ISOTOPE CROSSROADS

EXERCISE HANDBOOK

TABLE OF CONTENTS

EXERCISE OVERVIEW

PURPOSE

Isotope Crossroads: Syracuse*,* a Radiological Transportation Security Tabletop Exercise (TTX) is sponsored by The Department of Energy (DOE)/National Nuclear Security Administration (NNSA)/Office of Global Material Security (GMS) and the Federal Bureau of Investigation (FBI)/Weapons of Mass Destruction Directorate (WMDD)/Nuclear and Radiological Countermeasures Unit (NRCU).

The purpose of the TTX is to promote information sharing, joint situational awareness, team building, and problem resolution in a ***crisis response*** situation to Federal, State, and Local emergency response personnel and transportation companies when dealing with a Weapons of Mass Destruction (WMD) incident scenario involving Category 1 and 2 radioactive materials in commercial transit. Area of Responsibility (AOR) specific routes, transportation companies and response procedures, and radioactive materials transported through the AOR will be discussed. The TTX is a one-day, no-fault, discussion-based exercise.

What to expect during the TTX:

- The TTX is designed to stimulate discussion about a wide variety of topics, including interagency communication procedures, coordination processes, responder actions, and radiological security measures as they apply to Federal, State, and Local law enforcement, and other response and support agencies.

- TTX participants include representatives from organizations that would be involved either in radioactive material transport and/or a response to an incident involving it. Delegates from all echelons of government, from Federal, State, and Local and key stakeholder agencies will be seated at the main table, but everyone present is encouraged to participate.

- This is a no-fault exercise environment; there will be no evaluation, no assessment, and no formal after-action report prepared by the facilitators following the TTX. Participants and observers are encouraged to apply lessons learned within their own organizations.

- Both the Exercise Handbook and the TTX itself are unclassified; all content is derived from open-source materials. Some information presented during the exercise discussion may be considered sensitive and should be protected accordingly.

DISCLAIMER

Great care has been taken to develop a realistic and credible scenario. However, it does **not** represent any actual known threat or activity involving radiological transportation in/through the state. The scenario is intended to be a springboard for discussion; thus, some artificiality is needed to enable discussion of a wide range of issues in the time available.

INCIDENT VS. ACCIDENT

We recognize that during conversations many people do not differentiate the difference between an incident and an accident, However, for the purposes of Isotope Crossroads TTX, Incident and Accident are defined as follows:

INCIDENT

An intentional act attempting damage, theft, unauthorized use or loss of control of a radioactive materials shipment involving suspected criminal or terrorist activity.

ACCIDENT

An unexpected or unintentional occurrence, including natural disasters, involving a radioactive material shipment that does not involve suspected criminal or terrorist activity.

OVERALL OBJECTIVES

1. Promote interagency communication and situational understanding in support of radiological/nuclear transport through the state.
2. Bolster the interoperability of multiple response agencies in the event of an incident towards or involving a radiological/nuclear shipment.
3. Discuss prevention and response
    - Federal, state, and local first responders
    - Public health personnel
    - Transportation companies
    - Radioactive source manufacturing companies
    - Incident and unified command
    - Media relations
    - Turnover procedures
    - Plume/casualty modeling and evacuation/shelter-in-place
    - Tactical resolution
    - Crisis communications

DOE/NNSA EXERCISE OBJECTIVES

1. Examine current carrier and local responder secure transport plans, policies, and procedures
2. Discuss carrier-specific integrated response plans with federal, state, local, and private-sector partners
3. Exercise coordination between multiple law enforcement agencies and responders tasked with responding to a terrorist threat/incident

FBI EXERCISE OBJECTIVES

1. Discuss:
    a. FBI response mechanisms and procedures
    b. Suspicious activity awareness
    c. Awareness of routes/materials being shipped through the state
    d. Joint Terrorism Task Force (JTTF)
    e. National-level policy
    f. National Response Framework (NRF)
        i. Nuclear/Radiological Incident Annex
        ii. Terrorism Incident Law Enforcement and Investigation Annex
    g. Site control/command and control turnover

SYRACUSE EXERCISE OBJECTIVES

As they apply to the response to a radiological transportation security incident in New York:

1. Discuss the security measures, both federal- and state-level, regarding Category 1 and 2 radiological shipments across New York.
2. Examine the communication and notification process between federal, state, local and private industry organizations during a transportation security incident.
3. Discuss the evolution of the command-and-control structure, particularly as it involves coordination with multiple agencies, and the development of a Unified Command.

EXERCISE STRUCTURE

EXERCISE OUTLINE

The TTX is divided into four phases: Orientation, Relevant Information and Case Studies, Exercise Play, and Hot Wash.

ORIENTATION

- Orientation to the venue and schedule for the day
- Introduction of participating organizations and players
- An overview of exercise structure, reference materials and exercise injects.

RELEVANT INFORMATION AND CASE STUDIES

- Overview of the major players
- The science behind the radiological threat
- How radioactive material is being transported and protected
- Real-world events

EXERCISE PLAY – FOCUSED ON ***CRISIS RESPONSE***

- The TTX is comprised of scripted play and will focus on ***crisis response*** and federal, state, and local efforts to respond to an incident involving the transportation of radioactive material through the state.
- Multiple agencies throughout the state are involved in crisis response efforts. Accordingly, command, control, and coordination among these assets will be a priority during the immediate and follow-on response efforts. The central role for federal, state, and local agencies in responding to an incident becomes protection of life and property, while law enforcement investigates the cause of the incident and attempts to bring the perpetrators to justice.
- Crisis communications and the dissemination of timely and accurate information to emergency responders, response organizations, and the public is critical during a rapidly evolving incident involving WMD materials. As such, crisis communication strategies will be included in the discussion as they apply to the scenario.
- Participants will be asked to determine:

1. Who is in charge?
2. Who will respond to an incident involving the transportation of radioactive materials?
3. What level of response is warranted?
4. How to determine threat credibility?
5. How to balance keeping the public informed while protecting sensitive information related to an incident and protecting evidence during an investigation?

- Discussion will include emergency managers' actions to ensure responders have the most effective emergency response procedures available, given the situation.

- While there will be some elements of consequence management discussed, it is important to reiterate the TTX will focus on the crisis response portion, and efforts to prevent the scenario from becoming a full consequence management event.

HOT WASH

Immediately following the Exercise Play portion of the TTX, the facilitators will conduct a Hot Wash to gather immediate player feedback on the exercise. Useful feedback will include individual and agency takeaways from the TTX; recommended updates to agency policies and procedures; and suggested networking and planning opportunities for the agencies represented within the group.

After the TTX, registered participants will be sent an email containing a link to the Participant TTX Survey. This survey is focused on improving the overall **Isotope Crossroads** exercise series and solicits comments on specific portions of the TTX that worked well, areas where it could be improved, and the overall value of the exercise to the participants. This is **not** a critique of player actions but an opportunity to provide observations, comments and suggestions to improve the TTX series. Once the completed participant critique is submitted, a certificate of participation will be made available.

EXERCISE GUIDELINES

- **Use the scenario:** The scenario setting and incident details are designed to be used as a tool to stimulate discussion, not to portray weaknesses or vulnerabilities. The scenario timeline may be condensed or altered to provide the opportunity to maximize discussion topics.

- **Resist competition:** The TTX is not a zero-sum or win/lose game. Participants are not competing against the facilitators, nor are the facilitators leading the participants to a predetermined "right" or "wrong" solution.

- **Use time wisely:** As with any real-world incident, there is limited time for making decisions, and information will be incomplete and ambiguous.

- **Follow professional instincts:** Participants' knowledge and experience will determine how each organization will respond to an incident (or potential incident) involving a radiological shipment transiting through the state. Each participant is encouraged to think outside of the box, use critical decision-making skills, and personal experience to challenge the status quo and develop innovative approaches in a dynamic, group environment.

- **Be realistic:** Only those resources an agency/organization has on hand at the time of the exercise will be allowed in exercise play.

COMMON USES FOR RADIOACTIVE MATERIALS

"Radioactive sources are used in every country in the world, whether in industry, medicine, agriculture, or research. At the same time, high-activity radioactive sources can be used for malicious acts."

Source: 2014 Nuclear Security Summit Communique

Since radioactive materials, specifically cobalt-60, cesium-137 and iridium-192 are so commonly used in industrial, medical, and research applications across the nation, it is important to note that they are also transported to a wide variety of locations across the nation with significant frequency.

MEDICAL AND RESEARCH APPLICATIONS

Procedures involving radioactive material and radiation generating devices are used in medicine, specifically nuclear medicine and radiology, for both diagnostic and therapeutic reasons. Examples include radioactive materials used for diagnostic scans such as a nuclear stress test or HIDA scan in nuclear medicine, non-invasive radiosurgery for the treatment of tumors, and more.

Cobalt-60 is a common isotope used I non-invasive radiosurgery used to treat diseases such as brain tumors/lesions, arteriovenous malformations (AVM), and acoustic neuromas.

Iridium-192 is used as the source for high dose rate (HDR) brachytherapy often used to treat diseases such as prostate, head/neck, breast, and cervical cancers.

Cesium-137 is commonly used in blood irradiators to irradiate blood components prior to transfusion to help eliminate factors that can lead to graft-vs-host disease. It is also used in research irradiators for biomedical research.

Sources: https://www.cancer.gov/about-cancer/treatment/types/radiation-therapy , https://www.columbianeurosurgery.org/treatments/gamma-knife-radiosurgery/, and http://www.aabb.org/advocacy/regulatorygovernment/irradiation/Pages/default.aspx

INDUSTRIAL APPLICATIONS

Industrial Radiography works in much the same way as x-rays screen luggage at airports – the radiation penetrates the object leaving an image that can be studied. X-ray machines are often used for industrial applications. However, radioactive sources such as cobalt-60 and iridium-192 can also be used due to their emissions of gamma rays, which behave very similarly to x-rays.

Cobalt-60 and iridium-192 are commonly used in industrial radiography, a type of non-destructive testing (NDT), to inspect metal parts, high pressure vessels, welds, and other similar materials/components for defects. Because of its stronger gamma ray, Co-60 is used for thicker dense materials, whereas Ir-192 is used for thinner materials. NDT using Ir-192 is more common than NDT using Co-60. Sellinium-75 is another radioisotope used in industrial radiography. The sources are stored in containers, often called radiography cameras (see below) in order to provide personnel protection when in transport or otherwise not in use.

The complete device for industrial gamma radiography consists of :

- the Exposure Container including a Source Assembly (Sealed Source in Source- Holder)
- the Guide Tube (including Source Terminal / Collimator and the Connector)
- the Remote Control

The projector can only be operated if all of its components are properly connected.
The Exposure Container can be moved on a transport carriage.
This carriage could be supplied by MDS Nordion S.A. for the TK30 and the TK100.

Industrial gamma radiography device on towed carriage. Source Projector: TK-100

Industrial irradiators are devices that expose products to very high levels of gamma radiation for product sterilization, to kill insects or other organisms, or for other purposes such as increasing the shelf life. Food, food containers, spices, fruits, plants and medical supplies are the products most commonly irradiated. The process does not leave radioactive residue or cause the products to become radioactive. The radiation can come from radioactive sealed radioactive sources, an x-ray tube or an electron beam.

Aside from its use in medicine, cesium-137 – one of the most common radioisotopes produced from fission – is also commonly used in industry. Among its uses are for density/thickness gauging, well logging, level switches, and for low-intensity gamma sterilization. It is also commonly used to calibrate instruments that measure radiation.

RADIOLOGICAL TRANSPORTATION BACKGROUND

CAUSE FOR CONCERN

Radioactive sources that could be used for a Radiological Exposure Device (RED) or Radiological Dispersal Device (RDD) can be found at a variety of sites – such as transplant hospitals, research facilities, blood banks, and industrial facilities – around the world. Depending on the site, some sources may be poorly secured and vulnerable to theft. The vulnerability of these radiological sources, such as cesium-137 and cobalt-60, has caused concern for years, but today the risk is growing. The probability of a terrorist employing a RED or detonating a RDD is thought to be much higher than that of an Improvised Nuclear Device (IND) because of the widespread availability of radiological sources.

Source: March 2016 Nuclear Threat Initiative Radiological Security Progress Report

Cesium-137 has a half-life of slightly over 30 years. Cesium-137 is associated with both beta and gamma radiation, but the gamma rays are typically of most concern. It is one of several known isotopes that stand out as being highly suitable for radiological terrorism. Cesium-137 is oftentimes used in the form of cesium chloride (CsCl). CsCl can appear similar to table salt, but it can also be processed into a fine, light powder. This is done in order to better fill any voids within a sealed source capsule such as those found in cesium blood irradiators. If dispersed, cesium-137 can bind to concrete and other masonry, potentially making decontamination of buildings extremely difficult. Widespread dissemination of Cs-137 would likely result in significant economic impacts due to loss of land/facility/equipment use and associated cleanup.

In a Radiological Dispersal Device (RDD), most radioactive material will fall out within a time of approximately fifteen minutes or a distance of approximately 1 to 2,000 feet (although many variables exist). However, a small amount may be carried great distances – even hundreds of miles.

Source: GlobalSecurity.org, FEMA

SAFETY OF SHIPMENTS

About 3 million packages of radiological materials are shipped each year in the United States, either by highway, rail, air, or water. Regulating the safety of these shipments is the joint responsibility of the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT). The NRC establishes requirements for the design and manufacture of various packages intended for radiological transportation. The DOT regulates the shipments while they are in transit and sets standards for labels and markings.

Source: Nuclear Regulatory Commission (https://www.nrc.gov/materials/transportation.html)

CONTAINER STANDARDS

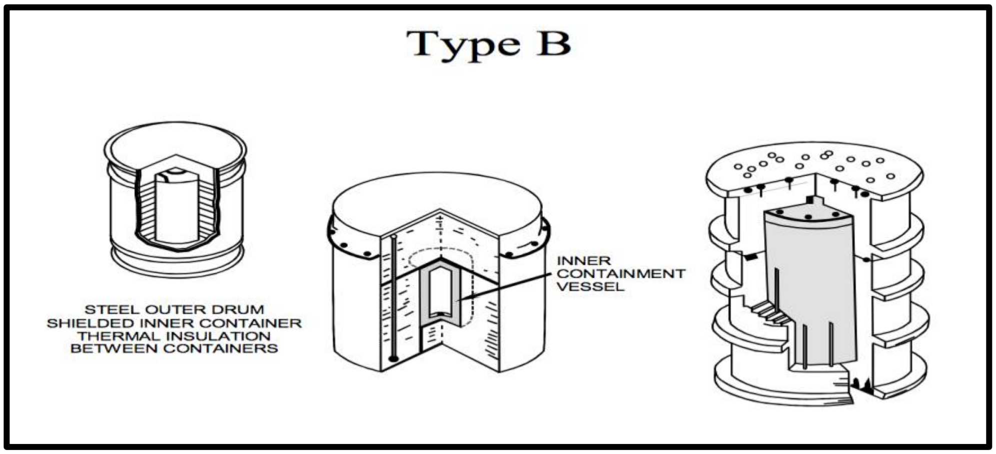
Shippers transport highly radioactive materials as defined by the NRC in packages that are extraordinarily strong called Type B packages. The NRC requires that the shipping container maintain its integrity under both normal and accident conditions. Type A packages must withstand various environments that may be encountered during normal transport conditions. Tests they undergo include a water-spray test to simulate heavy rain, a drop test onto a hard surface, a compression test, and a penetration test. Type B packages must meet Type A requirements and are tested for accident-type conditions; therefore, they must pass more severe impact, puncture, fire, and water immersion tests. The testing includes a 30-foot drop onto an unyielding surface at the package's most vulnerable point, a forty-inch drop onto an eight-inch steel rod, exposure of the entire package to 1,475 degrees Fahrenheit for 30 minutes, and immersion of the package into fifteen feet of water for at least eight hours. The package must retain its contents after completion of all the tests. According to the NRC, Type B packages meeting these standards would survive nearly all transportation accidents, thus keeping the public protected from a release of radioactive material.

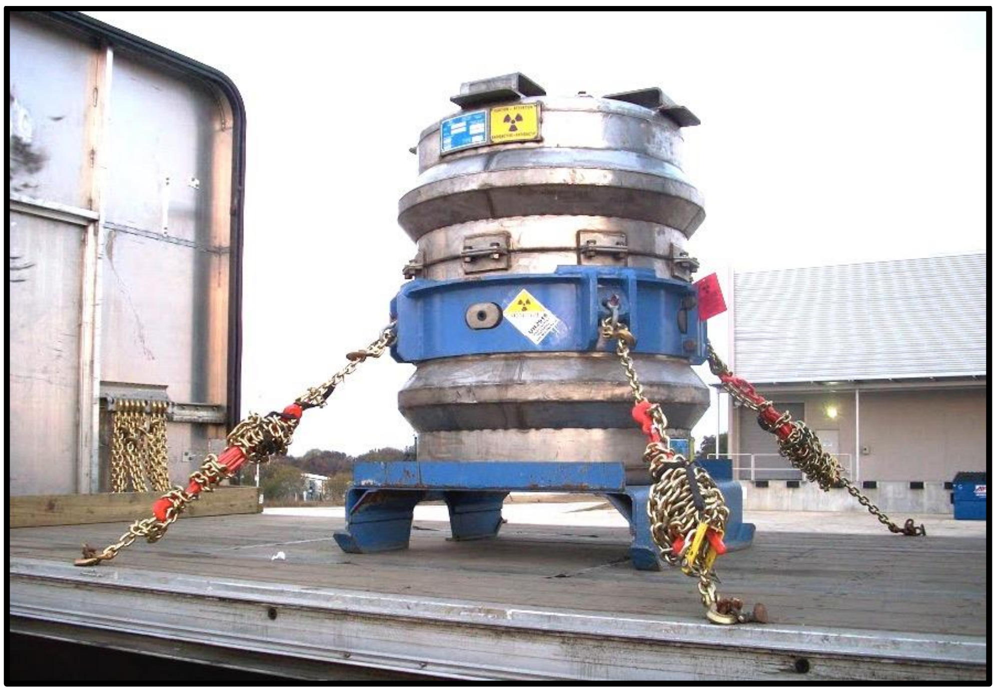
Sources: Nuclear Regulatory Commission; Department of Energy; World Nuclear Organization, and Nuclear Energy Institute; and Congressional Research Service Report for Congress: Transportation of Spent Nuclear Fuel

The following photographs and illustrations are examples of various types of shipping containers used to transport radioactive material.

Type B packages come in many forms and have been issued a Certificate of Compliance by the NRC.

Sources: NRC For more information visit - http://www.nrc.gov/reading-rm/basic-ref/teachers/11.pdf





Type B package secured to transport trailer. Photo courtesy of Jade Transportation

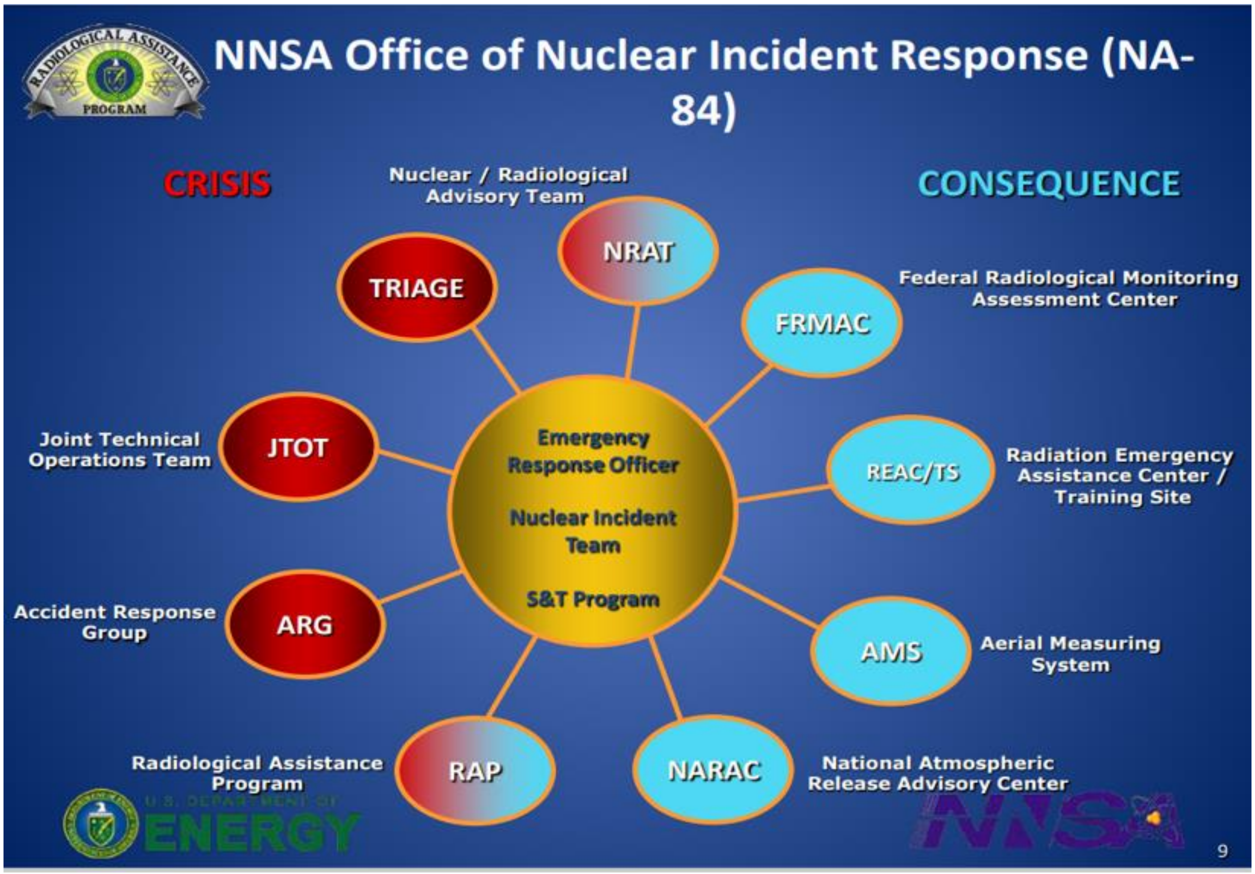
EMERGENCY RESPONSE

Federal Roles and Responsibility

DOE/NNSA

DOE provides technical expertise and authority to implement the appropriate response to a nuclear or radiological emergency. Because radiological or nuclear incidents could range widely in their implications (from lost or stolen materials to threat of terrorism and more), the emergency response assets available to DOE are vast.

The Radiological Assistance Program (RAP) contributes to the first response on a federal level with teams that can respond within four to six hours of an event. In addition to advising on public safety and conducting recovery operations for lost or stolen materials, the RAP team can aid in the assessment, monitoring, contamination control, and decontamination of the radiological environment.



Another DOE asset is the Nuclear/Radiological Advisory Team (NRAT). NRAT is capable of both domestic and international response and provides both highly specialized scientific and technical advice as well as operational support.

Helping to prevent an unnecessary full-scale response, Radiological Triage provides 24-hour-a-day, seven-days-a-week virtual assistance to first responders. Radiological Triage is an on-call team that supplies nuclear analysis and assessment to determine the threat level of a nuclear or radiological event, thereby providing support for Federal, State, and Local responders.

Another DOE response asset is Aerial Measuring Systems (AMS). AMS utilizes aviation-based equipment to conduct aerial radiation surveys, providing highly detailed spectral mapping and data telemetry. They also provide source searches in cases of stolen radioactive materials.

The Radiation Emergency Assistance Center/Training Site (REAC/TS) is also available during the response to a radiological emergency. REAC/TS provides expertise on health-related problems associated with radiological events. In addition to deploying three-person medical teams to respond to radiological incidents (available 24/7), REAC/TS trains health professionals, evaluates radiation doses, and maintains a Radiation Accident Registry System.

DOE's National Atmospheric Release Advisory Center (NARAC) supplies plume models, or predictions of atmospheric transport of radioactivity from a nuclear accident or incident. Based at the Lawrence Livermore National Laboratories in California, NARAC identifies the affected areas of airborne or ground contamination as well as radiation dosage on a 24-hour basis. In addition, NARAC models supply maps with terrain and population, accounting for observed and forecasted weather.

The Joint Technical Operations Team provides rapidly deployable technical and operational support to the FBI and DoD to counter WMD threats, including nuclear and radiological devices. Established in 1997, JTOT ensures that the full breadth of NNSA's scientific knowledge of nuclear weapons and devices is brought to bear during the response to a nuclear threat, including technical support from the National Laboratories. JTOT personnel are on-call 365 days per year / 24 hours per day to respond to nuclear incidents.

JTOT personnel are closely involved in the execution of the "Capability Forward" initiative. Under this program, FBI counter-WMD teams in American cities are trained and equipped to take decisive action to defeat WMD threat devices, accelerating life-saving responses to nuclear and radiological attacks.

The Accident Response Group (ARG) is composed of nuclear weapons experts who are on call to deploy rapidly within the United States and worldwide in response to accidents and significant incidents involving U.S. nuclear weapons or weapons components in DoD custody. ARG scientists, technical specialists, and crisis managers work closely with the NNSA Office of Defense Programs and DoD. Its personnel actively participate in the annual interagency Nuclear Weapon Accident Incident Exercise (NUWAIX) that is designed to practice a whole-of-government response to nuclear accidents and incidents.

A final DOE asset in responding to a radiological emergency is the Federal Radiological Monitoring and Assessment Center (FRMAC). FRMAC provides on-scene management of the consequences of a radiological event by providing multi-agency operational coordination, monitoring, and assessment. In addition, FRMAC has on-call reach-back capability for radiation protection and health physics advice within one hour of notification. FRMAC capabilities are both on the ground through field monitoring, data sampling and analysis, as well as digital data collection and telemetry.

Source: United States Department of Energy

FBI

The Attorney General (AG)/FBI Director leads the operational law enforcement response to, and criminal investigation of, terrorist threats/incidents within the US, its territories or territorial waters, as well as related intelligence collection activities within the United States.

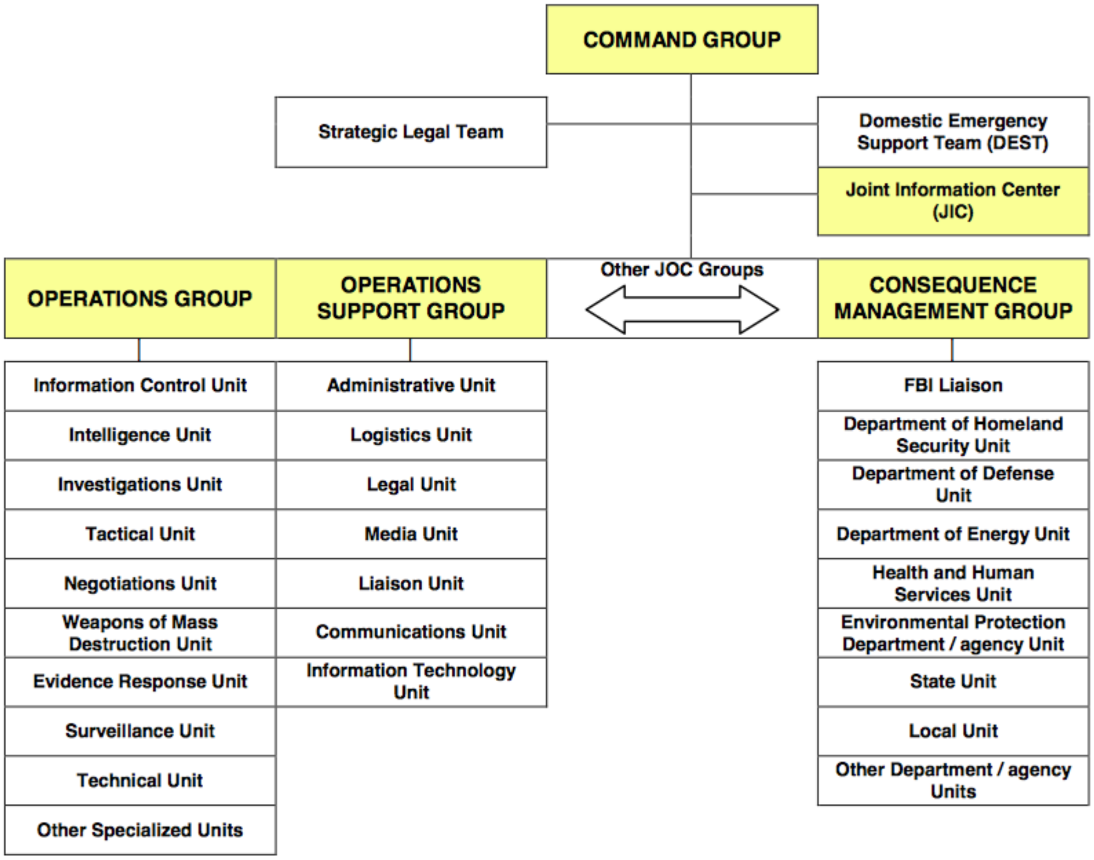
The Federal government evaluates Chemical, Biological, Radiological, Nuclear, or Explosive (CBRNE) threats through a Threat Credibility Evaluation (TCE). The TCE evaluates whether the threat is imminent, credible and capable of causing substantial loss of life or damage to property, which are all necessary for the triggering of the Counterterrorism National Policy. All WMD threat information having a potential impact on the United States will be immediately passed to the FBI to conduct a timely TCE to: 1) Assess the credibility of the WMD threat, 2) Determine the likelihood that the threat will result in substantial loss of life or substantial damage to property, and 3) When necessary, consider initiation of the appropriate WMD search or response protocols. Depending on the situation, State and Local representatives may be invited to participate in the TCE.

The FBI's JTTF combines Federal, State, and Local law enforcement resources in a terrorist event. JTTFs aim to enhance cooperation between the different law enforcement agencies.

The FBI-led WMD Strategic Group (WMDSG) is an interagency crisis action team consisting of subject matter experts from 16 Federal departments and agencies. The WMDSG coordinates and shares information during an incident and is located in the Strategic Information and Operations Center (SIOC) at FBI Headquarters. SIOC also maintains communications with the Department of Homeland Security (DHS) and the White House.

The FBI's Joint Operations Center (JOC) functions as an interagency command and control center for managing multi-agency preparation for, and the law enforcement and investigative response to, a credible terrorist threat or incident. The JOC consists of four main groups: the Command Group, the Operations Group, the Operations Support Group and the Consequence Management Group. Depending on the situational circumstances, State department/agency personnel may be requested to staff any or all of the JOC groups.

Typical Joint Operations Center Organizational Structure



Another asset that can be utilized by the FBI during a terrorism incident is the Domestic Emergency Support Team (DEST). The DEST is a rapidly deployable interagency emergency support team to assist the FBI during domestic terrorist events involving the use of CBRNE weapons. The DEST is incorporated directly into the existing on-site FBI crisis management structure to advise the On-Scene Commander (OSC) of Federal-level capabilities that can be brought to bear on the incident. Besides providing interagency crisis management assistance, the DEST can provide information management support and enhanced communications to ensure the OSC maintains connectivity with national-level decision makers during the on-going crisis. The DEST can be organized to provide the expert advice required for certain explosive devices and their components including CBRNE dispersal devices. Technical expertise and equipment is also available to conduct on-site activities like threat sampling, technical measurements, tactical intelligence collection, evidence collection, and other actions.

Source: Federal Bureau of Investigation

Local emergency personnel are typically the first responders in the event of an incident or accident. Their ability to act is extremely important. In the event of a radiological release, they are the first to perform life-saving duties, control the scene from a law enforcement standpoint, assess the situation to guide shelter or evacuation decisions, extinguish fires, and perform other necessary duties.

APPENDIX A
TERMS AND DEFINITIONS

Accident - An unexpected or unintentional occurrence, including acts of God, involving a radioactive material shipment that does not involve suspected criminal or terrorist activity.

Activity – As opposed to traditional units such as ounces, pounds, grams, or kilograms; radioactive materials are quantified by units reflecting their activities. Activity describes the number if disintegrations that occur per unit time (disintegrations per second – dps, or disintegrations per minute – dpm). Just as 5,280 feet make 1 mile, a certain number of dps or dpm define standard units of activity.

• A curie (Ci), commonly used in the United States, is equivalent to 3.7x1010 disintegrations per second (dps) or 2.22x1012 disintegrations per minute. A Ci can be subdivided into what may be more useful units such as the millicurie (mCi, 0.001 Ci, 2.22x109 dpm) or microcurie (µCi, 0.000001 Ci, 2.22x106 dpm).

• The Becquerel (Bq) is the international unit of activity. A becquerel equals one disintegration per second. There are 3.7x1010 Bq in one Ci. Commonly used multiples of the Bq include the megabecquerel (MBq, 1.00x106 Bq, 27 µCi), the gigabecquerel (GBq, 1.00x109 Bq, 27 mCi), and the terabecquerel (TBq, 1.00x1012 Bq, 27 Ci).**Air sampling** - The collection of samples of air to measure the radioactivity or to detect the presence of radioactive material, particulate matter, or chemical pollutants in the air.

ALARA - Acronym for "As Low As Reasonably Achievable," means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the State of technology, the economics of improvements in relation to State of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest (see 10 CFR 20.1003).

Alpha Particle – An alpha particle is a positively charged particle consisting or 2 protons and 2 neutrons emitted from the nuclei of various radioisotopes. Examples of alpha emitters include U-235, Pu-239, and Am-241. Alpha particles travel only a few centimeters in air and can be stopped by a sheet of paper.

Background radiation - Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission.

Beta Particle - Beta particles are negatively charged particles (comparable to an electron) emitted from the nuclei of various radioisotopes. Examples of beta emitters include H-3 (tritium), P-32, and Sr-90. Beta particles, depending on their energies, can travel a few meters in air and can usually be shielded by relatively thin pieces of plastic such as the facepiece of a full-face respirator or the lenses of reading glasses.

Bioassay - Used to determine the intake of radioactive material into the body and resultant dose, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed (in vitro) from the human body.

Contamination - Radioactive material that is deposited on the surface of or inside structures, areas, objects, or people.

Decontamination - The reduction or removal of contaminating radioactive material from a structure, area, object, or person. Decontamination may be accomplished by: (1) treating the surface to remove or decrease the contamination, (2) letting the material stand so that the radioactivity is decreased because of natural radioactive decay.

Detector - A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection instrument.

Disintegration - The transformation within an atom resulting in the emission of ionizing radiation.

Dose (also radiation dose) - Radiation energy deposited per unit mass of absorber. The standard units are rad (US) and gray (SI).

> Rad: The unit of radiation dose primarily used in the United States. One rad is equal to 100 ergs of energy deposited into a gram of material.
>
> Gray: The SI unit for radiation dose used internationally. A gray is equal to one joule of energy (1 joule = $1.0\text{x}10^7$ ergs) deposited into a kilogram of material.
>
> One gray equals 100 rads.

Dose equivalent (also, equivalent dose) - Radiation dose in tissue multiplied by a quality factor (QF) or radiation weighting factor (W_R). These factors are based on biological damage and resulting future risk associated with the type of radiation delivering the dose. Expressed in rem (US) or its SI equivalent, sievert (Sv), it is used to assess chronic exposures (such as occupational exposures) in order to evaluate the risk of a future effect, primarily cancer (stochastic risk).

> Rem equals rad x QF
>
> Sievert (Sv) equals gray x W_R
>
> Typical quality factors and/or radiation weighting factors: alpha = 20, beta = 1, gamma = 1
>
> One Sv equals 100 rem

Dose rate - The ionizing radiation dose delivered per unit time. For example, rads or Gy per hour. It’s also often expressed in rem or Sv per hour.

Dosimeter - A small portable instrument (such as a film badge, thermoluminescent or pocket dosimeter) for measuring and recording the total accumulated personnel dose of ionizing radiation.

Excepted packaging - is used to transport material with extremely low levels of radioactivity. Excepted packaging is authorized for limited quantities of radioactive material that would pose a very low hazard if released in an accident. Examples of material typically shipped in excepted packaging include consumer goods such as smoke detectors. These packages are excepted (excluded) from specific packaging, labeling, and shipping paper requirements; they are, however, required to have the letters “UN” and the appropriate four-digit UN identification number marked on the outside of the package. Requirements for excepted packaging are addressed in 49 CFR 173.421.

Exposure (or irradiation) - Occurs when one is in the presence of radioactive material. A person who has simply been exposed, or irradiated, has no radioactive material on them and is not a hazard to responders. This is similar to when someone shines a flashlight on you. You have been exposed to the radiation, but you don’t pose a hazard to someone else because of it.

Fissile material - The radionuclides uranium-233, uranium-235, plutonium-239, and plutonium-241, or any combination of these radionuclides. These are essentially materials that can undergo fission due to slow/thermal neutrons. For example, uranium-235 is the fissile material used as fuel in the commercial nuclear power reactors currently employed by the United States.

Gamma Radiation – Electromagnetic radiation emitted from the nuclei of various radioisotopes. Examples of gamma emitters include Co-60 and Ir-192. Gamma rays can travel many meters in air and are best shielded by dense materials such as lead.

Geiger-Mueller counter - A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes, between which there is an electrical voltage, but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of the radiation field. It was named for Hans Geiger and W. Mueller, who invented it in the 1920s. It is sometimes called simply a Geiger counter or a GM counter and is the most commonly used portable radiation instrument.

Half-life - The time in which it takes for the radioactivity of a sample to decay to ½ of its original value. Half-lives vary from millionths of a second to billions of years. It is also sometimes referred to as physical or radiological half-life.

Biological half-life: The amount of time it takes for the body to eliminate ½ of the internally deposited radioactive material without regard to its radioactive decay

Effective half-life: The combination of radiological half-life (decay) and biological half-life (biological elimination)

$T_{1/2\ eff} = (T_{1/2\ rad} \times T_{1/2\ bio}) / (T_{1/2\ rad} + T_{1/2\ bio})$

High-level waste - Radioactive materials at the end of a useful life cycle that should be properly disposed of, including:

1. The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste directly in reprocessing and any solid material derived from such liquid waste that contains fission products in concentrations.

2. Irradiated reactor fuel; and

3. Other highly radioactive material that the NRC, consistent with existing law, determines by rule requires permanent isolation.

Incident - An intentional act attempting damage, theft, unauthorized use or loss of control of a radioactive materials shipment involving suspected criminal or terrorist activity.

Industrial package - Used in certain shipments of low activity material and contaminated objects which are usually categorized as radioactive waste. Most low-level waste is shipped for disposal in industrial packaging. Department of Transportation (DOT) regulations require that industrial packages allow no identifiable release of the material to the environment during normal transportation and handling.

Ionizing radiation – Radiation that has the ability to remove of an electron from an atom (ionization) resulting in the creation of charged particles (ions). Not all radiation is ionizing. Non-ionizing radiation types include visible light, microwaves, and radio waves.

Isotope - each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei. The difference in the nuclear structure does not affect the element's chemical properties. For example, there are 3 isotopes of the element hydrogen; one of the three isotopes (tritium) is radioactive, yet they all three behave chemically as hydrogen.

Low-level waste - A general term for a wide range of wastes having low levels of radioactivity. Industries, hospitals and medical, educational, or research institutions; private or government laboratories; and nuclear fuel cycle facilities (e.g., nuclear power reactors and fuel fabrication plants) that use radioactive materials generate low-level wastes as part of their normal operations. These wastes are generated in many physical and chemical forms and levels of contamination (see 10 CFR 61.2). For the purposes of this definition, low-level waste has the same meaning as in the Low-level Waste Policy Act: radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11e.(2) of the Atomic Energy Act (uranium or thorium tailings and waste).

Low Specific Activity (LSA) Material – Radioactive material with limited specific activity as defined by 49CFR173

Plume Model - a computer model that simulates atmospheric transport of radioactivity from a radiological accident or incident.

Radiation - The propagation of energy through a medium in the form of waves or particles.

Radiation energy – The energy available to be deposited into an absorber measured in electron volts (eV). Energy is usually expressed in keV (kilo or thousand eV) or MeV (mega or million eV). Think of this as how strong a punch a particular radiation packs.

Energies associated with common radioisotopes are: Co-60 (1.17 MeV and 1.33 MeV gammas), Cs-137 (0.512 keV beta decaying to Ba-137m which emits a 0.662 MeV gamma), Sr-90 (0.546 MeV beta decaying to Y-90 that emits a 2.26 MeV beta).

Radioactive decay - The process by which unstable atoms reach a stable state by the release of particles (for example alpha or beta particles) or electromagnetic energy such as gamma rays.

Radioactive materials - materials the emit ionizing radiation

Radiography - The making of a shadow image on photographic film by the action of ionizing radiation.

Sealed source - Any radioactive material encased in a capsule designed to prevent leakage or escape of the material. Sealed radiation sources are commonly used in teletherapy, industrial radiography, and in various types of industrial gauges. When in operation, devices such as x-ray machines and accelerators are considered to be sources of radiation but are not radioactive sources because they don't contain radioactive material.

Shielding - material placed between a radioactive source and an object/person intended to absorb the radiation being emitted and resulting in a reduction of radiation dose.

Special nuclear material - Plutonium, uranium-233, or uranium enriched in the isotopes uranium-233 or uranium-235.

Specific Activity - The reason traditional units of measure such as pound and kilogram can't be used is the concept of specific activity. It relates an activity per unit mass of material, i.e.: Ci/kg, MBq/g, etc. For every gram of Ir-192, for instance, there are 9640 ($9.64x10^{3}$) Ci of activity; for every gram of U-235 there is only $2.1x10^{-6}$ Ci

Stay time - The period during which personnel may remain in a restricted area in a reactor before accumulating some permissible occupational dose.

Type A package - Type A packaging is used to transport small quantities of radioactive material with higher concentrations of radioactivity than those shipped in industrial packaging. Type A packaging is typically constructed of steel, wood, or fiberboard, and has an inner containment vessel made of glass, plastic, or metal surrounded with packing material made of polyethylene, rubber, or vermiculite. Type A packaging and its radioactive contents must meet standard testing requirements. These requirements ensure that the package retains its containment integrity and shielding under normal transport conditions. Type A Package requirements are addressed in 49 CFR 173.412. Type A Packages are not, however, designed to withstand the forces of an accident.

Type B package - Type B packaging is used to transport material with the highest levels of radioactivity. Type B Packages must withstand all Type A Package tests, and an additional series of tests that simulate severe or "worst case" accident conditions. Accident conditions are simulated by performance testing and engineering analysis. Life endangering amounts of radioactive material are required to be transported in Type B Packages. Requirements for Type B Packages are addressed in 49 CFR 173.413 and

10 CFR 71. Type B packaging sizes range from that used for small radiography cameras to large, heavily shielded, steel Type B packages that weigh up to 125 tons.

Type B package. Photo courtesy of Secured Transportation Services, LLC

X-rays - Electromagnetic radiation emitted when an excited inner orbital electron returns to its ground state. X-rays can be machine generated and result from energetic electrons "slowing down" after interacting with a metal target (x-ray machine).

RADIOLOGICAL TERRORISM TERMS

Improvised nuclear device (IND) - An IND incorporates materials designed to produce a nuclear explosion. It may be fabricated in an improvised manner or may be a modification to an existing nuclear weapon. In addition to mass destruction, thermal and blast injuries accompanied by radiation concerns affecting large populations must be considered.

Radiation Exposure Device (RED) - An RED is radioactive material, either as a sealed source or within some type of container, intended to expose people to radiation. With an RED there is no spread of contamination, so the primary concern is radiation exposure. An example of an RED is the placement of an unshielded Ir-192 industrial radiography source in a movie theater with the intent of exposing people to radiation.

Radiological Dispersal Device (RDD) - An RDD uses conventional explosives or some other means to spread radioactive contamination. An RDD poses both exposure and contamination concerns to varying degrees. Although many people's first thought is of a dirty bomb, introduction of radioactive materials into a building's ventilation system with the intent of spreading it around the building would also be considered an RDD.

Additional basic radiation information can be found here: https://summitet.com/wp-content/uploads/2020/10/SummitET_Basic_Rad_Information_web.pdf

APPENDIX B

ACRONYMS AND ABBREVIATIONS

A/O	Alert and oriented
ALARA	As low as reasonably achievable
AMS	Aerial Measuring Systems
Bq	Becquerel
CBRNE	Chemical Biological Radiological Nuclear Explosive
CFR	Code of Federal Regulations
Ci	Curie
CPM	Counts per minute
DEST	Domestic Emergency Support Team
DOE	Department of Energy
DOT	Department of Transportation
EMS	Emergency Medical Service
EPA	Environmental Protection Agency
ERG	Emergency Response Guidebook
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FRMAC	Federal Radiological Monitoring and Assessment Center
GMS	Global Material Security
HazMat	Hazardous Materials
HLW	High level waste
IC	Incident Commander
ICS	Incident Command System
JTTF	Joint Terrorism Task Force
LLW	Low level waste
LSA	Low specific activity

MLLW	Mixed low-level waste
mR/hr	Millirem/hour
NARAC	National Atmospheric Release Advisory Center
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NRAT	Nuclear/Radiological Advisory Team
NRC	Nuclear Regulatory Commission
NV RERP	Nevada Radiological Emergency Response Plan
OST	NNSA Office of Secure Transportation
PIO	Public Information Officer
PPE	Personal protective equipment
R	Roentgen
RAP	DOE Radiological Assistance Program
REM	Roentgen Equivalent Man
REAC/TS	Radiation Emergency Assistance Center/Training Site
RQ	Reportable Quantity
RSO	Radiation Safety Officer
RWMS	Radioactive Waste Management Site
SIOC	Strategic Information and Operations Center
SR	State Route
Sv	Sievert
TEPP	DOE Transportation Emergency Preparedness Program
TCE	Threat Credibility Evaluation
TRU	Transuranic
TTX	Tabletop Exercise
UC	Unified Command