

# ***Nuclear Technologies Challenges and Priorities***

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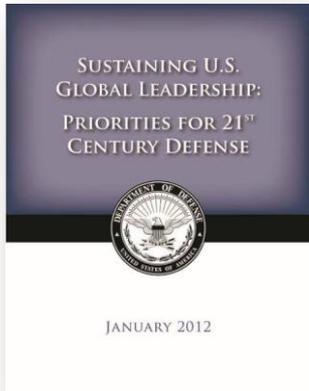
***2012 JOINT CBRN CONFERENCE & EXHIBITION  
March 13, 2012***





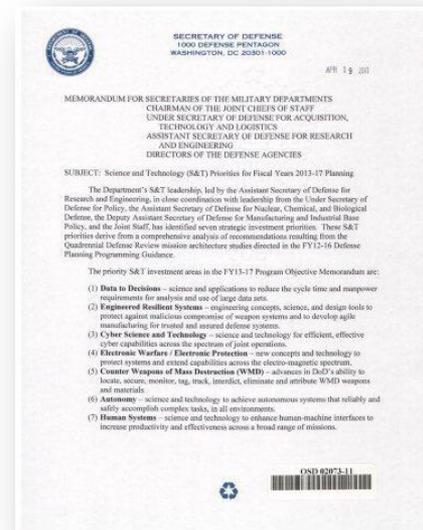
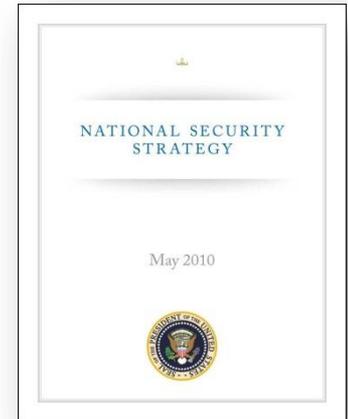
# Nuclear threats high in current National priorities

***“There is no greater threat to the American people than weapons of mass destruction, particularly the danger posed by the pursuit of nuclear weapons by violent extremists and their proliferation to additional states.”***



***“Terrorist access to even simple nuclear devices poses the prospect of devastating consequences for the U.S.”***

***“The priority S&T investment areas for the FY13-17 Program Objective Memorandum are...advances in DoD’s ability to locate, secure, monitor, tag, track, interdict, eliminate, and attribute WMD weapons and materials.”***





# DoD's nuclear mission space is defined by military utility

- International and U.S.
- Terrorism and nation state
- Cooperative and non-cooperative states
- Permissive and denied environments
- Interdiction
- Materials and weapons
- Overt and covert
- Science through transition
- Fixed and expeditionary



*DOE*



*DHS*

*DoD*



# Nuclear Technologies key strategic challenges

- **Radiation detection insufficient for wide-area search**
  - Redirect nuclear detection portfolio toward a more holistic nuclear THREAT detection ISR solution
- **Shorten nuclear forensics timeline**
  - Develop prompt diagnostics, forward-deployed collection capabilities, and fieldable analytic methods
- **Nuclear survivability must be robust to support effective deterrence and survivable U.S. nuclear response forces**
  - Develop survivability standards, hardening technologies, and the experimental capability to test survivability
- **Nuclear weapons effects expertise subcritical and declining**
  - Develop interagency Nuclear Weapons Effects Network
- **Terrorists and rogue nations pursuing nuclear capability**
  - Develop capability to detect, identify, and locate evasive and low-yield testing



# Nuclear Technologies Mission Areas

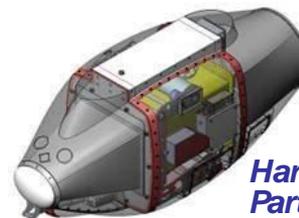
- Develop technologies to locate and identify nuclear and radiological threats
- Develop technologies to rapidly and reliably conduct post-detonation nuclear forensics
- Deliver nuclear weapon effects subject matter expertise, models, and tools
- Ensure that critical DoD systems and national infrastructure can accomplish their designated missions when exposed to a nuclear weapons effects environment
- Develop innovative approaches and technologies to support the full spectrum of current and future treaties



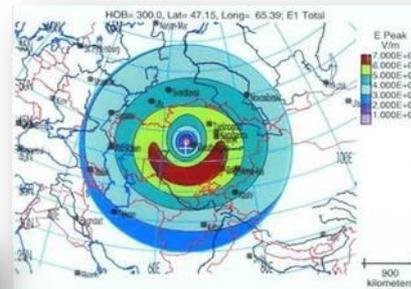
*Neutron Straws: Boron-carbide coated "straws"*



*Photonuclear Interrogation and Threat Assessment System (PITAS)*



*Harvester Particle Sampling Pod*



*Electromagnetic pulse modeling*



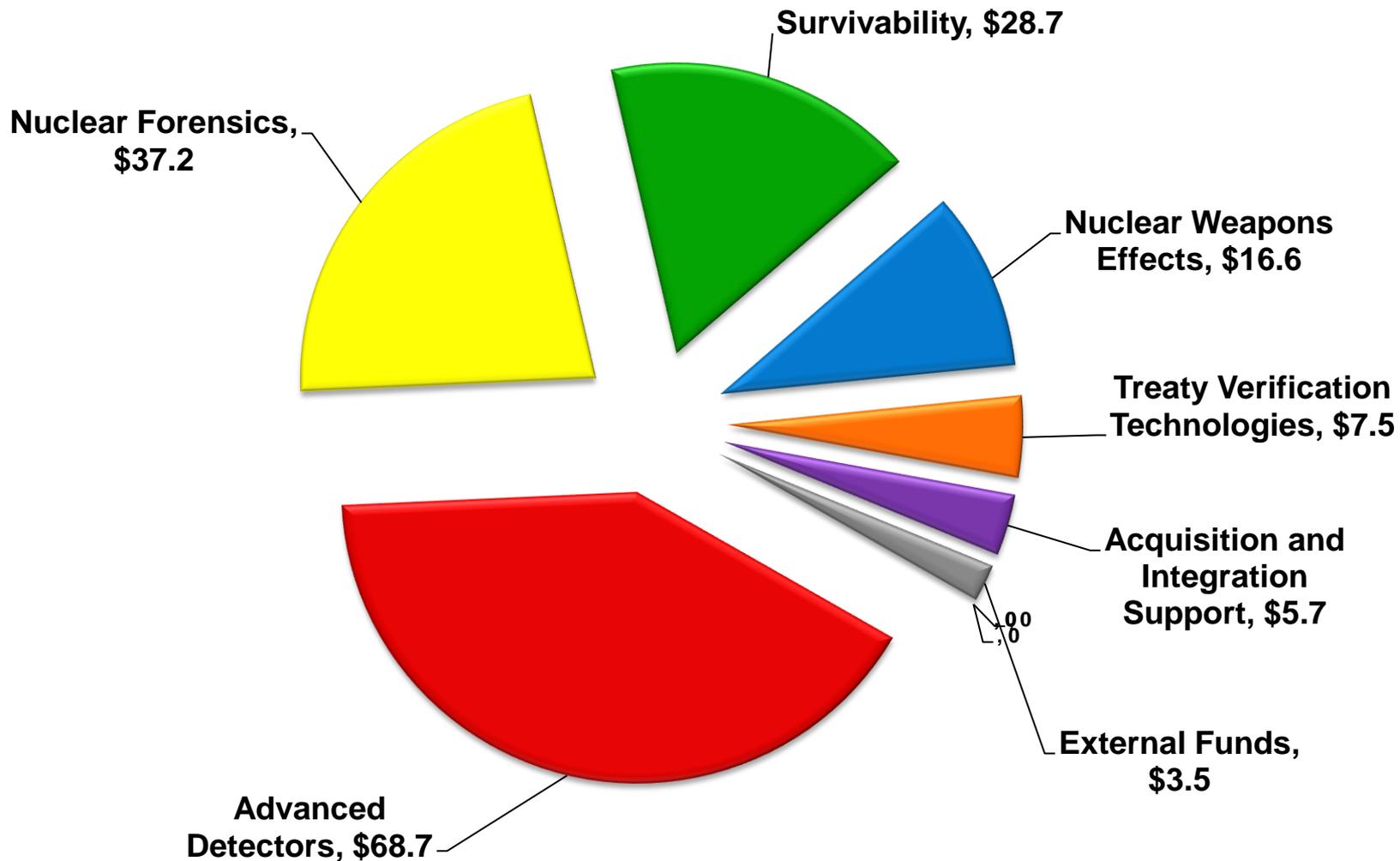
*Nuclear effects simulator*

*Interrogating nuclear material*





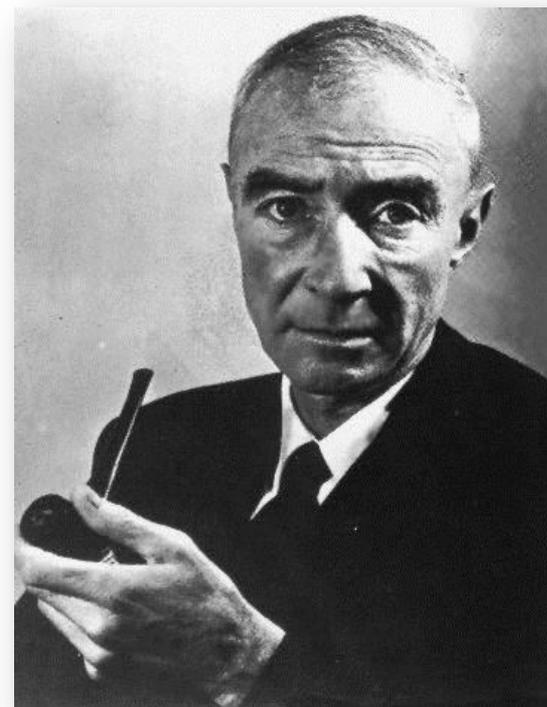
# FY12 Funding: \$168 M





***During a closed-door hearing in December, 1945, Senator Millikin asked "What instrument would you use to detect an atomic bomb hidden somewhere in a city?"***

***Oppenheimer responded dryly, "A screwdriver -- to open each and every crate or suitcase."***



***J. Robert Oppenheimer  
Scientific Director of the  
Manhattan Project  
1904-67***



# Fissile materials present vastly different source terms

	Particles per second passing through a perfect 1 m <sup>2</sup> detector at a distance of:		
	5 meters	20 meters	200 meters
8 kg Pu (n/sec)	20,284	1,586	54
25 kg HEU (g/sec)	18	1	1 every 7.5 min

Physical Limits of Detection against **bare** HEU IND for 10 sec integration time (100% intrinsic efficiency, known background):

Handheld (0.02 m<sup>2</sup>)



Backpack (0.16 m<sup>2</sup>)



Vehicle (1.0 m<sup>2</sup>)



**Better radiation detectors: part of the solution, not a silver bullet!**



# Inherent limitations in relying solely on radiation detection

- **What you can't change**
  - Material attenuation
  - Geometric attenuation
- **What you can change**
  - Source - active interrogation
  - Distance - get close
  - Size - larger detectors
  - Efficiency - more efficient materials
  - Time - longer counting times
  - Background mitigation - improve signal to noise ratio
  - Directionality/imaging



**Radiation detection can't confirm the absence of shielded radioactive materials**



# Advances in IED detection not a result of better explosives detection

- Ground Moving Target Indicator – vehicle tracks
- + Imagery – vehicles, dismounts
- + Synthetic Aperture Radar – digging signatures
- + MASINT – trace explosive, command wire detection
- + SIGINT – cell phone, radio emissions
- + HUMINT – human sources, dumpster diving
- + Forensics – exploitation and analysis
- + Data fusion

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= IED Threat Signature



**What are the analogous modalities and signatures for nuclear threats?**



# Nuclear Detection

**Mission: Develop technologies to locate and identify nuclear and radiological threats**

- Develop advanced radiological detection materials and systems
- Investigate novel signatures and active interrogation systems to extend stand-off detection ranges
- Develop advanced dosimetry systems
- Deliver detection capabilities to DoD Users and acquisition Programs of Record

*Neutron Straws: Boron-carbide coated "straws"*



*ARDIMS pod*



*Photonuclear Interrogation and Threat Assessment System (PITAS)*



*Real-time dosimeter*

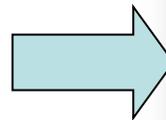
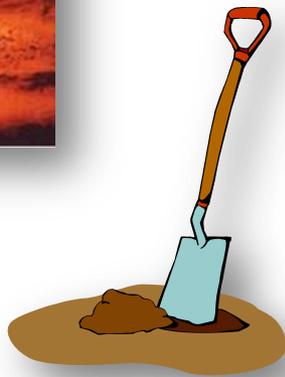
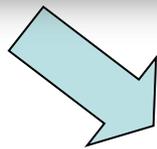
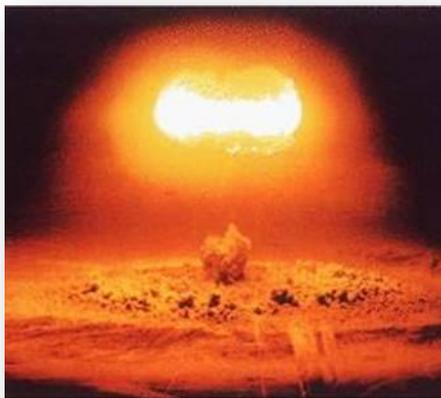
*GeMini portable high purity Germanium detection and identification*



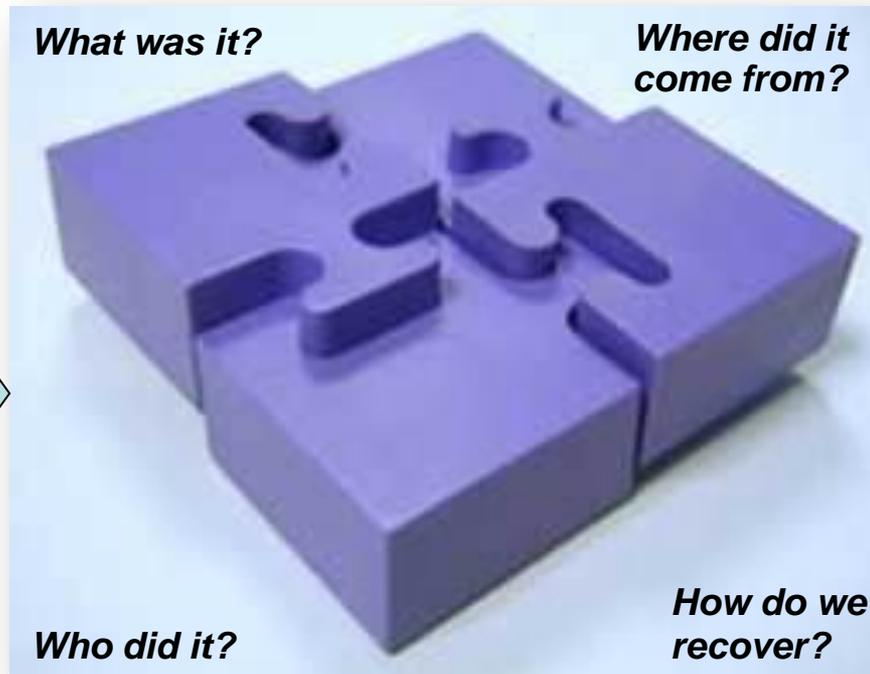
*Man Portable Detection System*



# Nuclear forensics supports attribution and response following a nuclear or radiological attack



Starting with  
Post-detonation samples



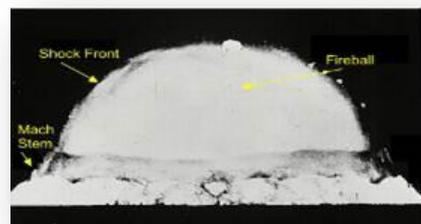
**Clues, not conclusions – nuclear forensics supports full range of national capabilities**



# Nuclear Forensics

**Mission: Develop technologies to rapidly and reliably conduct post-detonation nuclear forensics**

- **Develop prompt diagnostic capabilities for determining yield and characterizing device**
- **Improve ground and airborne debris sample collection capabilities**
- **Advance debris sample laboratory analysis**
- **Implement new data evaluation and knowledge management systems**



*Urban Optical Yield Determination*



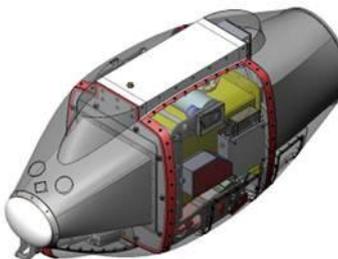
*Multi-Mission UAS*



*Fallout collection and analysis*



*Harvester Particle Sampling Pod*





# U.S. and Soviet Union conducted extensive high-altitude nuclear tests

## Hardtack I – Johnston Atoll, Pacific Ocean

- Yucca 28 April 1958, 1.7 kt, 26 km
- Teak, 1 August 1958, 3.8 Mt, 77 km
- Orange, 12 August 1958, 3.8 Mt, 43 km

## Argus – South Atlantic Ocean

- Argus I, 27 August 1958, 1-2 kt, ~480 km
- Argus II, 30 August 1958, 1-2 kt, ~480 km
- Argus III, 6 September 1958, 1-2 kt, ~480 km

## Dominic I – Johnson Atoll, Pacific Ocean

- Bluegill, 5 June 1962, failed
- Bluegill Prime, 25 July 1962, failed
- Bluegill Double Prime, 15 October 1962, failed
- Bluegill Triple Prime, 26 October 1962, sub-Mt, 10's km
- Starfish, 20 June 1962, failed
- Starfish Prime, 9 July 1962, 1.4 Mt, 400 km
- Checkmate, 20 October 1962, Low, 10's km
- Kingfish, 1 November 1962, sub-Mt, 10's km

## 1961 tests – Kapustin Yar

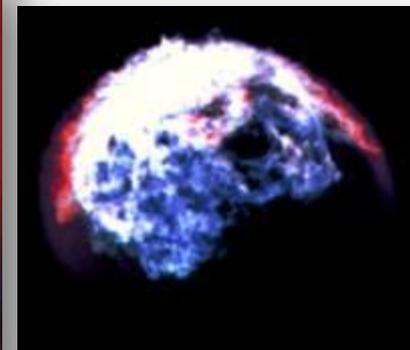
- Test #88, 6 September 1961, 10.5 kt, 22.7 km
- Test #115, 6 October 1961, 40 kt, 41.3 km
- Test #127, 27 October 1961, 1.2 kt, 150 km
- Test #128, 27 October 1961, 1.2 kt, 300 km

## 1962 tests – Kapustin Yar

- Test #184, 22 October 1962, 300 kt, 290 km
- Test #187, 28 October 1962, 300 kt, 150 km
- Test #195, 1 November 1962, 300 kt, 59 km



*Starfish Prime*

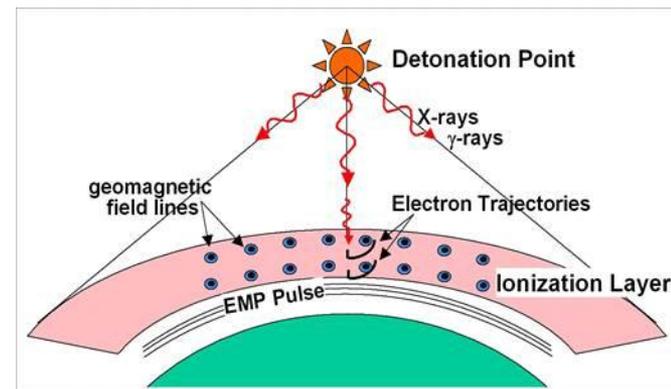


*Bluegill Triple Prime*

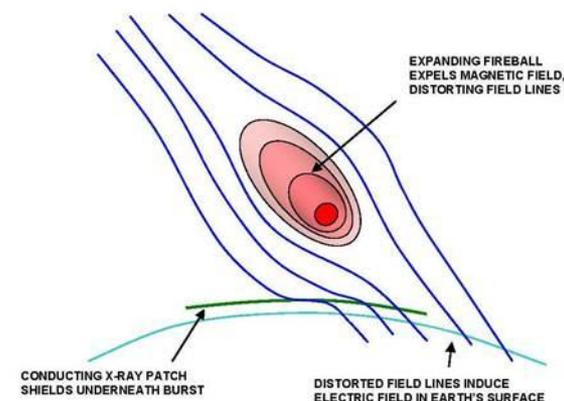


# High-altitude nuclear detonations produce 3 types of electromagnetic pulse

- E1 – prompt gammas produce Compton electrons in upper atmosphere which spiral around Earth's magnetic line producing large currents (nanoseconds)
- E2 – scattered gammas and inelastic gammas from neutrons induce Compton current. Similar to lightning (microseconds to 1 second)
- E3 – nuclear detonation distorts Earth's magnetic field which then restores creating MHD effect (tens to hundreds of seconds)



**E1 EMP**



**E3 EMP**



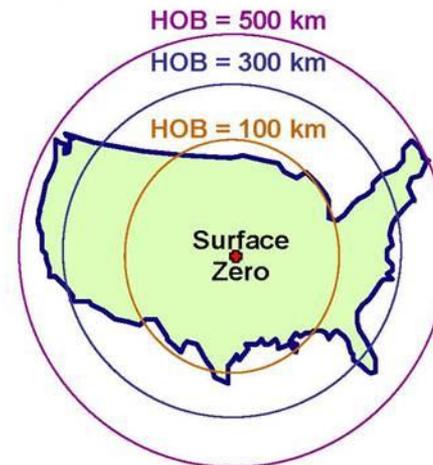
# NDAA of 2001 established an EMP Commission to assess EMP threat

EMP  
Commission

## Threat: Nature and Magnitude of EMP Threats Within the Next 15 Years

- EMP is one of a small number of threats that may
  - Hold at risk the continued existence of today's US civil society
  - Disrupt our military forces and our ability to project military power
- The number of US adversaries capable of EMP attack is greater than during the Cold War
- Potential adversaries are aware of the EMP strategic attack option
- The likelihood of attack depends on the actions we take to be prepared

EMP Coverage for Bursts of Various Heights



- Wide area coverage
  - A million square miles
- Intensity depends on:
  - Weapon design
  - Height of burst
  - Location of burst
- Broad frequency range
- Threat to all electronics in exposure

**Vulnerability may be an invitation to attack**





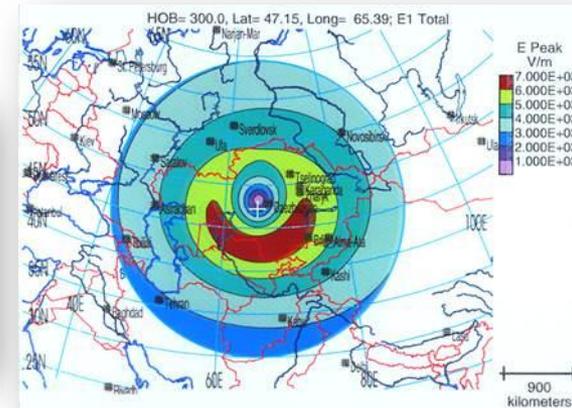
# Nuclear Weapon Effects

**Mission: Deliver nuclear weapon effects subject matter expertise, models, and tools at the level of fidelity required by specific users**

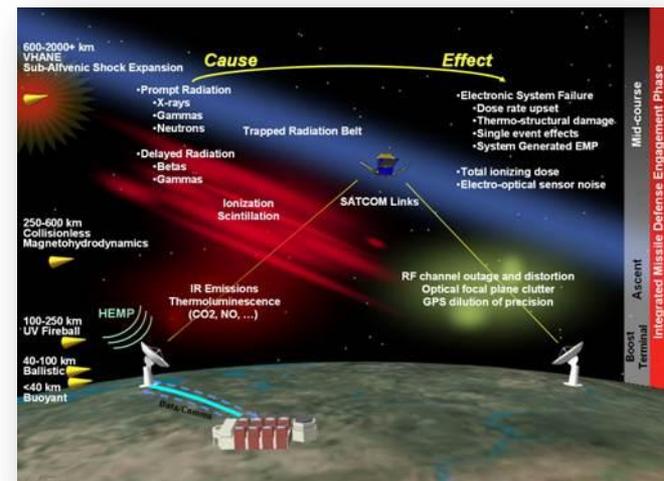
- Extract data from historical tests and experiments
- Design and perform V&V experiments
- Transition codes to users to support key DoD missions
  - Survivability
  - Targeting support/consequences of execution
  - Nuclear forensics
  - CBRNE response
  - Treaty verification and monitoring



*Thermal radiation and fireball*



*Electromagnetic pulse modeling*



*High Altitude Nuclear Effects*



# Nuclear Survivability

***Mission: Conduct R&D to ensure that critical DoD systems and national infrastructure can accomplish their designated missions when exposed to a nuclear weapons effects environment***

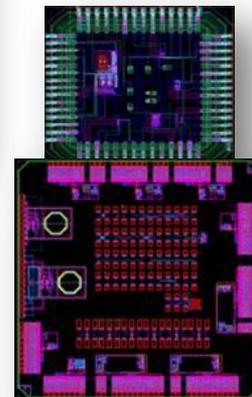
- **Develop survivability standards**
- **Develop radiation-resistant microelectronics, materials, and optics**
- **Develop a robust suite of next-generation experimental facilities to test survivability**
- **Manage the Nuclear Test Personnel Review Program**
- **Further our understanding of human survivability in support of consequence management**



*Aircraft EMP testing*

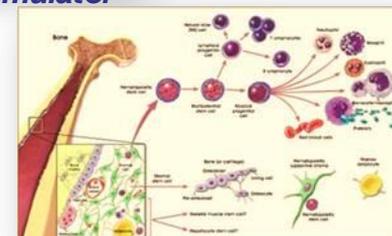


*Nuclear effects simulator*



*Rad hard electronics*

***Modeling combined effects of radiation and burns***





# Treaty and Verification Technologies

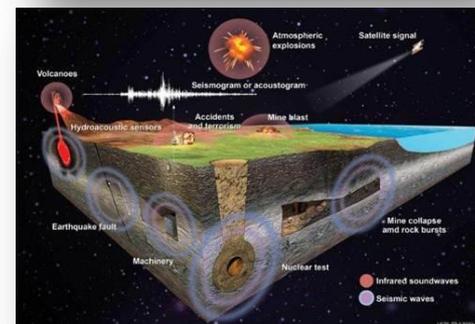
**Mission: Support on-site inspection, remote sensing and analysis, and early warning of emerging nuclear capabilities**

- **Support strategic arms reductions**
  - Radiation detection equipment and protocols for inspections
  - Warhead counting and discrimination
  - Arms Control Enterprise System (ACES)
- **Improve capability to detect, identify and locate evasive and low yield testing**
  - Near source strong motion and seismic
  - Alternative signatures
  - Radionuclide source, transport and collection/analysis
- **Develop technologies for remote monitoring of production signatures**
  - Optical and radiation isotope characterization
  - Nuclear forensics

*Interrogating nuclear material*



*Nuclear test monitoring*



*Potential large-scale decoupling experiment*

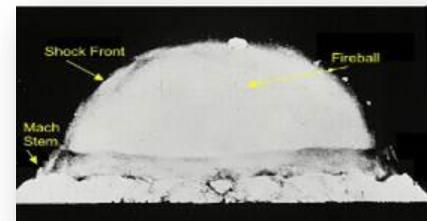




# Executive Secretariat

***Mission: To interact with national and international organizations to reduce the risk from WMDs and insure the prompt and proper release of documents***

- Collaborate with the UK under the 1958 MDA in areas of Nuclear Weapon Effects, System Survivability and Countering Nuclear Terrorism.
  - Support the transfer of atomic information through the Joint Atomic Information Exchange Group
- Enhance partners' capabilities thru participation with the GICNT, NATO Centers of Excellence, and EU Joint Research Centers
- Support the DOD-mandated classification and review process to insure the prompt and proper release of documents
- Integrate DOD Service Academy and technical graduate school faculty and student research efforts into the DTRA C-WMD mission





# Questions?

***“Gentlemen, we have run out of money. Now we shall have to think.”***



***Sir Winston Churchill (1874-1965)  
Prime Minister of the UK  
1940-45 and 1951-55***