Resources for nuclear and radiation disaster response

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An extensive array of government and military assets are readying to respond to nuclear and radiation disasters. Can we ever be fully prepared?

A NUMBER OF ORGANIZATIONS exist that can respond to radiation crises initiated by malevolent forces or resulting from an accident or the mismanagement of domestic radioactive sources. These organizations are operated by various federal and state government agencies and the military, including the states' National Guard Weapons of Mass Destruction–Civil Support Teams (WMD-CST). It would be exceedingly helpful for localities and their first responders to know how the deployment of these many assets would cascade from one agency to another or dovetail between agencies to produce a coordinated effort.

Deployment of some organizations is clear, dictated by the ownership of the nuclear/radiological material or the location of the incident (domestic or overseas). In other cases, particularly on home soil, the agency initially responding (after local first responders) is not so clear. Training, drills, and exercises are ways to test the relationships and identify any issues needing resolution or improvement.

Overall, radiological/nuclear emergency responses include these basic functions:

- Measuring and tracking radioactivity in the affected environment, especially if it is airborne. This includes the use of computer modeling in the early stages of the emergency.
- Measuring radiation levels in the affected area.
- Locating, securing, and/or disarming sources of radiation, e.g., lost medical or industrial sources or improvised nuclear or radiological dispersal devices.
- Providing information about the above to mitigate human health consequences.
- Securing and remediating the affected area.
- Treating affected personnel, if necessary.

Nuclear weapon incidents or accidents will involve a joint Department of Energy and Department of Defense (DoD) response. Local responders and state agencies, who always have the primary responsibility for the protection of the public, will also be involved.

This article summarizes the functions of the major response groups, with Fig. 1 and Table I providing a brief orientation for the reader. A section on the civilian medical response highlights problems in this area, and a brief final section derived from

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Alphabet soup

Since there are so many organizations and programs named in this article along with their acronyms, we decided that it would be helpful to the reader to have them collected in one easy reference box.—*Ed.*

AFRAT - Air Force Radiation Assessment Team
AFRRI - Armed Forces Radiobiology Research Institute
AMS - Aerial Measuring System
ARG - Accident Response Group
CIA - Catastrophic Incident Annex
CMRT - Consequence Management Response Team
DoD - Department of Defense
DOE - Department of Energy
DHHS - Department of Health and Human Services
DHS - Department of Homeland Security
DTRA - Defense Threat Reduction Agency
EPA - Environmental Protection Agency
FRMAC - Federal Radiological Monitoring and Assessment Center
IAEA - International Atomic Energy Agency
MRAT - Medical Radiobiology Advisory Team
NARAC - National Atmospheric Release Advisory Center
NDMS - National Disaster Medical System
NNSA - National Nuclear Security Administration
NRAT - Nuclear/Radioactivity Advisory Team
NRC - Nuclear Regulatory Commission
NRP - National Response Plan
RAMT - Radiological Advisory Medical Team
RAP - Radiological Assistance Program
REAC/TS - Radiation Emergency Assistance Center/Training Site
RTS - Radiological Triage System
TOPOFF - Top Officials
WMD-CST - Weapons of Mass Destruction–Civil Support Team

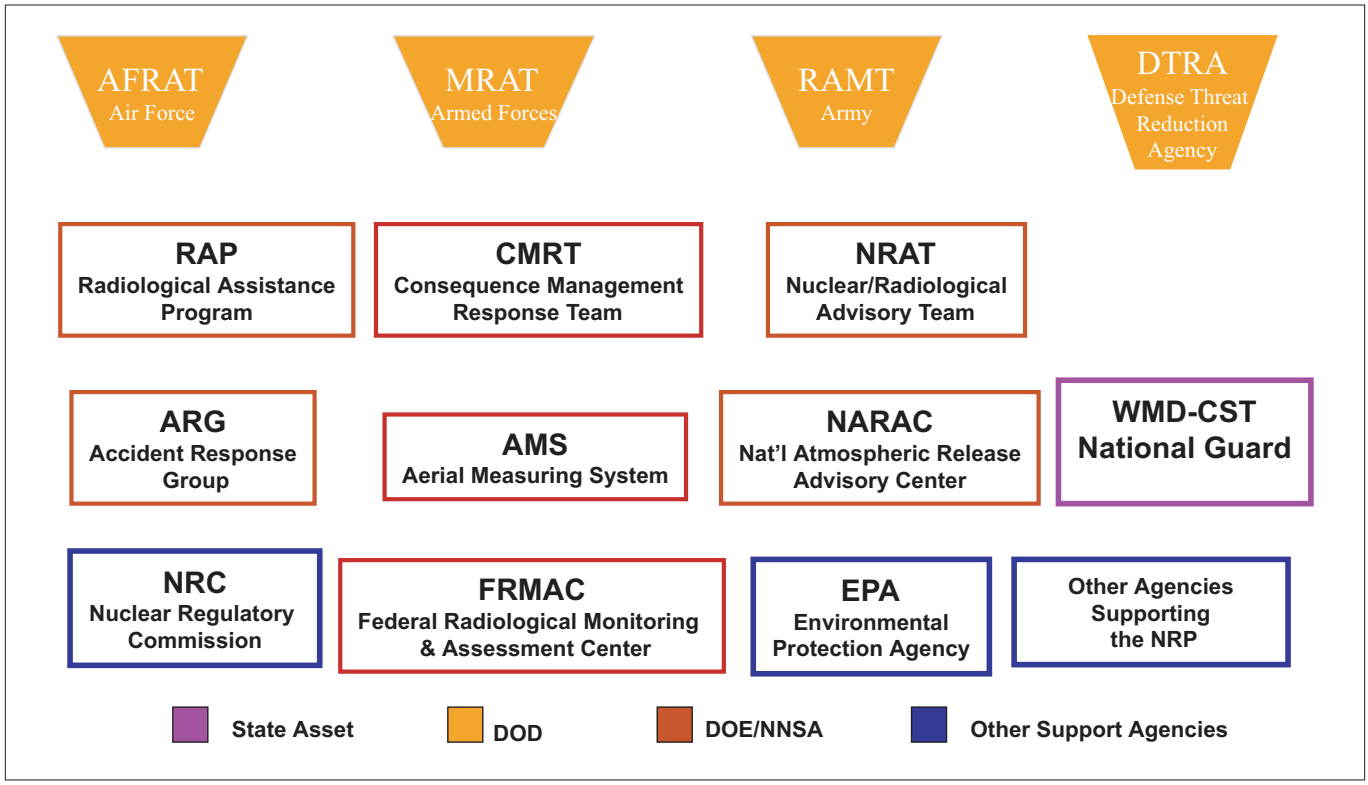

Fig. 1. Major U.S. civilian and military radiological response programs. Most programs are DOE/NNSA assets; military assets may contribute as needed or operate in strictly military crises. The NRC responds to incidents involving its licensees and those of agreement states, and the EPA participates during the crises and afterward, when remediation is being carried out. The National Guard is considered a state (not federal) asset. The civilian medical response is not indicated, but is crucial to the overall response effort.

extant information about large-scale drills discusses some concerns about coordination among agencies.

The military response

A military response will involve the DoD and may include the Defense Threat Reduction Agency (DTRA), which coordinates DoD responders to a nuclear/radiological incident. The DoD assists local, state, tribal, and federal civil agencies. The National Response Plan (NRP), which is available on the Department of Homeland Security's (DHS) Web site, establishes the interagency relationships for DHS's coordination of domestic incident management emergencies. Under the NRP, the federal responders, both civilian and military, have the lead in assessing the extent of the radiological release in support of the local Incident Commander—who manages operations at the incident site, develops strategies and tactics, and allocates resources—and a primary mitigation role in domestic incidents.

The National Guard CSTs are available through the states to assess the seriousness of radiological accidents, to predict the consequences, and to assist the Incident Commander in the management of the consequences. Again, this expertise is intended as a resource for local officials. The DTRA Operations Center serves as a single point of contact and communications hub in the event of an incident involving the DoD.

A global radiological/nuclear field response is provided by the Air Force Radiation Assessment Team (AFRAT), which is based in San Antonio, Texas. Its mission is to deliver radiological risk assessment to assist in the recovery of the affected area. For example, AFRAT provides hazard assessment for deployed troops facing possible nuclear or radiological threats. But it can also respond to a domestic or overseas terrorist attack on nuclear-use facilities, a nuclear reactor accident, or a radiological dispersal device (RDD), or "dirty bomb," incident. AFRAT is a 40-person mobile radiological response asset that includes a laboratory with the capability to sample air, water, soil, and foodstuffs. AFRAT can determine whether personnel have ingested or inhaled radioactive material (bioassay analysis), provide a site map indicating the locations of radioactive contamination, and implement decontamination and radioactive waste management operations.

Worldwide medical assistance is provided by the U.S. Army through its Radiological Advisory Medical Team (RAMT), headquartered at Walter Reed Army Medical Center in Washington, D.C. This organization provides medical information to a combat commander, but assistance to nonmilitary response teams and local hospitals is also mandated, both in peace and in wartime. RAMT capabilities include the radiological scanning and decontamination of 20 litter patients per hour, the scanning of 200 ambulatory patients per hour, and database tracking of patients.

The Medical Radiobiology Advisory Team (MRAT) is operated by the Armed Forces Radiobiology Research Institute (AFRRI), in Bethesda, Md. Activated by DTRA, MRAT provides radiological and medical expertise to military commanders and medical providers. This includes advice concerning wound decontamination, the use of radioprotective drugs, and personnel decontamination. MRAT is a small team consisting of about 14 individuals with expertise in medicine, health physics, nuclear engineering, and radiobiology. Additional specialized teams may be available from both the U.S. Army and the U.S. Navy to assist in radiological/nuclear emergencies.

Non-DoD federal response

The primary civilian government agencies responding to radiological incidents include the National Nuclear Security Administration (NNSA), which is a semiautonomous agency within the DOE, the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission, the Department of Health and Human Services, the Department of Agriculture, and others.

One of the best-known civilian response organizations is the Radiological Assistance Program (RAP), which is administered by the NNSA. RAP does not take control of the radiological incident, but rather supports the local responders and reports to the Incident Commander. RAP will leave

TABLE I.
SUMMARY OF MAJOR U.S. NUCLEAR/RADIOLOGICAL RESPONSE ASSETS AND FUNCTIONS

Responder	Main Mission	Parent Agency	Contingent and/or Equipment*
AFRAT	Reactors and weapons accidents; terrorist use of RDD or nuclear weapon; measurement of radiation; assessment of radiation hazard	U.S. Air Force/DoD	43 persons; field lab; radiation detectors
RAMT	Radiological medical support and decontamination; assist local hospitals	U.S. Army/DoD	Multiple radiation detectors and software for radiation analyses and patient dosimetry
MRAT	Medical expertise post-nuclear accident or detonation	AFRRI/DTRA/ JTAC**/State Dept.	13 persons + DoD "reachback" (in-office) assistants; on-site advice to attending physicians
RAP	First responder radiation assistance for general public and environment; assist other government agencies to detect, identify, and analyze nuclear/radioactive materials	DOE/NNSA	8 regions nationwide plus team in National Capital Region; 3 teams/region; 9 members/team; multiple radiation detectors; mitigative advice; public info support
NARAC	Real-time predictions of atmospheric transport and dispersion of radioactive material	DOE/NNSA	Computer-produced atmospheric transport and dispersion calculations
AMS	Radiation mapping around incident scene	DOE/NNSA	Fixed-wing and rotary aircraft
REAC/TS	Medical consultation/training concerning radiation accidents	DOE/NNSA	24-hour service; deployable team of health professionals; patient care at REAC/TS
ARG	Nuclear weapon accident response; advise DoD ordnance disposal teams	DOE/NNSA	Specialized equipment and personnel to advise on U.S. nuclear weapons recovery, transport, disposal, and safety
FRMAC	Coordinates and provides federal assistance in response to major radiological incidents. Response includes off-site assistance when requested by federal, state, local, and tribal authorities	DOE/NNSA	Coordinates federal, state, and local monitoring activities; CMRT I, II, and III teams w/increasing capabilities deployed, if needed; supplies include communications, living quarters, and power generation
National Guard WMD-CST	Support of civil authorities at a domestic chemical, biological, radiological, nuclear, and high-explosive incident. Will identify hazardous agent/substance, assess current and future consequences, advise on response measures, and assist civil responders in affected state(s)	U.S. Air Force/ U.S. Army National Guard/National Guard Bureau/DoD	22 member teams; 55 teams planned; vehicle and air deployment for rapid domestic response; assigned to governor of affected state; tactical/communications vehicles and analytical lab; medical and radiation survey teams

*Information as of July 2004. These missions and capabilities could be augmented.

** The Joint Technical Augmentation Cell (JTAC) plans and integrates overseas WMD exercises. It is a part of the Joint Task Force Civil Support (JTF-CS) operation that plans and integrates DoD support to the federal agency designated to lead a WMD consequence management operation. JTF-CS handles domestic incidents, while JTAC is involved in nondomestic incidents.

the scene once adequate resources are available and its assistance is no longer required. The main mission of RAP is to provide information or deployable assets (DOE measurement equipment and personnel) in order to assess and mitigate a radiological incident. RAP teams are organized across the nation in eight regions, and there is also a team for the national capital region. They can be on site within six hours of notification and are probably the most easily accessible radiological responders. They respond to telephone inquiries (see Table II), often resolving many situations via this route of communication.

If radiological materials become airborne, two NNSA response assets can be brought into operation. One of these, the National Atmospheric Release Advisory Center (NARAC), uses current meteorological data, land topography, computer codes, and incident time and location to predict the dispersion of airborne radiological materials. The results, continually refined until the threat is fully assessed, are also available via the Internet. This information is a "first cut" decision-making tool that can be used to geographically deploy responders efficiently and effectively. (See <http://narac.llnl.gov> for more information.)

The other airborne assessment tool is the NNSA's Aerial Measuring System (AMS), which can be intiated by RAP. Nellis Air Force Base, in Las Vegas, Nev., and Andrews Air Force Base, in Washington, D.C., are the locations for the fixed- and rotary-wing aircraft used in this program. The radiological detectors mounted on the craft provide real-time information about ground contamination. The mission of AMS includes assessments of the location, size, dispersion pattern, radioisotope content, and radiation intensity of the contamination on the ground.

The DOE's radiological triage capability can be requested from DOE headquarters in Washington, D.C., or through a RAP team member, to identify unknown radiation sources and to advise about possible hazards. The DOE assists on-site responders and other NNSA assets by interpreting the results of gamma-spectrographic analysis. This program supports other federal and state agencies whose personnel may search out radioactivity as a part of their jobs, such as the Federal Bureau of Investigation.

Another NNSA radiological response asset is the Radiation Emergency Assistance Center/Training Site (REAC/TS), which provides medical information, medical

TABLE II.
RADIOLOGICAL ASSISTANCE PROGRAM REGIONS AND 24-HOUR TELEPHONE NUMBERS

Regions	Telephone Number
National Capital Region: Washington, DC Site Office, DOE/NNSA Headquarters	202/586-8100
Region 1: Brookhaven, NY Area Office	631/344-2200
Region 2: Oak Ridge, TN Ops Office	865/576-1005
Region 3: Savannah River, SC Ops Office	803/725-3333
Region 4: NNSA Service Center (NA-42) Albuquerque, NM	505/845-4667
Region 5: Chicago, IL Ops Office	630/252-4800
Region 6: Idaho Ops Office, Idaho Falls, ID	208/526-1515
Region 7: Livermore, CA Site Office	925/422-8951
Region 8: Richland, WA Ops Office	509/373-3800

See <www.lm.doe.gov/rap/map.htm> for a map of the states covered by each RAP region.

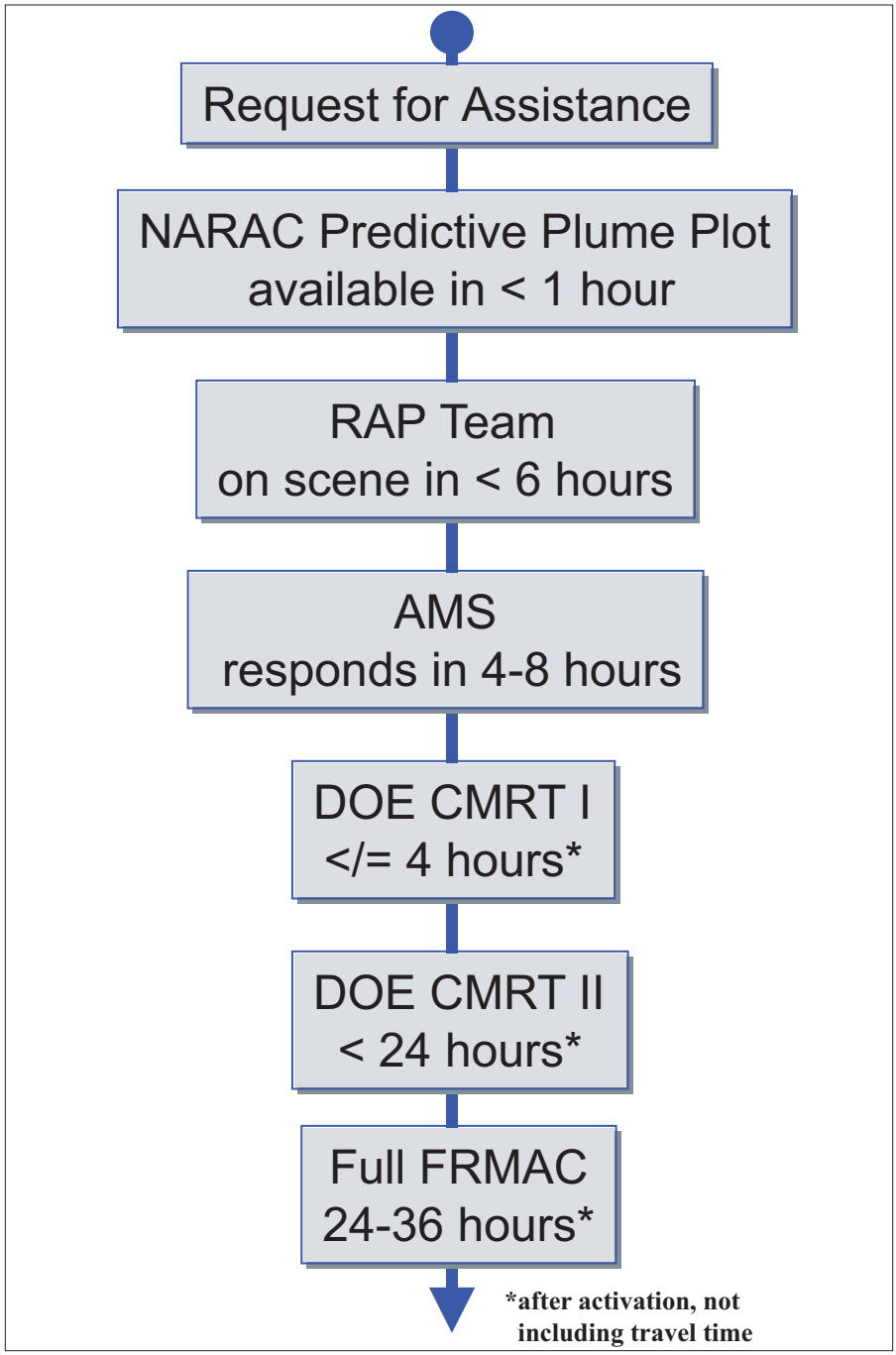

Fig. 2. Typical timeline for deployment of DOE emergency response components

personnel, and patient care in the event of a radiological accident. REAC/TS has a domestic and international mission by virtue of its designation as a World Health Organization Collaboration Center for Radiation Emergency Assistance. It maintains a radiological laboratory and radiation dose assessment and training facilities in Oak Ridge, Tenn.

Responses to incidents involving nuclear weapons under DoD or DOE custody can involve the DOE's Accident Response Group (ARG), whose expertise includes weapons designers, radiation health professionals, and nuclear scientists, so that knowledge of all weapons in the U.S. stockpile is at hand. Advice is provided to federal agency explosive ordnance disposal teams to identify weapon components, render weapons safe, and work together to package, transport, store, and dispose of damaged weapons/nuclear material.

The DOE maintains a number of other specialized teams to respond in support of the Department of Justice and other federal and state agencies when terrorist-related radiological/nuclear material is involved. These teams are activated by contacting the Emergency Operations Center at DOE headquarters or by going through one of the RAP teams.

The Nuclear Regulatory Commission will respond to terrorist and emergency incidents at the nuclear, industrial, and medical facilities it licenses. Some states, designated "agreement states," are authorized by the NRC to regulate their own licensees using state versions of NRC regulations. The NRC will also respond to terrorist actions at agreement state facilities. The NRC acts as a "coordinating agency" when responding to incidents involving its licensees or agreement states and as a "cooperating agency" under all other circumstances. This agency can provide incident assessments and probable consequences, public protective measures, and oversight of the affected licensee.[1]

The augmented civil response

The National Guard has been organized into 55 jointly staffed (Army and Air Force) Weapons of Mass Destruction-Civil Support Teams (WMD-CST). Their role is to support civil authorities—e.g., a state governor—by identifying a WMD, assessing the immediate and future hazard, advising on countermeasures, and determining whether additional expertise is needed. Their role includes assistance to local civil responders.

A CST advance party can be en route to a scene within 90 minutes of an alert. Follow-up team members can deploy within three hours. Transport by rotary- or fixed-wing aircraft is authorized. Equipment assigned to CSTs includes SUV-type vehicles, a mobile analytical laboratory, and communications vans. Each of the CSTs has 22 full-time team members and a number of response vehicles, including trailers totaling about 40 tons, and can be airlifted by military craft.

Coordinating the response effort

The coordination effort that is to occur among government agencies during a devastating or potentially devastating "Incident of National Significance" is defined in the DHS's National Incident Management System.[2] Lesser incidents will not require as extensive a response.

Coordination among federal and state agencies during the emergency phase of a nuclear/radiological incident may be handled by the NNSA's Consequence Management Planning Team. This is an advance component of the Federal Radiological Monitoring and Assessment Center (FRMAC), which is a response asset implemented in sequential phases. The origin of the FRMAC can be traced back to the nuclear power plant accident at Three Mile Island in 1979, when it was realized that a federal radiological emergency response plan was called for.[3] The mission of the FRMAC, which is composed of representatives from several federal agencies and state and local radiological response agencies, is to coordinate federal and state/local radiological monitoring and assessment activities. It is initiated through a request to the DOE by an affected federal or state government agency. If the emergency involves

a nuclear weapon, either the DOE or the DoD is the lead agency (whichever organization had custody of the weapon at the time of the incident/accident). If an RDD is the issue, the FBI becomes the lead agency representing the Department of Justice. An accident at a nuclear power plant will put the NRC in the lead role. Monitoring and situation assessment data are passed to state personnel, as well as to the federal agency that has the lead under the NRP. State personnel and the lead agency are both considered FRMAC "customers."

FRMAC will activate Consequence Management Response Teams (CMRT) in a phased manner. An initial CMRT can respond within four hours after notification. Reliable communications links are set up, and coordinated measurements, analysis, and consequence management of the radiological situation are implemented. This capability can be expanded to an around-the-clock response by setting up additional voice, video, and data links, enhancing radiological monitoring and environmental sampling, and augmenting expertise with additional RAP personnel. Additional services of the CMRT are on-site accommodation services, photo/video specialists, and data control expertise for any high-level crises. Once the incident enters the recovery phase, the EPA takes over the management of FRMAC from the DOE by mutual agreement. For a summary of the timeline for deployment of CMRTs involved with airborne radioactive materials, see Fig. 2.

FRMAC activation parameters are broad. A nuclear detonation, terrorist threat, or radiation release from a nuclear reactor are FRMAC considerations. If the incident requires an accelerated national response, the NRP establishes such a strategy in its Catastrophic Incident Annex (NRP-CIA), which would be brought to bear under conditions of mass casualties or damage that severely impinges on the infrastructure, economy, environment, or functions of government. The NRP-CIA is activated only by the secretary of Homeland Security. The following local services are to be augmented by NRP-CIA through so-called "push packages": hospital care for mass casualties, search and rescue capabilities, decontamination capabilities, mental and public health expertise, fatality management, medical instrument and pharmaceutical supplies, and dispersal of public information.*

Civilian medical response

It is generally conceded that even if all the government assets outlined above are properly implemented, perceived or real radiation exposures from a WMD or a nuclear detonation will likely present overwhelming challenges to first responders and local medical personnel. If a 1-kiloton nuclear device is detonated in an urban environment, "7000 prompt casualties may occur, along with 20 000 victims requiring intensive care."[6]

There are two basic needs for a successful medical response: (1) sufficient and adequate radiation detection equipment for first responders and medical staff, and (2) expertise in the treatment of radiation-related casualties, including those with internal radionuclide contamination.

It is not clear at this time that either need has been met in the United States. First responders are being equipped with belt-type devices that alarm when radiation dose-rates are high or when a preset cumulative dose level has been reached. Wide distribution of these devices is ongoing but not yet fully achieved. The identification of contaminating radionuclides via the use of portable spectrometers is of great assistance in the treatment of affected patients. Most first responders and hospitals, however, are not so equipped. It is postulated that patients of a nuclear or radiological incident would begin arriving at hospitals relatively quickly compared with off-site federal or military responders, thus making the collection of radionuclide data even more relevant.

Physicians who are triaging victims must be able to recognize acute radiation sickness and have knowledge of the few drugs that can be administered to block radioactivity uptake, e.g., potassium iodide in the case of radioactive iodine, or to accelerate the elimination of internalized radioactivity, e.g., DTPA in the case of plutonium, and Prussian Blue in the case of cesium. This requires training, and the radiological disaster training of medical personnel must compete with their continuing education needs. The latter, in most cases, will have the higher priority. This is unfortunate since about 55 000 professionals with some medical knowledge (not necessarily all are physicians) are members of radiological or nuclear medicine societies based in the United States. Clearly, extensive literature concerning radiobiological effects and the ability to produce training materials exist, but the means to efficiently deliver this material to physicians and their attendants has not been found.[6]

Once introduced into the health care system, the potentially contaminated patient presents issues of concern. First, an event such as the successful detonation of an RDD will probably result in a massive influx of potential patients at the available health care centers, a situation that could overwhelm the ambulance dispatching system,[7] causing victims and others to use alternative means of transportation. More than half of the patients are expected to arrive within the first two hours of the event. Therefore, even if all emergency medical technicians were equipped with a radiation alert detector, many patients would arrive at hospitals without a contamination survey, placing the detection effort on the already burdened emergency room staff. This implies, then, that the proper radiological detection equipment must be made available to hospitals, as well as to first responders. Otherwise, victims may bypass an initial contamination survey. First responders and hospitals have not yet widely acquired these instruments.[6]

The fear of radiologically contaminated patients is of real concern in the medical community. Health care providers have indicated that radiological emergencies are one of the least likely scenarios in which they would participate. The concern about radiological exposures among emergency room responders is not totally unjustified, although expected by many experts to be uncommon in a real radiological attack. One study[7] discusses such low-probability but plausible patient contamination scenarios.

To summarize, a fraction of admittees may be radiologically contaminated, and a fraction of these may have enough contamination or radiation source shrapnel to be a hazard to a potentially depleted medical treatment staff. To combat this, radiation training and radiological emergency drills must be held periodically with doctors and attending staff so that the fear of radiation is controlled and the skill to recognize a true radiological hazard is achieved. Medical staff cannot become experts on short notice, and so the assistance of radiation specialists such as health and medical physicists will be required during the training period and during real-life response efforts.

The government has resources to assist the civilian medical response to large-scale disasters. Under the NRP, the Department of Health and Human Services (DHHS) coordinates the Emergency Support Function, providing for public health and medical services. DHHS may deploy assets from the U.S. Public Health Service Commissioned Corps and the Strategic National Stockpile of drugs. An important supporting organization is the National Disaster Medical System (NDMS),[8] which is a coordinated partnership of DHS, DHHS, DoD, and the Department of Veterans Affairs. The mission of the NDMS is to design, develop, and maintain a national capability to deliver medical care to both responders and victims of a domestic disaster. The NDMS provides on-site medical care, patient transport from the disaster, and medical care at preassigned hospitals outside the affected area. The response capability of the NDMS includes Disaster Medical Assistance Teams to deal with on-site medical triage and treatment, Disaster Mortuary Operational Teams to handle mortuary procedures, National Nursing Response Teams to provide nursing ser-

*The previous sections on military and non-DoD assets were primarily derived from references 4 and 5 (see References at end of article).

vices where feasible, National Pharmacy Response Teams, and Veterinary Medical Assistance Teams. Participation in the NDMS by hospitals is achieved and maintained by federal coordinating centers that perform drills, develop emergency plans, and design patient reception, transport, and communication plans. Members of the NDMS teams are civilian volunteers. The Medical Reserve Corps, which is coordinated by the Office of U.S. Surgeon General, is another network of local volunteer medical and public health professionals.

Conclusions

Perhaps the only way the public can access nuclear response readiness is through the results of the congressionally mandated "Top Officials" (TOPOFF) drills conducted biennially by federal, state, and local emergency agencies with the inclusion of public and private health care providers. TOPOFF drills began in 2000 with "TOPOFF 2000," also known as TOPOFF 1. Both TOPOFF 1 and the later drill, TOPOFF 2, included the detonation of an RDD.

Although these drills did not include a nuclear weapon scenario, they were useful, among other things, for highlighting two important deficiencies:

1. There appears to be an inadequate "surge" response to the sudden influx of wounded and "worried well" at health care facilities.
2. The lack of a well-run communications network hindered the efficient response of the numerous response agencies (41 federal government agencies were involved in TOPOFF 2).

An additional observation was common to both drills: The chaotic atmosphere of a large-scale disaster makes the smooth integration of agency response assets very difficult.[9] Both communications and incident management/participant coordination problems also appeared in TOPOFF 3.[10]

To at least improve the coordination of response between FRMAC and the states, including local governments, a close working relationship must be developed between the two entities. The state of California has been cited as a good model for developing this working relationship.[11,12] Building this federal/state bridge initially involved federal/state coordination in nuclear power plant emergency response drills. This allowed the state to study FRMAC procedures, and FRMAC team members became informed about California's response procedures. FRMAC also allowed state representatives, including one California member from the Conference of Radiation Control Program Directors' Committee on Emergency Response Planning (E-6), to participate in working groups tasked with modifying FRMAC response procedures. At this depth of integration, response procedures were well understood by both entities, allowing a reasonably successful implementation during mock events to be achieved. Other states are attempting to achieve a similarly firm handshake with FRMAC. It must be noted, however, that the California/FRMAC relationship took years to develop. Although there are means for individual states to maintain periodic contact with FRMAC personnel, it is difficult for drills to be conducted with individual states on a regular basis, given the present limitations of FRMAC staffing and funding. And, of course, state response organizations differ in response capability and expertise. Therefore, it is to be expected that present response ability will vary for a given event, depending on the location.

As the reader has undoubtedly noted, the nation's plan for dealing with a nuclear or radiological attack is a complicated mix of response protocols, government agencies, military assets, civilian volunteers, and a supporting administrative and technological infrastructure. With so many components, it will have its critics, and at this stage of development, perhaps rightly so. No response requiring so many varied assets acting together in a situation so devastating as a nuclear attack will be without serious flaws. As recently as December 2005, 9/11 Commission member Timothy Roemer expressed his grave concerns about the United States' ability to deal with the catastrophe of a nuclear attack.[13] He cited the poor governmental responses to hurricanes Rita and Katrina in support of this. The response landscape of the nation is a dynamic one, however, with the ability to change and correct itself through repeated practices such as the series of TOPOFF mock attacks (TOPOFF 4 is planned for 2007). Efforts to eliminate or at least partly correct the major flaws cited earlier in this paper must continue.

It is also important to understand that response assets do not function alone. Programs to protect the nation before a response is required are presently in effect. For example, the security of nuclear material worldwide is ongoing because of the threat posed to U.S. ports (and ports elsewhere) from a clandestine nuclear weapon aboard a container or other type of ship. Efforts to accomplish this, not without faults of their own, have focused on the nuclear materials stored under poorly guarded conditions, primarily in nations of the former Soviet Union.[14] And improvements continue to be made in the ability to detect clandestine nuclear weapon materials at foreign and domestic ports.[15] We must also recognize the nonproliferation efforts of the International Atomic Energy Agency. The IAEA has also been instrumental in the recovery of abandoned and potentially lethal radiological sources. The protection of the nation requires activities on many fronts to detect and identify nuclear and radiological sources.

A 2005 review concluded that many years and millions of dollars will be needed to improve the nuclear and radiological preparedness of the nation.[16] Until the threat of nuclear/radiological terrorism is contained (if ever), or until the geopolitical climate of the planet reduces such a threat to an insignificant probability (if ever), continuous refinement of forward-deployed measures such as foreign nuclear weapons security and the homeland response assets described above will be necessary. Continued and rigorous testing of the response capabilities that need improvement, such as the domestic medical sector response, remains an imperative.

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