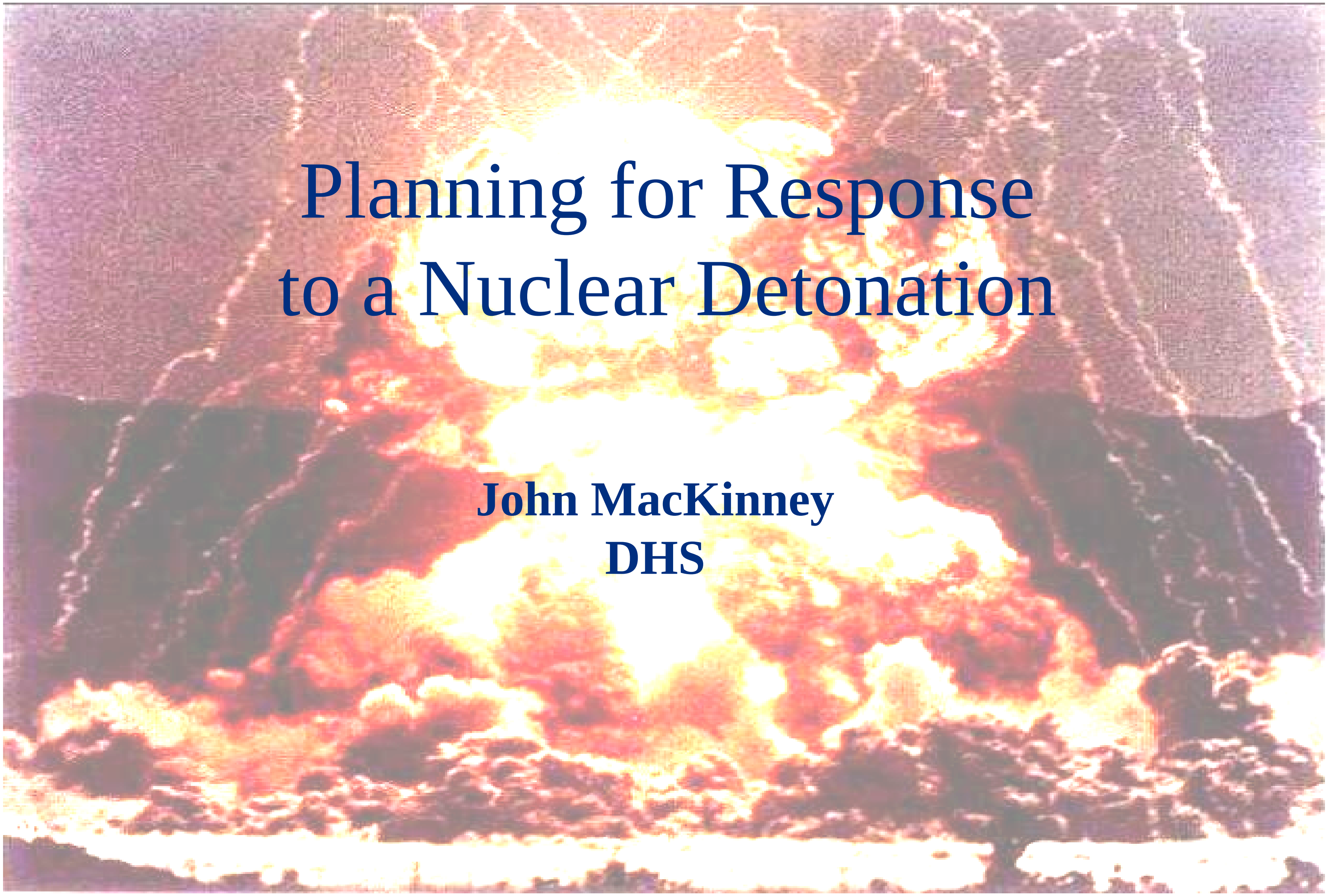

Planning for Response to a Nuclear Detonation

John MacKinney
DHS

Homeland Security

Outline

- Part 1. The new nuclear threat; Threat-101 (open source primer)
  - Strategic change
  - Difficult part - acquire sufficient fissile nuclear material
  - Nuclear basics
  - Transport and deploy

- Part 2. Nuclear attack impacts and response
  - Impacts on urban environment
  - Response planning
    - Zones, planning factors
  - Recommendations

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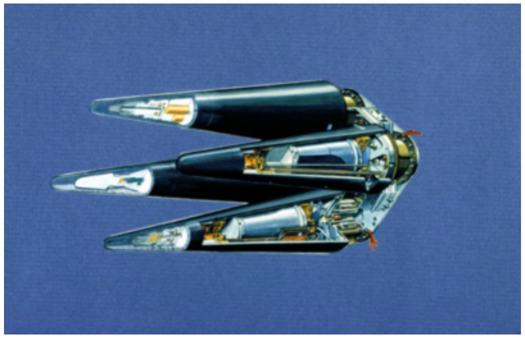
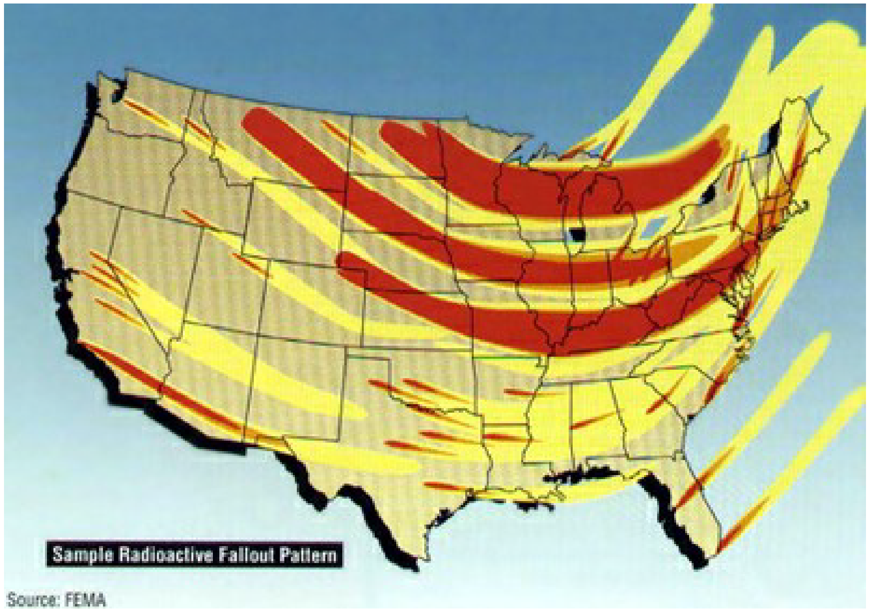
Threat-101: The Strategic Situation Has Changed



- During the Cold War the U.S. studied nuclear weapons effects on enemy targets
  - Infrastructure loss
  - Over-the-pole MIRV, high height-of-burst,
  - Focused on macro impacts; total casualties,



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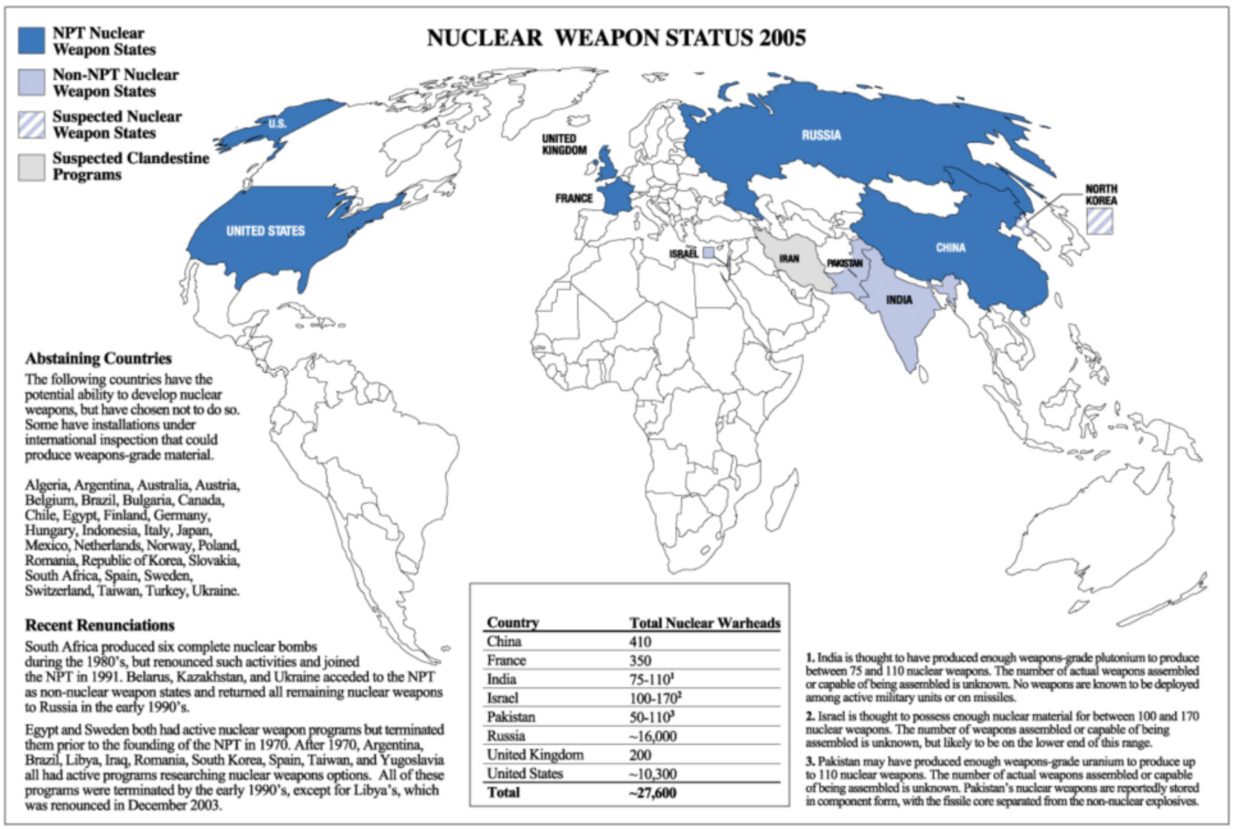
Threat-101: The Strategic Situation Has Changed

- Civil Defense efforts centered around <u>survivability</u> of the nation as a whole in global thermonuc. war
- Fallout shelters, survival supplies, “duck-n-cover”

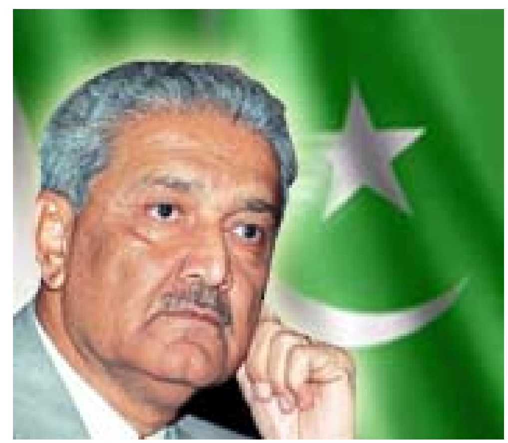
Threat-101: Rise of Terror Threat

- 9/11/01 resurrected the nuclear threat
  - Terrorist threat, single(?) small weapon(?), smuggled in, ground-level detonation(?) in a city
  - AQ Kahn nuclear proliferation network uncovered, 2003-4



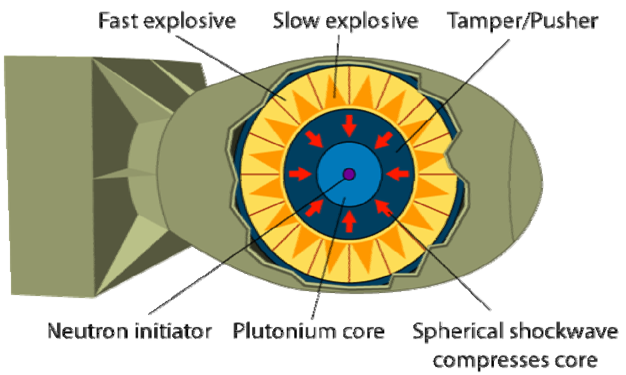
Country	Total Nuclear Warheads
China	410
France	350
India	75-110[1]
Israel	100-170[2]
Pakistan	50-110[3]
Russia	~16,000
United Kingdom	200
United States	~10,300
Total	**~27,600**

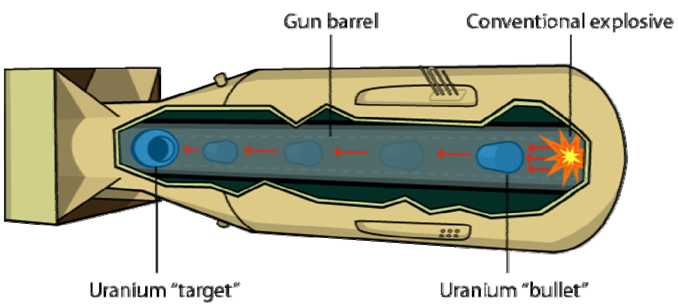
1. India is thought to have produced enough weapons-grade plutonium to produce between 75 and 110 nuclear weapons. The number of actual weapons assembled or capable of being assembled is unknown. No weapons are known to be deployed among active military units or on missiles.
2. Israel is thought to possess enough nuclear material for between 100 and 170 nuclear weapons. The number of weapons assembled or capable of being assembled is unknown, but likely to be on the lower end of this range.
3. Pakistan may have produced enough weapons-grade uranium to produce up to 110 nuclear weapons. The number of actual weapons assembled or capable of being assembled is unknown. Pakistan's nuclear weapons are reportedly stored in component form, with the fissile core separated from the non-nuclear explosives.

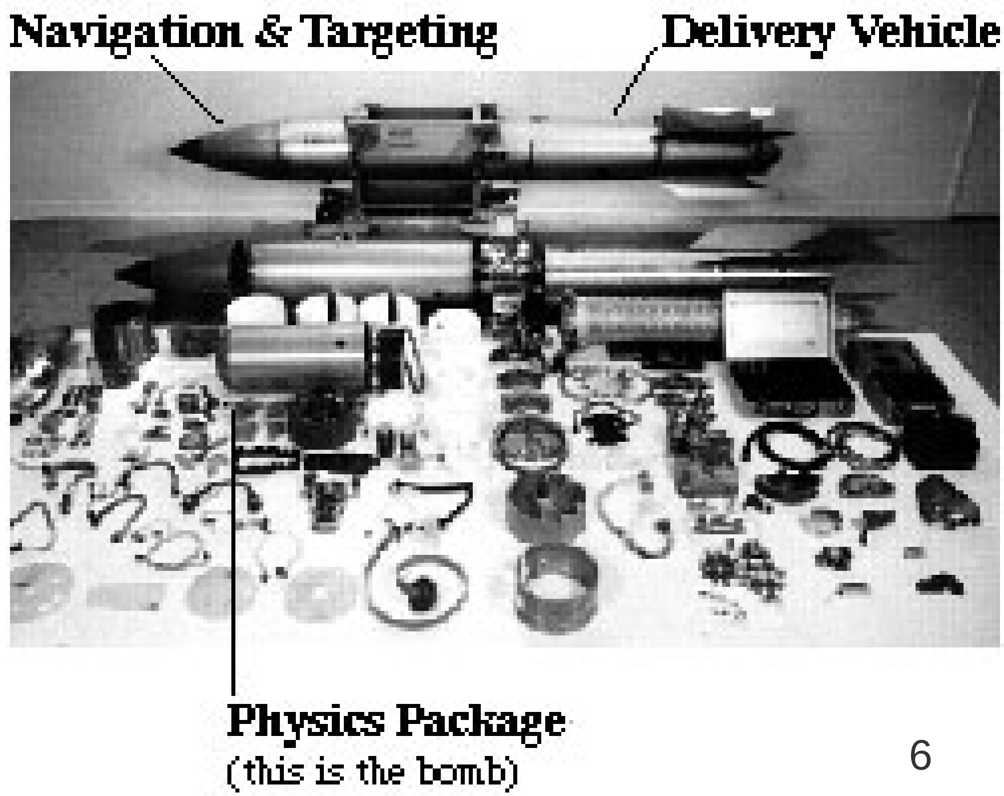


Threat-101

- What would it take for terrorists to acquire a functioning nuclear explosive device?







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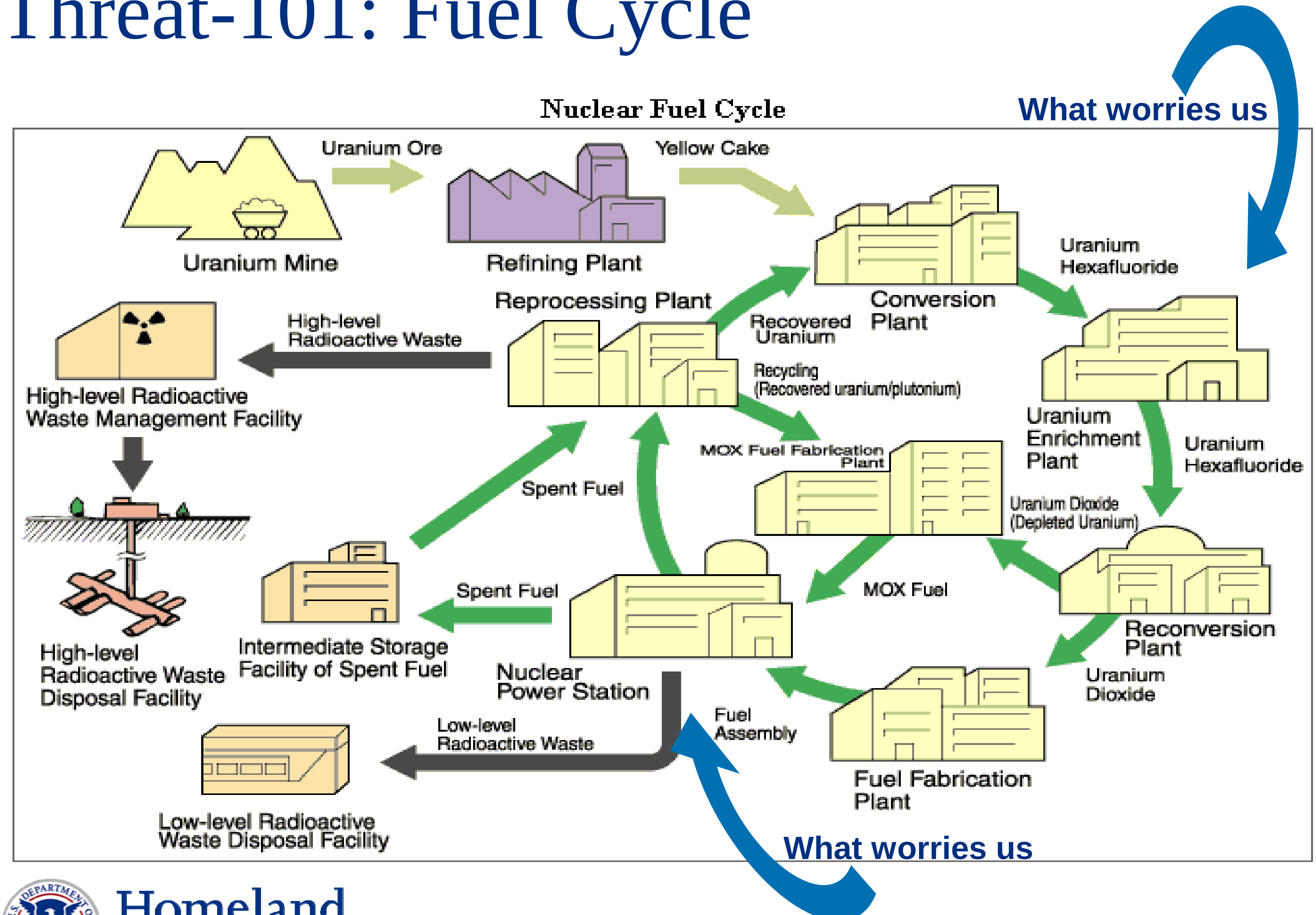
Threat-101: Fissile Nuclear Material

- A nuclear weapon functions by the release of energy from the “fissioning” of large nuclei; esp. U-235 and Pu-239
  - How do you get U-235 or Pu-239?
- U-235 is naturally occurring, but very difficult to refine and “enrich” in percentage of fissile isotope U-235 (80%+)
  - Big industrial footprint, high-tech, very expensive
- Pu-239 is extracted from fuel rods in certain types of reactors
  - Very high-tech, very expensive, nasty byproducts (highly radioactive, highly caustic), but smaller industrial footprint

Threat-101: Fuel Cycle



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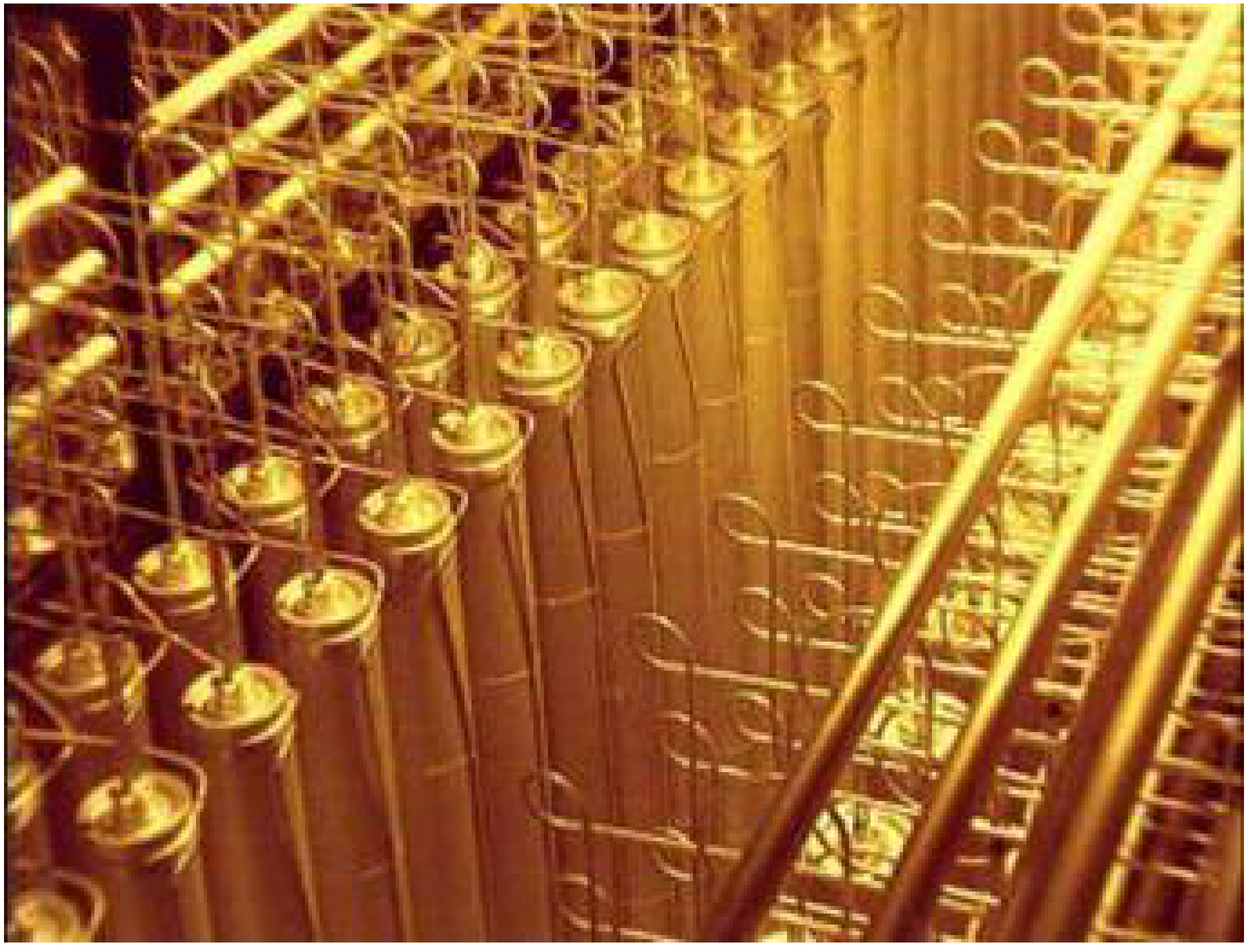
Threat-101: U Enrichment



Newer centrifuges have a relatively small footprint, but technologically difficult

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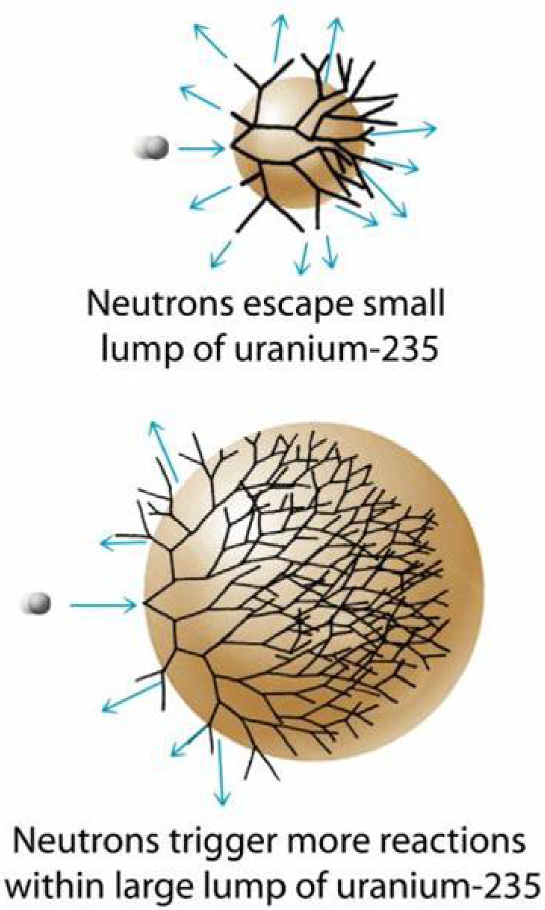
Threat-101: Acquire Nuc. Material

- It is highly unlikely any terrorist organization could indigenously produce either U-235 or Pu-239
- Terrorists must acquire a minimum quantity in order to develop a functioning weapon
  - About 50 Kg U, or 8 Kg Pu
- Terrorist could acquire NM via:
  - Theft from a nuclear state
  - Black market purchase
  - Nuclear state insider (financial/sympathetic motive)
  - Coup of a nuclear state



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Nuclear Basics: Chemical vs. Nuclear Fuel

- Explosions are all about heat and speed
- Source of chemical explosive energy is exothermic chemical reaction – between molecules
- Chemical explosions (TNT, TATB, C4, Comp B, Semtex, …) release about 10^6 cal/kg fuel
  - This chemical energy heats the exploded fuel into a hot gas to about 5000°K
  - Burn time 10^{-5} seconds
  - Heat drives the shock wave

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Nuclear Basics: Chemical vs. Nuclear Fuel

- Source of nuclear energy is binding energy in the nucleus
  - Approx. 170-200 MeV/fission (2.5×10^{24}N/kg U)
- Nuclear explosions release about 10^{13} cal/kg, a 10 million fold increase
  - Temperatures are 10-50 million degrees
  - Burn time 10^{-7} seconds
  - Heat drives the shock wave
  - Many electromagnetic phenomena

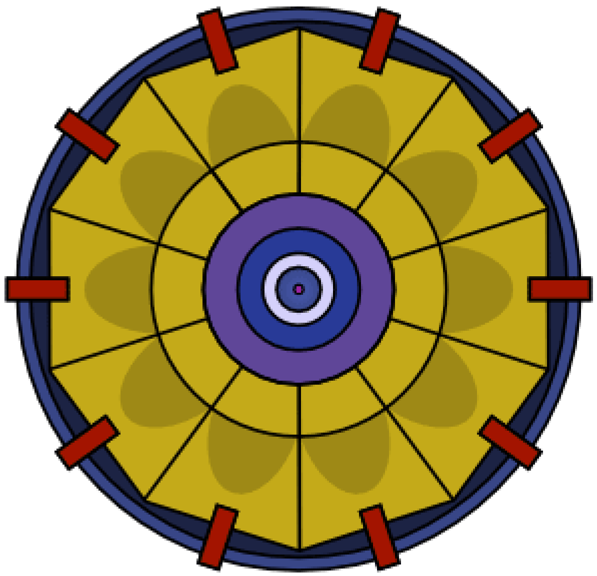
Nuclear Basics: Yield Potential

- The "yield" of a nuclear weapon is a measure of the amount of explosive energy it produces. Yield is usually described in terms of the amount of TNT that would generate the same explosive energy
  - Thus, a 1-kiloton nuclear weapon is one which produces the same amount of explosive energy as 1,000 tons of TNT
- The fission of 1 pound of U or Pu will theoretically release the same amount of explosive energy as about 8,000 tons of TNT
  - Thus, in a 20-kiloton nuclear weapon 2.5 pounds of material would ideally undergo fission
  - However, the actual weight of U or Pu in such a weapon is greater than this amount, because only part of the material undergoes fission

Nuclear Basics: Design

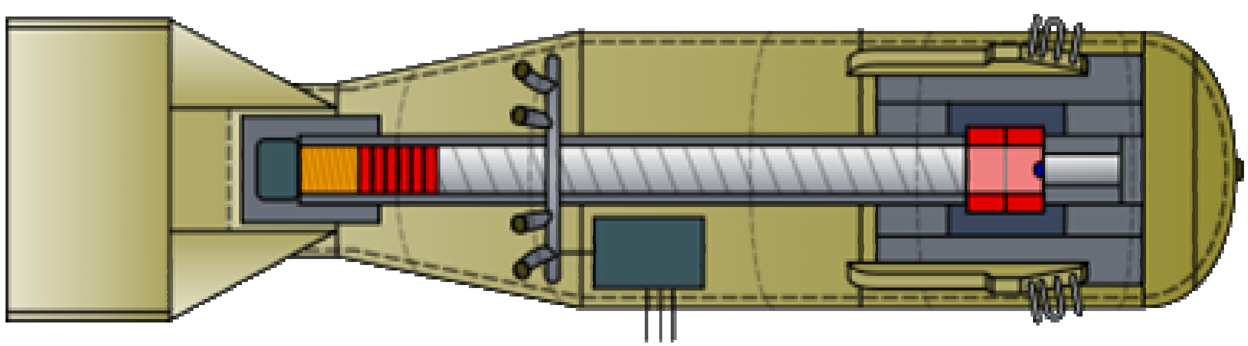
- The fissile material must go from sub-critical to super-critical, whereby a nuclear chain reaction rampantly fissions fissile material
  - Must change the geometry of the material
  - If it happens too slowly, or is poorly designed, the device will fly apart before the reaction is complete (a fizzle)
- Weapon designs fall into two categories
  - Implosion: compress a sphere from sub- to super-critical (using U or Pu)
  - Gun-type: slam two sub-critical pieces together into a super-critical mass (only with U)

Nuclear Basics: Design



- Implosion: carefully timed high explosive lenses compress fissile material to super-critical density
  - Difficulty - high

- Gun-type: U “bullet” is shot down a barrel into another U “target”
  - Difficulty - low



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Threat-101: Transport and Deploy

- Assume a terrorist device would enter from abroad
- It's hard to detect a nuclear device in a shipping container, or in a truck
  - The whole device may only be several hundred pounds
  - Contrary to popular opinion, nuclear weapons materials are *not* very radioactive, can be easily shielded
- Possible targeting objectives
  - Kill the most people
  - Damage critical infrastructure/resources (e.g., oil industry)
  - Cause long-term contamination of a large area
- Generally, we do response planning based on an attack against a major metropolitan area

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What Does a Nuclear Attack Look Like?

Nuclear Aftermath - Like This?

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How Do We Respond?

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What Does Nuke Response Look Like?

- Does our current response model work? Where do we begin?
- Start with the nature of the incident - details of urban impacts that affect response are required:
  - What are the damages really like?
  - Will we be able to communicate; will cell phones, radios, internet function?
  - Can we access the area? Can people get out?
  - What are the injuries to which we would be responding?
  - What is the impact on utilities, and how does that impact response?
  - What about fires? What do we do about them?
  - What can we expect from fallout?

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What's Unique About an Urban Nuclear Attack? Will Our Standard Response Model Work?

- Everything that makes response to the nuclear attack uniquely daunting is about *scale*, not effect
- The nuclear attack is fundamentally an enormous explosion coupled with radiations
  - Blast + heat, radiation, electromagnetic pulse
- Response communities have some experience managing all of these, but can't currently manage the scale of impact
- Federal interagency determined that scientifically sound guidance was needed for how to prepare for and respond to a nuclear explosion in a city

Purpose of the New Planning Guidance

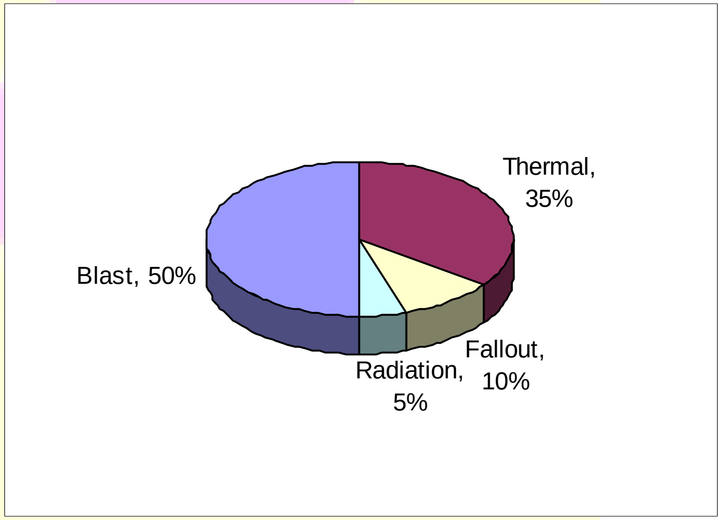
- To address the planning gap, an interagency committee developed Planning Guidance for Response to a Nuclear Detonation
- "*The purpose of this guidance is to provide emergency planners with nuclear detonation-specific response recommendations to maximize the preservation of life in the event of an urban nuclear detonation.*"
- Audience is state and local emergency response officials
  - State/local officials, generally, do not know where to begin
- Target time period is first 72 hours
- Assumes 10KT ground-level, and no Federal response

Nuclear Weapons Effects and Urban Impacts

- Much is known about weapons *effects*
- Little is known about the details of *impacts* in an urban environment that can make/break response efforts
- Must predict the impact to be able to plan for it
- Modifying existing computer models, integrating models, and applying new data sets, modelers can now explore the nature of urban impacts in hopes of helping planners and responders
- Results have been eye-opening, and have made the incident less ‘impossible’ – we can now begin to focus response planning, resourcing, and exercising

Nuclear Weapons Effects and Urban Impacts

- A nuclear weapon release energy as blast, thermal, and radiation (prompt and latent)
  - Blast, ~50% of total energy, is the principle impact
  - Thermal, ~ 35% of total energy
  - Radiation, ~15% of total energy
- Secondary effects include electromagnetic pulse and fallout (latent radiation)



- Large buildings have a tremendous influence on what occurs
  - Buildings channel blast
  - Buildings become rubble, create missiles
  - Buildings shield against prompt emissions, and fallout
- We rely infrastructure - roads, utilities, etc. - to respond

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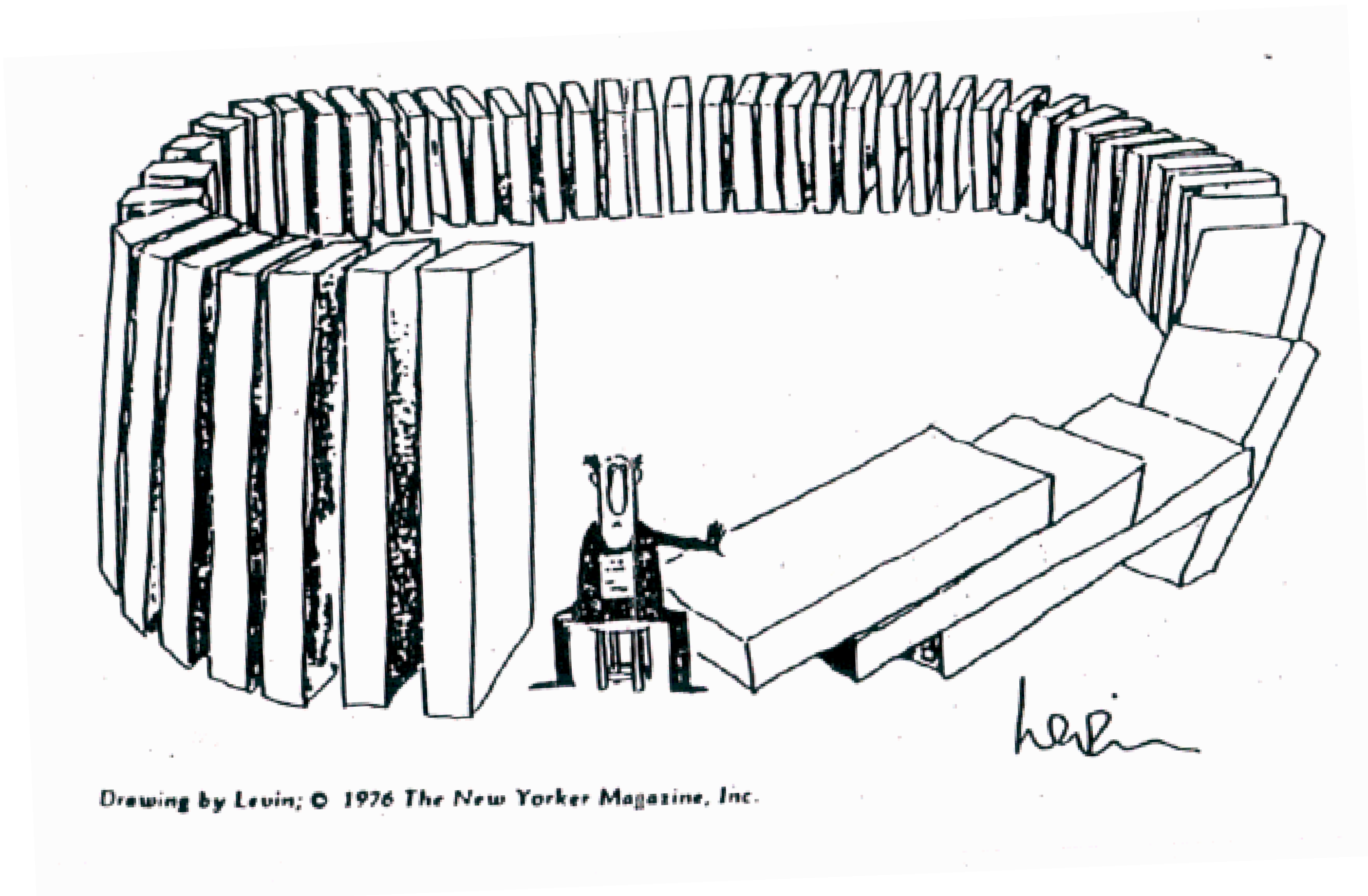
Nuclear Weapons Effects and Urban Impacts

- Some General Observations (for 10 KT, urban, ground-level) :
  - Blast is the primary effect, will cause most casualties; building collapse and flying glass and debris
  - Prompt thermal and radiation are shielded by buildings resulting in less casualty than previously expected
  - Blast results in a major rubble/debris impact precluding prompt entry; may impede entry as far out as 2 miles
  - Flash-blindness will cause numerous automobile accidents as far as 15 miles, jamming roads and highways
  - Utilities will be damaged/nonfunctional out to 1-3 miles; lack of water pressure will severely hinder fire-fighting
  - Critical impact zone is between ~0.6-1.0 mile (MD zone)
  - Triage most effectual in the zone ~0.6-1.0 mile
  - Fallout is unpredictable, and could cause substantial loss of life
  - Fallout presents the greatest life-saving opportunity

Cascading Infrastructure Failure?
Don’t Really Know



Drawing by Levin; © 1976 The New Yorker Magazine, Inc.

Response Should Be Done In Zones

- Zones help Incident Commander organize response efforts, and maximize the overall effort
  - Specialized teams operate in targeted zones
  - High priority missions occur in targeted zones
- Certain zones are low priority
- Other zones are high priority for different missions; shelter/evacuation, medical triage, fire suppression, utility/infrastructure actions
- Some zones are too dangerous to enter initially
- Zones require demarcation based on observational criteria, and radiation dose rate assessment

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Impact Zones

- **Light Damage (LD):** Outer boundary may be defined by the prevalence of broken windows, ~25% broken; essentially all windows will be shattered out to 1 psi and perhaps 25% at 0.5 psi (~3 mi); shattering of windows and associated injury from flying glass will occur to about three miles from ground zero
- As responders move inward, windows and doors will be blown in (2 psi) and gutters, window shutters, roofs, and light construction will have increasing damage; litter and rubble will increase moving towards ground zero; increasing numbers of stalled and crashed automobiles, making emergency vehicle passage difficult
- Outer boundary, ~3 miles, and inner boundary ~1 mile (2–3 psi); more significant structural damage to buildings will indicate entry into the moderate damage zone.

Impact Zones

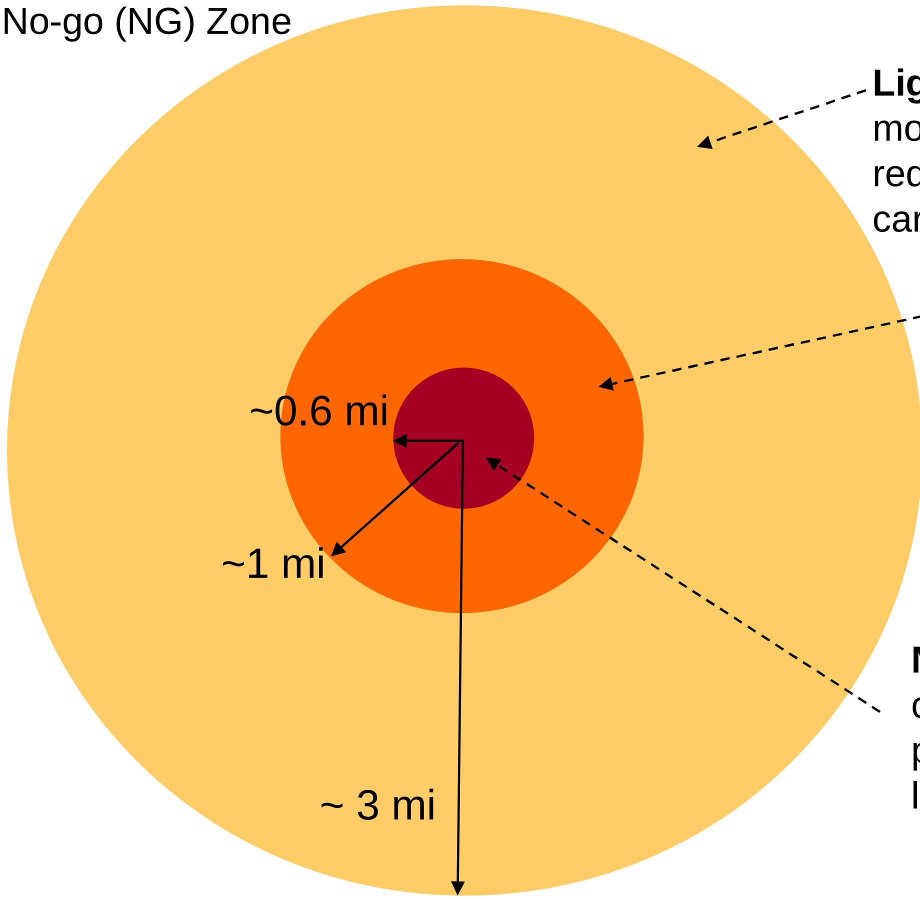
- **Moderate Damage (MD):** Responders may transition to the MD zone when building damage becomes substantial; a distance of about 1 mile from ground zero; observations include significant structural damage, blown out building interiors, blown down utility poles, overturned automobiles, some collapsed buildings, and fires; sturdier buildings (e.g., reinforced concrete) will remain standing, lighter commercial and multi-unit residential buildings may be fallen or structurally unstable, and most single-family houses would be destroyed; visibility in much of the MD zone may be limited for an hour or more; high radiation possible
- Substantial rubble and crashed/overturned vehicles in streets; rubble will completely block streets and require heavy equipment to clear; broken water and utility lines are expected and fires will be encountered; many casualties in the MD zone will survive and will benefit most from urgent medical care
- Outer boundary, about 2–3 psi (~1 mi), and inner boundary, about 5–8 psi (~0.6 mi); when most buildings are severely damaged or collapsed, responders have encountered the no-go zone

Impact Zones

- **Severe Damage, or No-Go (NG):** Few, if any, buildings are expected to be structurally sound or even standing in the NG zone, and very few people would survive; however, some people protected within stable structures (e.g., subterranean parking garages or subway tunnels) at the time of the explosion may survive the initial blast
- Very high radiation levels and other hazards are expected in the NG zone making this zone gravely dangerous to survivors and responders; therefore, the NG zone should be considered a no-go zone during the early days following the explosion
- Rubble in streets is estimated to be impassable in the NG zone making timely response impossible; approaching ground zero, all buildings will be rubble and rubble may be 30 feet deep or more
- The NG zone may have a radius on the order of 0.6 miles; overpressure that characterizes the NG zone is 5–8 psi and greater

Zones - Damage

Light Damage (LD) Zone
Moderate Damage (MD) Zone
No-go (NG) Zone



Light Damage (LD): Windows mostly broken, injuries requiring self- or outpatient-care

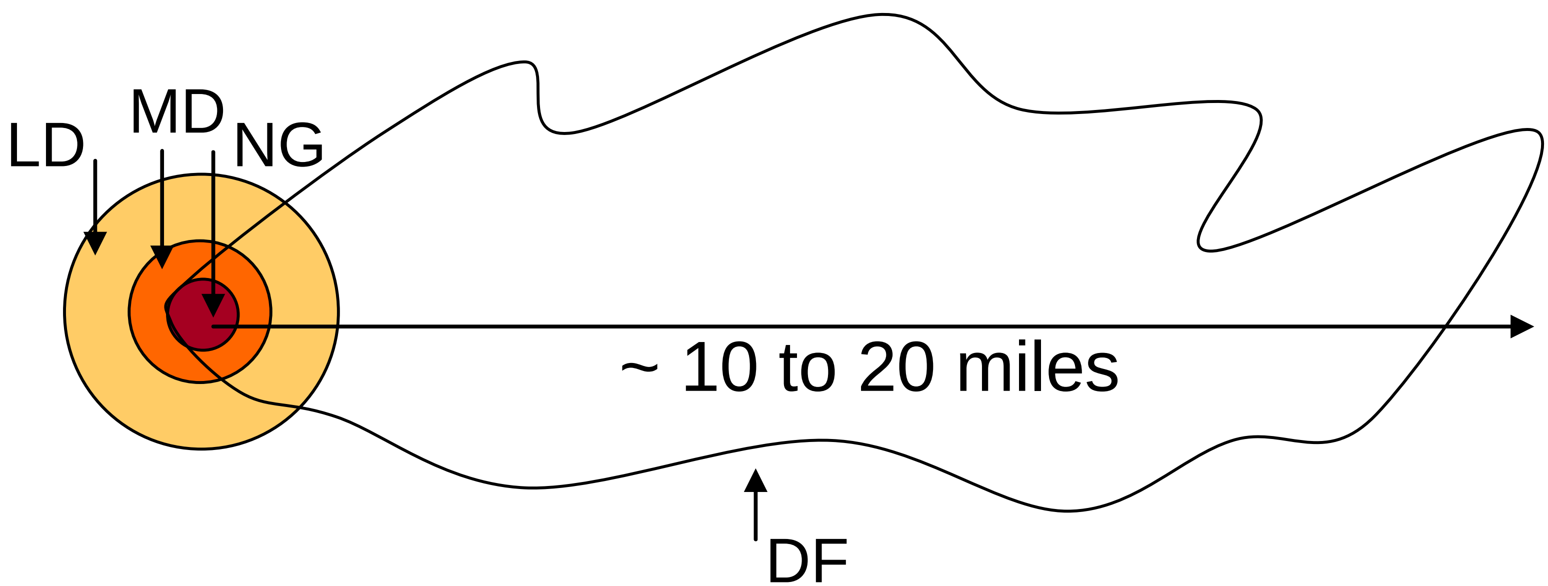
Moderate Damage (MD): Significant building damage and rubble, downed utility poles, overturned automobiles, fires, many serious injuries; greatest lifesaving opportunities

No-go (NG): Buildings completely destroyed; radiation prevents entry into the area; lifesaving is not likely

All approximated distances from center of detonation site

Zone - Fallout

- **Dangerous Fallout (DF):** The DF zone is distinguished not by structural damage, but by fallout radiation levels; a radiation exposure rate of 10 R/hour is used to delimit this zone; this zone is a hazardous area and any response operations within the DF zone must be justified, optimized, and planned; responders should refrain from undertaking missions in areas where radioactivity may be present until radiation levels can be accurately determined



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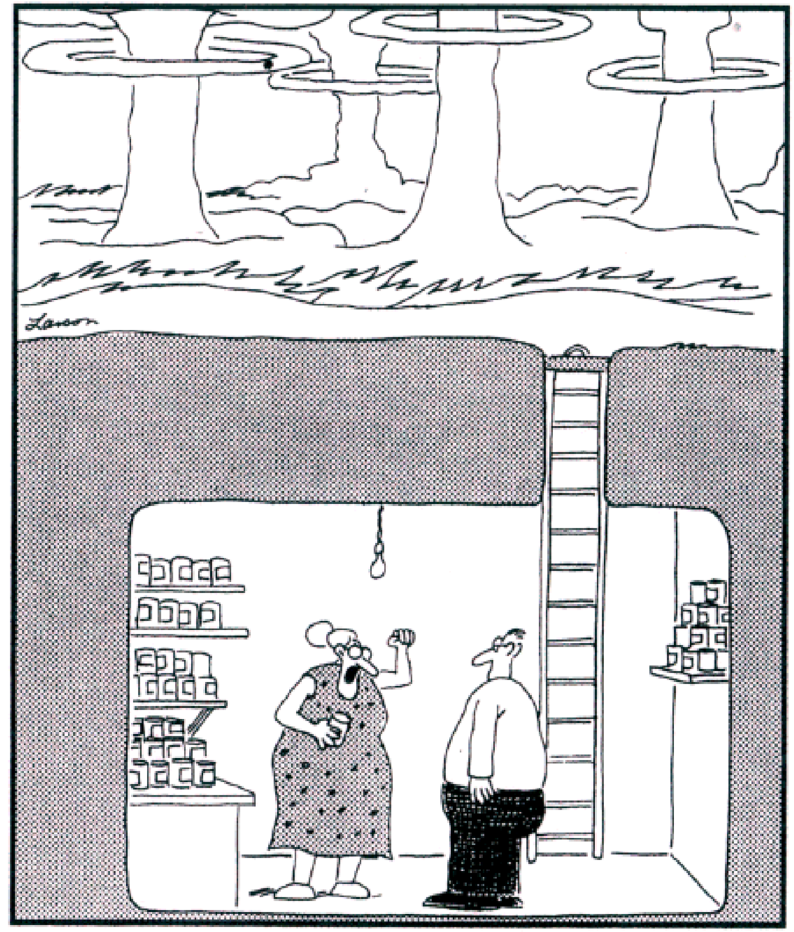
Recommendations

- The best initial action immediately following a nuclear explosion is to take shelter in the nearest building or structure and listen for instructions from authorities
- The most important mission in the DF zone is communicating protective action orders to the public. Effective preparedness requires public education, effective communication plans, messages, and means of delivery in the DF zone
- Evacuations should be prioritized based on the fallout pattern and radiation intensity, adequacy of shelter, impending hazards (e.g., fire and structural collapse), medical and special population needs, sustenance resources (e.g. food and water), and response operational and logistical considerations

Recommendations

- Shelters such as houses with basements, large multi-story structures, and underground spaces (e.g., parking garages and tunnels), can generally reduce doses from fallout by a factor of 10, or more, generally "adequate"
  - *"Adequate" shelter is shelter that protects against acute radiation effects, and significantly reduces radiation dose to occupants during an extended period*



"How many times did I say it, Harold? How many times? 'Make sure that bomb shelter's got a can opener—ain't much good without a can opener,' I said."

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Recommendations

- Zoned approach to response should be used to maximize life-saving, while managing risks to emergency response workers
- Radiation safety and measurement training should be required of any workers that would be deployed to a radiation area
- Radiation detection equipment should be capable of reading dose rates up to 1,000 R/hour (but, 100 R/hour will do)
- Responders should resist spending time and resources on minor injuries in order to maximize the use of medical resources on more critical needs

Recommendations

- A healthy, viable responder workforce is critical to saving live after a nuclear explosion. Incider Commanders should use great discretion in sending workers intc highly radioactive areas, and planning and training are critical to successful post-nuclear response

Once again, a meeting between management and the Plutonium Truckers' Union grows tense.

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Recommendations

- No response action will take place without road clearing of debris/rubble; therefore, this should be a major issue in planning
- Response will be provided mostly by neighboring units; therefore advance planning is required to establish mutual aid agreements and response protocols
- The MD zone should be the focus of medical triage and early life-saving operations

Recommendations

- Response in the MD zone requires planning and preparation for elevated radiation levels, unstable buildings and other structures, downed power lines, ruptured gas lines, hazardous chemicals, sharp metal objects, broken glass, and fires
- Because of damage to infrastructure, limited availability of resources, and presence of radiation, paramedics and clinicians will have to bypass conventional clinical standards of care in order to maximize the overall preservation of life
- Management of serious injury takes precedent over decontamination. Decontamination of personnel and patients from fallout or visible debris involves brushing off, shaking, washing, or wiping off the radioactive dust and dirt and should not be a limiting factor in providing medical care

Recommendations

- There will be a spectrum of casualties including one or more of blast, radiation, and thermal injury. Initial triage and management will be based in part on victim's post-detonation location history, physical examination, dosimetry predictions from initial models and real-time physical dosimetry (dose measurements), and from available clinical laboratory studies
- Because of damage to infrastructure, the limited availability of resources, and presence of radiation paramedics and clinicians will have to bypass conventional clinical standards of care, preferably using predetermined criteria, in order to maximize the overall preservation of life. Such conditions are to be expected until medical staffing, logistical support, and infrastructure can be restored

Recommendations

- There is no established USG interagency medical triage system specifically validated for an urban nuclear detonation; therefore, existing emergency triage algorithms are used with modification for the impact of radiation
- To maximize overall preservation of life with insufficient resources to manage mass casualties, severely injured victims may be placed into an "expectant" (expected to die) category early on although the criteria for "expectant" will vary depending on resources available. Although expectant, palliation (treatment of symptoms) should be performed when possible
- Initial mass casualty triage, also known as sorting, should not be confused with follow-on clinical triage for more specific medical management

Recommendations

- For the time frame considered (72 hours) processing of the deceased will likely not be a priority in lieu of saving lives; however, fatality management will be one of the most demanding aspects of the nuclear response and should be planned for as early as possible
- State and local agencies should establish survivor registry and locator databases as early as possible. Initially, the most basic and critical information to collect from each person is his or her name, address, telephone number, and contact information
- Response within the NG zone should not be attempted until radiation dose rates have dropped substantially in the days following a nuclear detonation, and the MD zone response is significantly advanced

Response Actions - General

- Issue and execute protective action orders – shelter/evacuate
- Establish Command and communications
- Plot and confirm path of fallout, and local hot zones
  - 10+ R/hr perimeter (IMAAC, over-flights, and survey teams)
- Map key access and egress routes; commence road clearing
  - Plows, earth-movers, trucks, etc.
- Assess damage to key infrastructure – communications, transportation systems, water-sewer-gas-electric, etc.
- Assess building damage, establish response zones
- Assess fire (over-flights)
- Predict casualty load/location; send in USAR, medical response teams, support teams
- Selectively evacuate

We Need Better Information

- Recent analyses have shed light on the destructive details, casualties, and other factors that should be expected, and for which planners should plan

  (This has allowed a first version of response planning guidance)

- However, considerable refinement needed:
  - Better understanding of damages in modern cities; building response, subterranean structures, transportation systems, etc.
  - More detail on casualties; types, quantities, compound health effects
  - Impacts on utilities, other critical infrastructure
  - Nature of fallout from an urban detonation
  - Fire potential, and potential for fire-fighting
  - Safety of shelters
  - Evacuation optimization
  - Electromagnetic pulse (SREMP)
  - Secondary hazards

"I wish you'd learn to spend your time more destructively!"

Homeland Security

- John MacKinney

  Director (acting), Nuclear/Radiological/Chemical and Science and Technology Policy

  Office of Policy

  US Department of Homeland Security

  202-447-3885

  John.mackinney@dhs.gov