



The Evolution of the Federal Radiological Monitoring and Assessment Center



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The Evolution of FRMAC



DOE/NV/25946—1559

The Evolution of the Federal Radiological Monitoring and Assessment Center (FRMAC)



Preface

The Federal Radiological Monitoring and Assessment Center (FRMAC) is a federal emergency response asset whose assistance may be requested by the Department of Homeland Security (DHS), the Department of Defense (DoD), the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and state and local agencies to respond to a nuclear or radiological incident. It is an interagency organization with representation from the Department of Energy's National Nuclear Security Administration (DOE/NNSA), the Department of Defense (DoD), the Environmental Protection Agency (EPA), the Department of Health and Human Services (HHS), the Federal Bureau of Investigation (FBI), and other federal agencies.

FRMAC, in its present form, was created in 1987 when the radiological support mission was assigned to the DOE's Nevada Operations Office by DOE Headquarters. The FRMAC asset, including its predecessor entities, was created, grew, and evolved to function as a response to radiological incidents. Radiological emergency response exercises showed the need for a coordinated approach to managing federal emergency monitoring and assessment activities.

The mission of FRMAC is to coordinate and manage all federal radiological environmental monitoring and assessment activities during a nuclear or radiological incident within the United States in support of state, local, tribal governments, DHS, and the federal coordinating agency.

Radiological emergency response professionals with the DOE's national laboratories support the Radiological Assistance Program (RAP), National Atmospheric Release Advisory Center (NARAC), the Aerial Measuring System (AMS), and the Radiation Emergency Assistance Center/Training Site (REAC/TS). These teams support the FRMAC to provide:

- Atmospheric transport modeling
- Radiation monitoring
- Radiological analysis and data assessments
- Medical advice for radiation injuries

In support of field operations, the FRMAC provides geographic information systems, communications, mechanical, electrical, logistics, and administrative support. The size of the FRMAC is tailored to the incident and is comprised of emergency response professionals drawn from across the federal government. State and local emergency response teams may also integrate their operations with FRMAC, but are not required to.



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The 1980s and Before

Early Development and Planning of FRMAC

The history of the Federal Monitoring and Assessment Center (FRMAC) is tied to the development of federal agency planning that followed the Three Mile Island (TMI) accident in 1979.

At the time of the accident, the Department of Energy (DOE) and some other agencies had an existing response agreement. An Interagency Committee on Radiological Assistance operated under an *ad hoc* arrangement until 1961 at which time a formal Interagency Radiological Assistance Plan (IRAP) was signed by the Atomic Energy Commission (AEC), (predecessor to the DOE); Department of Defense (DoD); Department of Health, Education, and Welfare (DHEW); Department of Labor (DOL); Department of the Treasury; Department of Commerce; Office of Civil Defense Mobilization; Federal Aviation Administration; the National Aeronautics and Space Administration (NASA); the Post Office Department; and the Interstate Commerce Commission.

In 1973, the AEC; the DHEW; the Defense Civil Preparedness Agency (DCPA) (formerly Civil Defense); and the Environmental Protection Agency (EPA) signed an agreement to assist each other in responding to a radiological incident at a fixed facility.¹ The AEC was responsible for maintaining the 1973 IRAP, which superseded the earlier 1961 agreement.

The Energy Reorganization Action of 1974² abolished the AEC and created the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Agency (ERDA)—another predecessor organization to the DOE. The responsibilities of the AEC were divided between the two newly created agencies; the division became effective January 19, 1975 by Executive Order.³ The NRC took on the lead responsibility for planning and training; ERDA had responsibilities for working with state and local governments to coordinate radiological capabilities. The federal agency planning was expanded to cover transportation accidents and the agreements were signed by the NRC, EPA, ERDA, DHEW, Department of Transportation (DOT), DCPA, Department of Housing and Urban Development (HUD), and the Federal Preparedness Administration (FPA).⁴

The NRC now focused on licensing and inspecting reactors and no longer had the capacity to do expansive radiation monitoring. In a 1977 agreement, the NRC agreed to notify ERDA immediately of any emergency that may require its assistance, and ERDA agreed to provide Aerial Radiation Measuring System (ARMS) and Nuclear Emergency Search Team (NEST) resources to the extent they were available under the IRAP. ERDA also agreed to do radiological surveys and mapping at all NRC sites. ERDA developed its internal response plan, which included an Emergency Action Coordinating Team at headquarters to coordinate the ERDA response.⁵ In that same year, ERDA became the DOE; however, the agreement and response capabilities continued established by ERDA continued.



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AEC/ERDA/DOE Response Resources

DOE (and its predecessor agencies) had been developing the resources and programmatic structures to form the basis of a response system. Although these DOE “assets” had different names and missions, the equipment and personnel were often the same. The names of the response elements themselves also changed through the years.

Aerial Radiation Measuring System/Aerial Measuring System

The U.S. Geological Survey (USGS) had operated a DC-3 aircraft fitted with radiation detection equipment to search for uranium deposits and to measure the radioactive fallout from the nuclear weapons tests of the 1950s. When aerial radiation measurements proved useful after the 1957 reactor accident at Windscale, England, the AEC bought the DC-3 and began measuring radiation levels around government nuclear facilities. The AEC decided to contract the operation of the plane to EG&G Energy Measurements, Inc., the Maintenance and Operations (M&O) contractor for the AEC’s Nevada operations.

The aerial radiation detection and measurement system used thallium-activated sodium iodide (NaI) radiation detectors and a Doppler radar navigation system to track the plane’s position. Combining this data allowed the analytical staff to prepare a map of the radiation levels in the area. This detection and mapping system was called ARMS, which later became the Aerial Measuring System (AMS).

In August 1976, the EG&G staff surveyed the TMI nuclear power plant, which had been operating for about two years. By this time, the DC-3 had been replaced by a twin-engine Beechcraft. The detailed aerial survey was augmented by soil samples from two sites east and southeast of the plant. The radioisotopes identified and the gamma exposure rates were consistent with the expected background radiation levels.⁶

Radiological Assistance Team/Radiological Assistance Program

In 1958 and 1959, as part of the AEC’s radiation safety program, a Radiological Assistance Program (RAP) was created. The national laboratories and AEC sites had organized qualified employees into radiological assistance teams (RATs) with responsibility for particular states. Any government agency, commercial operation, or even a private citizen could ask for help with nuclear-related problems, such as lost sources, malfunctioning equipment, or discovery of radioactive materials. The AEC assistance teams would travel to the scene, if necessary, survey the area, and advise local officials how to prevent people from being harmed. This program has continued to the present day under DOE. There are currently nine RAP regions.

Accident Response Group

In 1957, the DoD and the AEC began to develop plans for a joint response to an accident involving atomic weapons. The agencies signed formal agreements in 1958 to coordinate radiation monitoring and medical safety efforts. In October 1958, this agreement was extended to any military or civilian radiological emergency.⁷ A Joint Nuclear Accident Coordinating Center (JNACC) was staffed by AEC and DoD representatives who tracked the agencies’ response capabilities.⁸



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In 1973 an Accident Response Group (ARG) was formed in 1973, using staff from the AEC's national laboratories and contractors, especially EG&G, Energy Measurements to operate the Surveillance Accident and Nuclear Detection System (SANDS), to locate lost weapons.

Nuclear Emergency Search Team

The SANDS capability formed the basis for the Nuclear Emergency Search Team (NEST). By the early 1970s, Los Alamos National Laboratory (LANL) and EG&G were working on ways to detect nuclear materials in urban areas with long-range search efforts. After a nuclear extortion threat to Boston in 1974, the Nevada Operations Office was given responsibility for planning and conducting field operations to search for lost or stolen weapons and special nuclear materials and to respond to bomb (radiation-related only) and radiation dispersal threats. Experts from the national laboratories, particularly the weapons programs, and EG&G and other AEC contractors were prepared to assemble when needed as the NEST.⁹ DOE and other sponsors funded the procurement of the transportable command post, communications equipment, and detection equipment by EG&G.¹⁰ As the response role of SANDS broadened, its name was changed to the Nuclear Emergency Support Team, to reflect its increased role.

Atmospheric Release Advisory Capability/National Atmospheric Release Advisory Center

The AEC asked Lawrence Livermore National Laboratory (LLNL) if it were possible to create an integrated system for providing data on potential and ongoing atmospheric hazards. The Atmospheric Release Advisory Capability (ARAC) was developed in 1974. It combined a sophisticated plume model with meteorological data to predict the location and intensity of atmospheric releases of radiological materials released into the atmosphere. The ARAC got its first major test during the TMI accident.¹¹ The capability had now expanded beyond radioactive releases; it became known as the National Atmospheric Release Advisory Center (NARAC).

A Pre-FRMAC Response

Cosmos 954 (Operation Morning Light)

Cosmos 954 was a satellite launched on September 18, 1977, by the Union of Soviet Socialist Republics. It was powered by a small nuclear reactor containing enriched uranium. When the North American Air Defense Command (NORAD) began tracking the satellite, it was in a 150-mile high orbit designed to cover the world's oceans from the Arctic to the Antarctic. Shortly after the launch, Cosmos 954 began to slip from its orbit. The Soviets reported that they attempted by radio command to separate the satellite into three sections, but the attempt to separate was unsuccessful. By early January 1978, the orbit started to decay more rapidly and a projected impact date of January 23 was identified. DOE was directed by the National Security Council (NSC) to place its nuclear emergency response capabilities into full alert status to assist in the protection of public health and safety should radioactive debris from Cosmos 954 come to earth in the United States. Response organizations such as the ARG and NEST included the technical experts and equipment necessary for search and recovery. These capabilities were not designed for a large-area search; however, if local



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contamination occurred, DOE had the resources to perform radiological mapping of the contaminated area. The NSC then further directed DOE to prepare to take operational control of federal emergency response efforts in the United States and directed the Department of State (DOS) to coordinate assistance that might be requested by other nations. As of January 22, 1978, all equipment was loaded on Air Force C141 transports at Andrews Air Force Base, Washington, D.C., Travis Air Force Base, Fairfield, California, and McCarran International Airport, Las Vegas, Nevada. All response personnel were placed on a two-hour alert. COSMOS 954 had landed near Great Bear Lake in northern Canada on January 24, 1978. By the end of February, DOE teams, along with various Canadian recovery teams, had located and removed many pieces of radioactive debris. In early March, the U.S. search and computer equipment assets and personnel were returned to their U.S. locations. A full discussion of Operation Morning Light is contained in the official report.¹²

Although this was not a FRMAC response (FRMAC had not yet been developed), Morning Light represented a genuine emergency response, much larger and more challenging than any previous simulation. The participation in Morning Light provided invaluable experience that was incorporated in to the FRMAC mission as it developed and as the mission of NEST was redirected.

Changes in Planning Environment

While DOE and its predecessors had been developing potential response resources, there had been no large-scale tests of the plans. Before the accident, TMI had its own emergency plans, as did the Commonwealth of Pennsylvania. The General Accounting Office released a report at the time of the TMI accident that cited deficiencies in emergency planning and preparedness at DOE, DoD, and NRC nuclear facilities, particularly in the off-site planning. The IRAP was not mentioned. The TMI accident also occurred at a time of growing public concern about nuclear power.

When the TMI accident occurred, the Federal Emergency Management Agency (FEMA) was in the process of being created. The agency was proposed on June 19, 1978 in President's Carter's Message to the Congress Transmitting Reorganization Plan No. 3 of 1978.¹³ FEMA was assigned responsibilities from a number of other agencies. These agencies included the National Fire Prevention and Control Administration, the Federal Insurance Administration, oversight responsibility for the Federal Emergency Broadcast System, the Defense Civil Preparedness Agency, the Federal Disaster Assistance Administration, and the Federal Preparedness Agency, including policy for the National Stockpile. FEMA also took over the Earthquake Hazards Reduction Program, promotion of dam safety and assistance to communities in developing readiness plans, coordination of natural and nuclear disaster warning systems, and coordination of preparedness to reduce the consequences of terrorist incidents.¹⁴ The reorganization was accomplished by Executive Order¹⁵, signed March 31, 1979 and effective April 1, 1979. The newly created agency immediately had a crisis to manage.

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The Catalyst—Three Mile Island¹⁶

DOE first became aware of a problem at Three Mile Island (TMI) Nuclear Power Plant (NPP), located near Middletown, PA, when, on March 28, 1974, a worker in the control room, following plant procedures, notified the Brookhaven radiation assistance team that they had lost feedwater and were measuring high radiation levels in the containment building.

DOE headquarters was notified. Then the NRC called Brookhaven management to tell them the reactor had tripped and some fuel might have melted, but they said they did not need radiological assistance right then. The DOE's Emergency Operations Center (EOC) alerted the AMS/NEST resources at Andrews AFB. The request for assistance finally came from the Pennsylvania Bureau of Radiation Protection, but only after the Brookhaven contact convinced the state that they should do so. The NRC requested the aerial monitoring team from the EOC. At that point, DOE had separate requests from different groups for AMS and radiological assistance. The transportable command post equipment, usually associated with NEST, would clearly be useful.

AMS/NEST set up operations in a hangar at the Capital City airport, Harrisburg, PA. ARAC was connected over the telephone. Unfortunately, the DOE resources were not familiar with each other. AMS/NEST operations were often secret. ARAC was a new organization and the Radiological Assistance Teams were used to working on their own.



Figure 1. AMS Survey around Three Mile Island

Two days into the accident response all the agencies involved in monitoring met in the hangar to report on what they were doing. By this time, DOE had 60 people working at the site. The agencies agreed that one agency should coordinate the results of all the groups monitoring, and based on the resources, DOE was the logical choice. A subsequent White House meeting of agency officials, with no DOE representatives, ended with the NRC assigned the role for coordinating monitoring data. No one told DOE, so they continued the coordination at the command post.

The monitoring and data analysis fell into a routine—regular aerial monitoring by AMS helicopters (shown in Figure 1) and fixed-wing aircraft, an ARAC computer terminal in the hangar for developing projections, and state and DOE teams taking readings and bringing back samples for analysis. More AMS/NEST communications equipment arrived at the command post. However, during this time DOE kept a low profile and communication with the NRC were still poor.

Representatives from all agencies continued to meet daily. The “5 o’clock briefings” allowed everyone to get the information, resolve discrepancies, and plan future data collection. The data were collected and distributed to NRC headquarters and Pennsylvania officials. But there was continued doubt about whether it was being



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used as the basis for decisions. For example, the Governor was talking about evacuation when the data showed little cause for concern offsite.

Getting the DOE resources out of Pennsylvania was more difficult than getting them in. The scientists felt the response could be terminated, but the politics required some presence. DOE reduced the number of people, and the Environmental Protection Agency (EPA) assumed more of the monitoring responsibilities. (Most of the EPA monitoring staff was under an agreement with DOE to perform monitoring to support nuclear testing.)

Officials at DHEW and EPA headquarters realized that DOE was collecting the radiological data that went to the NRC and coordinating all of the monitoring activities. Concerned that the public might think the data was not being collected objectively, these agency officials wanted to have EPA do the coordination. Despite a request from the state that DOE continue its work, the headquarters agencies had EPA take over on April 15. DOE, DHEW, and NRC agreed to share pertinent post-accident data and release any information through the NRC, but EPA refused to sign.

In May, DOE responders met to evaluate their response. DOE had done well in data coordination and in providing communications to other responders. Never before had so many parts of DOE been involved in a single response. Some DOE staff thought the IRAP had worked well, but others disagreed as to whether the IRAP had actually been used. The need to move communications equipment to the site immediately was recognized.

DOE was better prepared to respond than most agencies. The agency and the DoD had exercised and responded to weapons accidents in a series of exercises called NUWAX. There was an EOC at DOE headquarters in Germantown, Maryland, and an emergency management structure was in place.

However, even DOE had its problems. Communications between the field and headquarters were not always the best. The telephones were overloaded at first, but the command post soon had better communications than the plant or the NRC. The monitoring teams had not worked with ARAC or AMS/NEST. The aerial monitoring flights were complicated by press helicopters. However, the players involved started making things work. Additional DOE monitoring teams arrived, and the DOE command post began coordinating state and federal monitoring efforts on an ad hoc basis.

Today, the TMI response is often considered the epitome of a failed federal response. The problems were many. Communications were poor. Various response plans, if they were being used, were not coordinated with the other agencies' plans. It appeared no one was in charge. There was no evidence the radiological information DOE was collecting was getting to the NRC and the state, and information on the plant was not getting to DOE. While the radiation readings seemed very small to those doing the monitoring, the public's impression of a catastrophe grew.



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Cosmos 1402 (Bright Light)

In 1983, DOE prepared a field operations plan in preparation for the reentry of Cosmos 1402, a Cosmos 954-type satellite containing a uranium-fueled nuclear reactor. The NSC named FEMA the lead agency if the satellite hit the U.S., while the Department of State had the responsibility if the U.S. were asked to assist another country. DOE was assigned technical responsibility for providing for public health and safety. DOE headquarters assigned this to its Nevada Office, which implemented the responsibility using the NEST response structure. This action took place during the planning for the first Federal Field Exercise. Although no FRMAC was planned for this event, the concept of how a FRMAC could be implemented was being discussed at this time.

Cosmos 1402 was expected to reenter in two pieces. The satellite reentered the earth's atmosphere on February 7, 1983, over the South Atlantic. However, it was thought to have burned up in the atmosphere. Scientists detected uranium dust from the satellite in the atmosphere a year later.¹⁷ The preparations identified the need for satellite communications capability¹⁸. DOE-NV filed an "after-action report" to DOE headquarters, which included the DOE field operation plan,¹⁹ resource lists, and supporting documents.²⁰

Development of the Federal Radiological Emergency Response Plan

To improve the response if there were another accident, Congress included a provision in the Nuclear Regulatory Commission Authorization Act of 1980.²¹ This provision required the President to issue a "National Contingency Plan" to provide for expeditious, efficient, and coordinated action by appropriate Federal agencies to protect the public health and safety in case of accidents at commercial nuclear power plants. This law also established emergency planning and preparedness (including state, local, and tribal plans) as a legal basis for power plant licensing.

On September 29, 1980, President Jimmy Carter, signed Executive Order (E.O.) 12241. This E.O. delegated to the Director of FEMA the responsibility for publishing the National Contingency Plan for accidents at nuclear power facilities. It was to be published from time to time in the Federal Register.

In November 1980, FEMA and the NRC jointly published the *Criteria for Preparation and Evaluation of Radiological Emergency Response Plan and Preparedness in Support of Nuclear Power Plants*²² to establish the standards and criteria for offsite radiological emergency planning around power reactors. This joint document, sometimes called NUREG-0654, with its supplements and revisions, continues to provide the requirements for emergency planning around nuclear power plants. Even today, in many circles, NUREG-0654 is considered the fundamental radiological emergency preparedness "document."

In December 1980, the *National Radiological Emergency Preparedness/Response Plan for Commercial Nuclear Power Plant Accidents (Master Plan)* was published²³ for interim use and public comment. The Master Plan incorporated lessons learned from the TMI response. A subcommittee of the interagency Federal Radiological Preparedness Coordinating Committee (FRPCC) developed the plan. A tabletop exercise was conducted at the headquarters level to validate the concepts behind the master plan.



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Prior to 1987, FRMAC was operated as a regional response asset. The first two full-field exercises (FFE) held in 1984 and 1986 were executed by RAP Region 3 (1984, St. Louis) and RAP Region 5 (1986, Zion Nuclear Power Plant) as part of the “Master Plan.” DOE was asked to develop a Federal Radiological Monitoring and Assessment Plan (FRMAP) to replace the IRAP. The plan called for DOE to work with state and local authorities to coordinate offsite radiological monitoring and assessment data. DOE would be the point of contact for radiological assistance requests and would get assistance from other federal agencies as needed. The plan also applied to the smaller responses DOE made under its radiological assistance program.

In March 1982, 44 CFR part 351²⁴ established the Federal Radiological Preparedness Coordinating Committee (FRPCC), chaired by FEMA and including NRC, EPA, Department of Health (DOH) and Human Services (DHHS), DOE, Department of Transportation (DOT), DoD, Department of Agriculture (USDA), Department of Commerce (DOC), and on an ad hoc basis, other federal departments and agencies. A Regional Assistance Committee (RAC) was established in each of 10 standard federal regions, with a regional representative of the same agencies. The interagency committee sponsored a tabletop exercise, Headquarters Interagency Exercise (HIEX-82), in October 1982 to test the coordination of response to a nuclear power plant accident.

While the focus of the interagency group was on commercial nuclear power plant accidents, DOE headquarters began to develop “annexes” to the FRMAP to deal with other types of radiological accidents. These annexes would incorporate interagency planning that was being done by other groups for nuclear weapon accidents, DOE and DoD nuclear facilities, nuclear terrorism, and transportation. The location from which DOE coordination would take place was called the Federal Radiological Monitoring and Assessment Center, or FRMAC.

The FRPCC decided that broader radiological response planning was desirable and delegated the development of a Federal Radiological Emergency Response Plan (FRERP) to the “Federal Response Subcommittee (FRS).” The plan was developed in stages—planning guidance²⁵, draft plan²⁶ for use in an exercise, and interim plan²⁷. The plan designated a Cognizant Federal Agency (CFA), which was responsible for onsite response. Offsite, DOE coordinated radiological assistance, while FEMA coordinated non-radiological assistance. FEMA and the CFA would jointly coordinate the federal response. At each step, there were small exercises to test the concepts. The draft FRERP was tested in a large, multiagency exercise before the interim plan was published to replace the Master Plan. The DOE-prepared FRMAP was incorporated in the FRERP as Section III (a “plan within a plan”). After minor changes, the FRERP was approved by the 12 participating agencies and released as an operational plan in November 1985²⁸. ***This event has been accepted across the emergency response community as constituting the “Birth of FRMAC.”***

The First Federal Field Exercise (FFE-1)²⁹

The multiagency exercise planned to test the FRERP before publication had a commercial power plant scenario. Florida Power and Light’s St. Lucie Nuclear Power Plant was chosen for the March 1984 exercise. FFE-1 (Federal Field Exercise or FRERP Field Exercise) was held in conjunction with the facility’s annual exercise. In addition to the federal agencies, Florida Power and Light, the State of Florida, and the counties of



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St. Lucie and Martin were to participate. FEMA's Director referred to the exercise as "an historic event" noting that "for the first time, the federal agencies will be able to evaluate both their own emergency response plans and their working relationships with other agencies." He said it would also test the federal responsiveness to state and local requests for assistance.³⁰

On December 1, 1983, the exercise planners conducted a tabletop exercise in the St. Lucie Emergency Operations Facility. After a series of briefings by participating groups, the tabletop progressed through a controlled discussion. After the simulated notifications and deployment, the participants were seated with others from their response center, such as the FRMAC.

Because the St. Lucie site was within the DOE radiological assistance region covered by the Savannah River Site, the Savannah River Operation office was in charge of the FRMAC. The FRMAP called for regionally based FRMAC; this assignment was based on DOE's belief that someone from the regional radiological assistance coordinating office would be more familiar with the state and local personnel with whom they had to work during an emergency. The DOE Savannah River Office had the lead in planning and also provided the Offsite Technical Director (OSTD). To enhance the training experience, many of the FRMAC controllers



Figure 2. FFE at St. Lucie

and evaluators were drawn from other DOE offices for radiological assistance.

The Savannah River Office had developed an organization structure to be used in the FRMAC (Fig. 1) and a representation of the way data and assessments were expected to flow (Fig. 2). This concept shows the OSTD providing data to the state and to the Cognizant Federal Agency (CFA); FEMA was to get the radiological information from one of these two groups.

The tabletop was followed by a "dry run" drill, January 25–26, 1984, which used the expected response centers, but the field monitoring activities were simulated. The exercise controllers were located in the Jensen Beach Holiday Inn. The DOE OSTD established a FRMAC at Witham Airfield in Stuart, Florida. After the TMI experience, an aircraft hangar was the first thing DOE considered as a location. The drill was interrupted for a couple of hours, when a test tube labeled "Nitro G" was discovered at the entrance of one of the auxiliary buildings. The tube turned out to be a prank instituted by an employee of the security contractor (the employee was promptly dismissed).

The exercise was scheduled for March 6–8, 1984. There was a great deal of press coverage. The Treasure Coast Alliance for Peace, a local group opposed to nuclear power and nuclear weapons, planned to release 500 balloons at the plant on the first day of the exercise to represent the radiation coming from the plant.³¹ One community took additional insurance for its police force, fearing confrontations with demonstrators and disrupters.



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The field exercise was scheduled for three days. The first day focused on the St. Lucie plant’s required exercise for the NRC and FEMA. Federal responders received notifications and “traveled” to the site, although in reality they were already there. On the second day, the federal response was in place. The FRMAC, the Federal Response Center (established by FEMA) that was a precursor to the Joint Field Office (JFO), and the Joint Information Center were activated. A 48-hour time jump between the second and third day allowed consideration of longer-term challenges, such as the food ingestion pathway measurements and the return of evacuees.

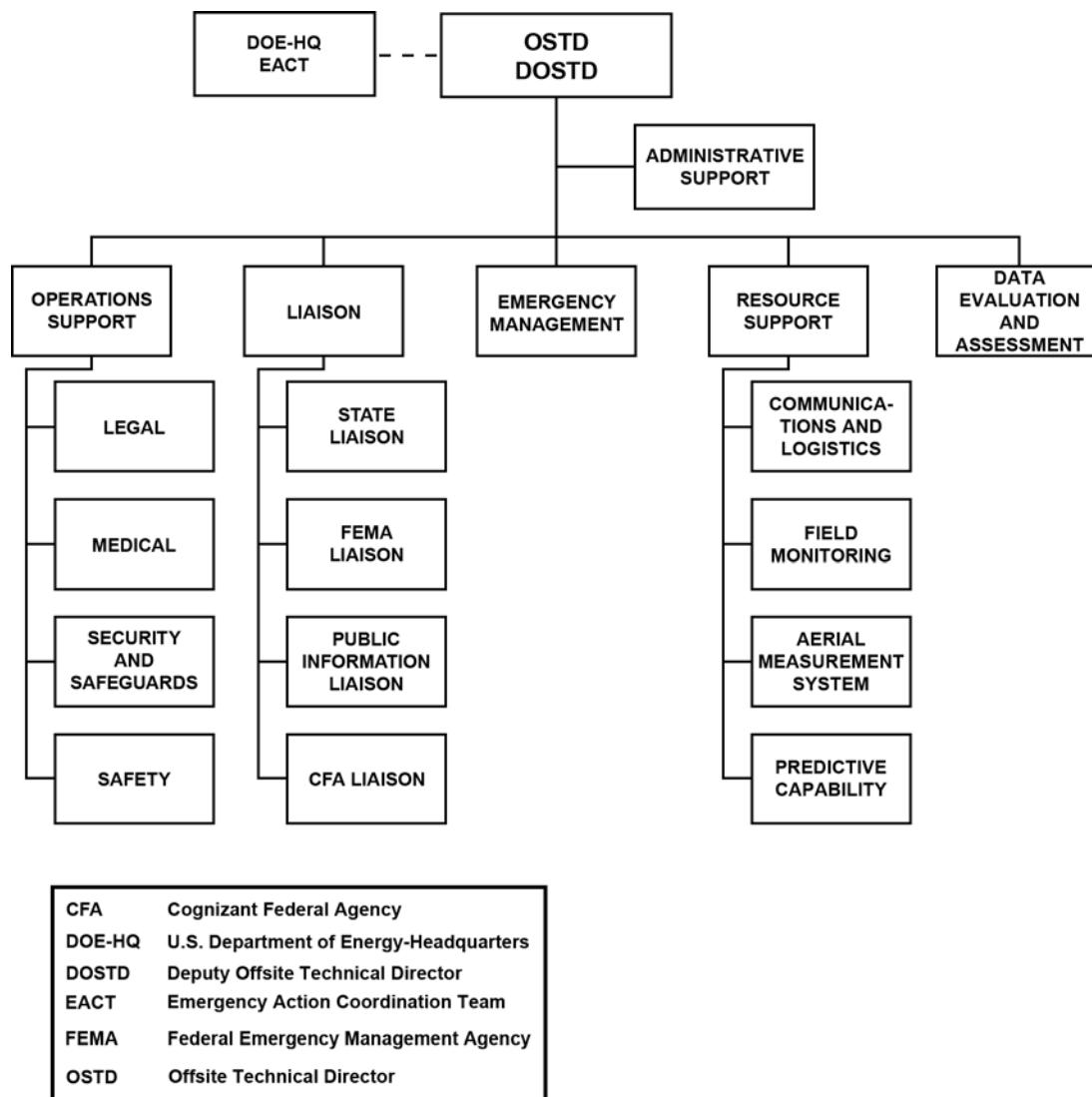


Figure 3. Data flow diagram for FRMAC in FFE. Source: Federal Radiological Monitoring and Assessment Center Orientation Program for DOE Region 3, prepared by the Savannah River Operations Office

An exercise evaluation report³² concluded that, “overall, the Draft FRERP had worked well in its first full-scale test.” The exercise was evaluated based on 40 agency interfaces that needed to function. About half of



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the interfaces worked fine, but the other half required minor changes. Four new interfaces were identified for future inclusion.

Most of the DOE interfaces had worked well, but a few problems were identified. It was not always feasible for the NRC to coordinate and present federal protective action recommendations (PARs), but agency coordination was needed when reentry recommendations were involved. The FRMAC did need to know what protective action decisions were made. DOE did not want to provide raw data directly to FEMA as they felt they supported the state and NRC. FEMA felt they needed assessed data. HHS and USDA needed additional representatives in the FRMAC to work with the data assessment group. DOE needed a list of agencies to notify. DOE and EPA negotiated a memorandum of understanding for turnover of the coordination of radiological assistance that became the basis for later events.

Within the FRMAC, there were practical lessons from the attempt to coordinate and collocate with other agencies. The location of activities such as contamination control, interoperability of equipment, and laboratory coordination had provided challenges. Among the needs identified were more training and development of uniform dose calculation factors and assumptions.

Around St. Lucie, anti-nuclear activists were not satisfied. Most of their complaints, however, were focused on the state and local problems of “evacuating” a large population.

Post-FFE Federal Radiological Response (FRMAC) Demonstrations

After the FFE, DOE made a great effort to tell utility, state, and local responders as well as other DOE staff about the FRMAC. A series of FRMAC capability demonstrations were held in different parts of the country to show FRMAC’s capabilities and explain how FRMAC functioned. The usual format included briefings, tours of FRMAC areas, and time to walk around and talk to FRMAC staff. Two demonstrations followed the FFE in 1984: one in Las Vegas in June and another at Fort Gillem, outside Atlanta, in December. The Savannah River Office held another FFE critique for key players after the Atlanta session to discuss improvements in their FRMAC operation. A demonstration in Chicago in April 1986 served as part of the preparation for the second FRERP field exercise and another in Philadelphia in October 1987 preceded a planned third exercise.

DOE also prepared a videotape, “Federal Radiological Emergency Assistance,”³³ using footage from the FFE, to explain the concept and operation of the FRMAC. This video was distributed to the regional assistance office and other interested parties for use in their briefings.

Ingestion Pathway Exercise at Farley Nuclear Power Plant

Outreach efforts with the states had some success. Through the FRMAC, DOE provided simulated aerial monitoring data for an ingestion pathway exercise at the Joseph M. Farley Nuclear Power Plant near Dothan, Alabama. The exercise took place November 28–29, 1984. This was the first exercise in which the federal agencies and the states integrated their efforts. The State of Alabama had requested this assistance through DOE headquarters within a year of the FFE.³⁴



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Relocation Tabletop

After FFE-1, the FRERP was revised to include what was learned during the exercise. DOE's revisions focused on data flow and coordination of reentry recommendations. The FRERP was published as an operational plan in November 1985. The FRS conducted another tabletop exercise in December 1985. This tabletop covered a longer period after a nuclear power plant accident in order to look at the criteria for reentry and relocation of the population.

Chernobyl Power Plant Accident

On April 26, 1986, the largest nuclear power reactor accident occurred during unauthorized testing at the Chernobyl Power Plant in the Ukraine (formerly part of the Soviet Union). Reactor 4 exploded and burned, releasing intense heat and large amounts of radioactive material.

The FRERP, as written, dealt only with accidents in the United States or its territories, and so it did not apply. The White House appointed EPA to lead the U.S. response and respond to concerns about any health effects here. EPA continued to monitor for radioactivity, established an information center for facts and data, held daily press conferences, and established a group to provide advice on protecting the food supply and public health. Slightly elevated radiation levels were detected in the United States, but they were much too low to trigger any protective actions.³⁵

DOE asked EG&G Energy Measurements scientists from Nevada to come to DOE headquarters to assess the data and create a database of information (using a database concept they were developing for use in the FRMAC). ARAC was actively modeling the release and predicting the plume movement and deposition. The data were reviewed by the interagency team providing advice on food effects and health.

Although the FRERP was not used, portions of the response structure were extracted and applied to this new situation. The accident emphasized that borders provided no protection against radiation and prompted the development of two International Atomic Energy Agency international agreements: the Convention on Early Notification of a Nuclear Accident³⁶ and the Convention on Assistance in the Case of a Nuclear or Radiological Emergency³⁷.

Humble Servant Exercise

Humble Servant was a Transportation Safeguards Division operational effectiveness exercise at Fort Chaffee, located at Fort Smith, Arkansas, March 8–12, 1986. In the scenario, two portable nuclear weapons were stolen by terrorists. Since Arkansas was in the Oak Ridge radiological assistance region, an Oak Ridge National Laboratory representative was appointed the OSTD.

Radiological health and safety activities were not well integrated into the exercise. Both ARG and NEST assets were involved. The FRMAC was placed within the ARG structure, but none of the other federal agencies that would participate in the monitoring and assessment effort were actually present. Portions of



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FEMA and EPA were simulated. The Arkansas Division of Radiation Control and Emergency Management played only by telephone.

Humble Servant provided a preview of the struggle to get the FRMAC accepted in something other than the response to an NPP accident. It also exposed the need for expansion and clarification in the FRERP of FRMAC's role in an emergency response. The division of responsibilities between the Federal Bureau of Investigation (FBI) and DOE's ARG program were not clear. The FBI did not want to share some important information with the state radiological officials. There were advantages and disadvantages of locating the FRMAC with the ARG. While co-location facilitated some technical information flow, it created problems for uncleared state personnel trying to work with the FRMAC. A FRMAC required something more than just renaming the DOE to the Joint Radiological Control Center (JRCC).

The question of how the FRMAC functioned when DOE also had an onsite role also had to be addressed. Because FRMAC does not make protective action recommendations (PARs) for on-site recommendations, it was difficult for them to assist the on-site DOE OSTD. To identify these problems, the FRMAC concept needed to be exercised with non-reactor accident scenarios.

Mighty Derringer



Figure 4. FRMAC at Mighty Derringer, Camp Atterbury, Indiana

Mighty Derringer was a national exercise under the direction of the National Security Council. The exercise window was set for December 1–12, 1986. The scenario involved two nuclear devices: one in a hypothetical bordering country (actually the Nevada Test Site); the other in the city of Indianapolis. The Indianapolis portion of the response was located at Camp Atterbury, near Edinburgh, Indiana, from December 8–12.

Here NEST and FRMAC collided. The NEST incident commander was aware there was to be a FRMAC, but knew little about it. FEMA was named as the Cognizant Federal Agency (CFA) and DOE was asked to coordinate public information. At this time, the FRERP provided only loose guidance for choosing the LFA for this situation because no agency owned the material, and the CFA and FEMA were supposed to coordinate the public information activities.

The NEST FRMAC management started drawing up operational plans, unaware of plans that already existed in the region. Problems that had been, or were being, worked out in the interagency planning surfaced again due to lack of familiarity with the past planning. Some of the more prominent issues were the identity of FRMAC's customers, control and dissemination of data, data quality, the need for liaisons, and the lack of involvement of the regional and state staff.



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With time, the players found ways to work together and began to form interagency functional groups. DOE was spending time and money publicizing the FRERP and telling states what kind of assistance they could expect from FRMAC. DOE had stressed the interagency aspects of the FRMAC and the supporting role of the federal agencies.

Again, an exercise had identified a situation where the FRERP could be more specific about the assignment of the LFA. It had also emphasized the need for DOE to define how its onsite response and offsite assistance (FRMAC) were going to work together.

The Second Federal Field Exercise (FFE-2)



Figure 5. Operational Planning at FFE-2

A second large field exercise of the FRERP took place in 1987. This exercise was scheduled to coincide with the required exercise at the Zion Nuclear Power Plant in Zion, Illinois. Zion was operated by Commonwealth Edison, and two states, Illinois and Wisconsin, lay within the planning zone. The Scenario Development, Control and Evaluation Work Group was composed of representatives from the participating organizations and chaired by the NRC. Zion was in the Chicago DOE radiological assistance region. The Chicago office was responsible for organizing the FRMAC and providing the OSTD.

FEMA provided access to an electronic mail system hosted at their headquarters. Other agencies only had to pay the telephone charges for time to transmit and receive messages. The electronic communication facilitated the development of the scenario and the process of getting input from the participants. Electronic mail was “innovative,” at that time, and many players were reluctant to try the technology.

An initial tabletop exercise was held on January 22, 1987, in Chicago, Illinois. The session opened with short briefings by the states, utility, and a federal representative. The drill progressed using a reactor scenario, while a moderator led a discussion of expected actions at each stage. After activation and deployment, the participants were reseated according to their event location. EG&G staff played the support and assessment roles in the FRMAC. Several of the areas that needed clarification or resolution after the exercise had some application to the FRMAC. These included:

- clarification of the role of FRMAC in dose assessment and the role of the CFA in coordinating federal PARs with offsite authorities;
- detailed procedures for disseminating data and assessments from FRMAC to emergency responders;



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- a better understanding of dose assessment models (assumptions and application); and
- the role, organization, and timing of a Recovery/Reentry Advisory Group.

The Chicago Operations Office had developed an organization chart for its FRMAC (Fig.6) as part of the regional Federal Radiological Monitoring and Assessment Plan (FRMAP). The plan included flow charts for data inside (Fig. 7) and outside (Fig. 8) the FRMAC.

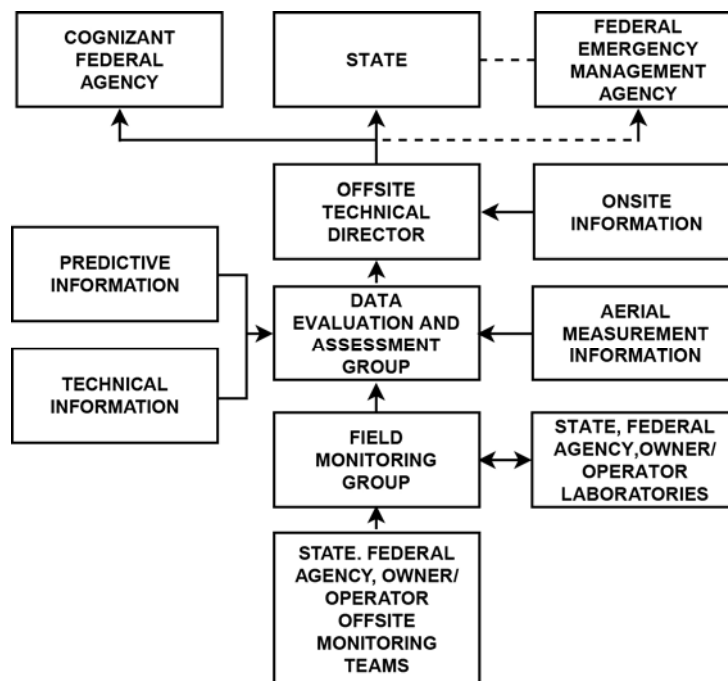


Figure 6. FRMAC organization for FFE-2. As shown in the Federal Radiological Monitoring and Assessment Plan, U.S. Department of Energy Radiological Assistance Plan, Region V, April 1987.



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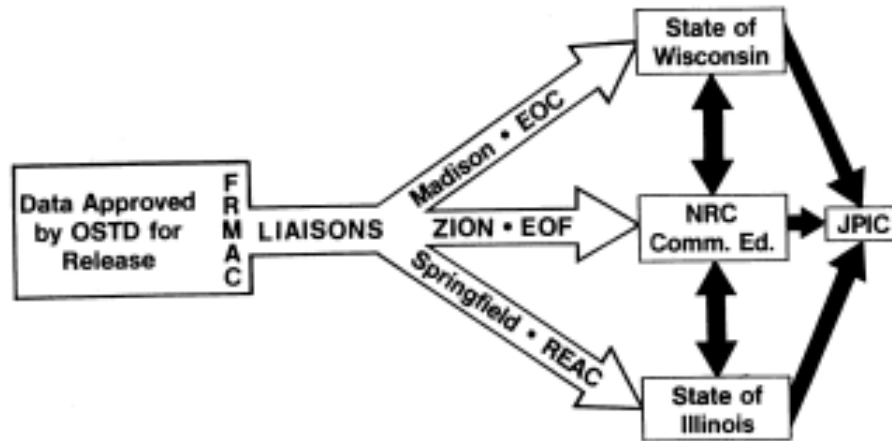


Figure 7. Data flow inside FRMAC for FFE-2. As shown in the Federal Radiological Monitoring and Assessment Plan, U.S. Department of Energy Radiological Assistance Plan, Region V, April 1987

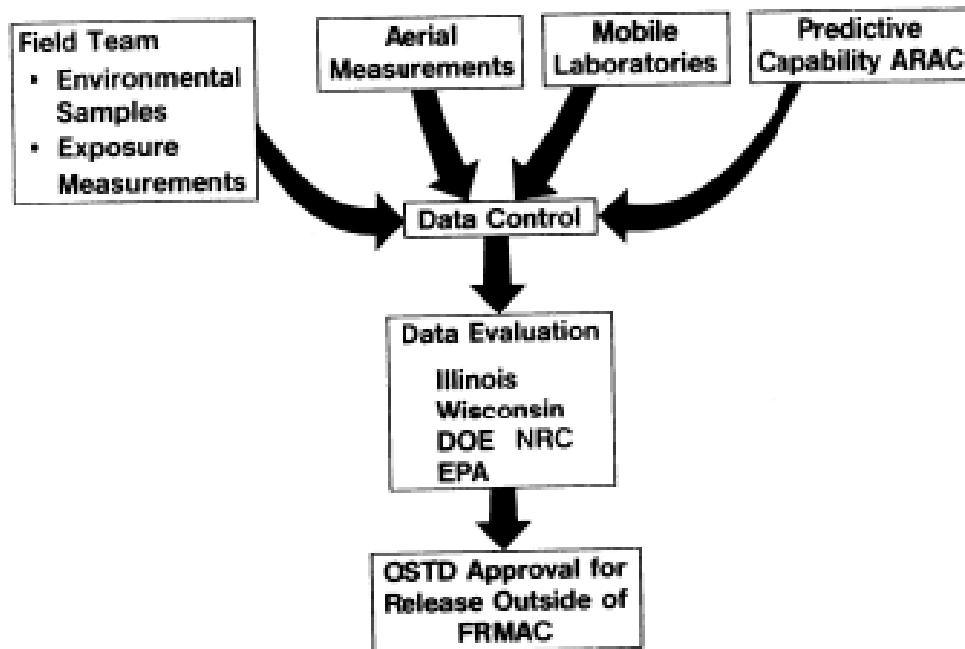


Figure 8. Data flow outside FRMAC for FFE-2. As shown in the Federal Radiological Monitoring and Assessment Plan, U.S. Department of Energy Radiological Assistance Plan, Region V, April 1987



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DOE had established general criteria for a FRMAC location and was resisting pressure from some states and utilities to preselect a location for their nuclear facilities. DOE felt that the site should be selected at the time of the accident so the facility location and size could be matched to the expected response. DOE also candidly admitted that, once an accident had occurred, they could obtain use of a facility at minimum cost. However, for the exercise, an exhibition building at the Lake County Fairground, Grays Lake, Illinois, about 15 miles from the plant was reserved and arrangements were made to install additional communications on a non-emergency basis. The building had adequate space, electrical power, and access could be controlled. FEMA's Federal Response Center was located in another building on the fairgrounds. These locations were used for both the "dry run" and the full exercise. During the full exercise, over 200 people from DOE, two states, and 12 federal agencies were in the FRMAC.

The dry run drill took place on May 5–6, 1987. No formal after-action report was developed, although a short report on player and controller activities was submitted by the planning group.

Some problems were indicative of areas of coordination that were still being ironed out:

- FRMAC did not operate as some groups expected and needed to manage priorities better
- Liaison officers and facilitators needed to be more familiar with the liaison role
- One state decided it might not locate its field teams and mobile laboratory at the FRMAC

NRC did not want FRMAC to provide data to the agency representatives *in the FRMAC* until data were approved by NRC at the utility's Emergency Operating Facility.³⁸

Most importantly, the dry run identified some problems with the radiological data to be provided to field monitors and laboratories that would have created major problems in the field exercise. The measurements available to field monitors and the format in which they had to be prepared were very specific to meet state requirements. Data had to be prepared for more than 80 pre-designated sampling points for multiple instruments, monitoring procedures, times, and isotopes. Additional information was needed for controllers so they could provide data at other locations.³⁹

The FFE-2 took place June 23-25, 1987. The first day of the exercise was the utility's regulatory exercise. Federal agencies were notified and hypothetically deployed to the site. FRMAC activity began on the second day. The third exercise day represented the tenth day after the accident.

Operationally, there were problems in starting the FRMAC in place on the second day. The data groups were overwhelmed by data "collected during the night" and had no chance to process it before making decisions about monitoring activities that day. DOE used an electronic Digital Imaging Technology System (DITS) to store and share data. This system required that special equipment be set up in the state centers and EOF to receive the information, but other transmission systems had to be developed and used at other locations.



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Recommendations for the FRMAC included the following:

- Develop a mechanism for release of qualified raw and assessed data for use by CFA, states, and agencies with statutory responsibilities while controlling public release of data.
- Improve FRMAC management procedures and define roles of federal responders.
- Establish an interagency working group under DOE to consider standardizing reporting units, nomenclature, sampling methods, and analytic procedures.
- Examine differences in sample collection and analysis between states and federal agencies.
- Continue to educate federal, state, and utility personnel on the role and capabilities of FRMAC.
- Develop a transmission system suitable for transmitting assessed FRMAC graphical data to appropriate agencies.⁴⁰

DOE participants concluded that the FRERP had worked, federal agencies could support two states at once, and the cooperation and coordination at the FRMAC had been excellent. Comments from state representatives indicated they were happy with the federal response interface and were especially pleased that they were integrated into FRMAC activities and their input was considered in planning activities and assigning priorities.

Other areas for improvement were also defined:

- The role of a reentry/recovery group was unclear and not institutionalized.
- Potential responders needed training not only on their own roles, but also on the capabilities, responsibilities, and information needs of other agencies.
- The administrative process for approving raw and assessed data for release needed streamlining.

The FRMAC organization, as detailed in the regional FRMAP, worked well. The use of a management subgroup with other agency representatives established a cooperative working arrangement; however, the FRMAC suffered from a shortage of trained management personnel. The OSTD filled both his role and that of his deputy.⁴¹

Service Response Force Exercise Series

The SRFX was a series of annual exercises of the Army's Service Response Force. Many had a nuclear weapon scenario and DOE/ARG was an active participant. The first SRFX-86 took place July 14–17, 1986, prior to FFE-2. The command post exercise had the physical play at the Savanna Army Depot Activity in Savanna, Illinois, although the scenario placed the accident at Seneca Army Depot in New York.

The implementation of the FRERP was accomplished with a representative from the state of New York, a FEMA representative, and a representative from Brookhaven, playing the FRMAC. The FRMAC had a minor role, and the DOE ARG contingent was in charge of DOE activities.⁴²



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The exercise report concluded that there should be a closer working relationship between the Joint Radiological Control Center and the FRMAC and that the FRERP should be “promulgated” to Army agencies. DOE’s introduction of the FRMAP took most of the controllers and players by surprise, as they were not aware of the plan or the responsibilities of the DOE-Brookhaven Office in the region. Personnel realized the need for communication between those coordinating on-site and off-site activities. The report recommended incorporating some elements of the FRMAC into the JRCC.⁴³

Busy Force

The Strategic Air Command held an exercise August 13–17, 1987 that involved DOE. Busy Force was a nuclear weapons accident. The scenario involved a mid-air collision of two planes, one of which was carrying four weapons, over the Smoky Hill Kansas Air National Guard Range near Selina, Kansas. There were numerous injuries and deaths, and the local hospital used its mass casualty plan. Thus state and local personnel were involved in portions of the exercise. The principal responders were DoD (Air Force), DOE, and FEMA, who brought along some EPA staff as advisors.

The response operated under the DoD-DOE Nuclear Accident Response Plan (NARP), without a FRMAC as described in the FRERP. State and local radiological personnel were active in the JRCC. The EG&G survey data collection and assessment system was tested as an ARG asset, although it would be used in a FRMAC. DOE personnel eventually moved to help fill leadership gaps in the JRCC. There was some hope that NEST plans, the NARP, and FRERP could be made more consistent.

Compass Rose



Figure 9. FRMAC at Compass Rose 1988, Camp Pendleton, California

The welcome letter to participants, described Compass Rose-88 as the most ambitious nuclear terrorism exercise DOE had sponsored. This large, multiagency exercise was staged on the Camp Pendleton Marine Base in California, May 1–5, 1988. The scenario started one evening, with DOE’s Safe/Secure Transport (SST) vehicles driving a circular route, practicing traffic stops and other interruptions. The convoy was attacked the next morning, and nuclear weapons were taken by the terrorists.

The scenario was difficult to follow, and the control communications were not up to the task. When the convoy defeated the terrorists, several terrorists were resurrected so the law enforcement people could catch them. After the nuclear weapons were recovered and disarmed, one was “exploded” to provide consequence management play. The exercise scenario notationally contaminated the town of Fallbrook, outside the base.



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Consequence management play was better integrated into the scenario for this exercise, although the effort needed to create useful play was not well understood by the senior exercise planners. A FRMAC was established by the San Francisco Operations Office. The planning for Compass Rose was already in progress when the FRMAC responsibility was transitioned to the Nevada Operations Office, so the previous arrangement was used. Much of the security portion of the exercise was “free-play,” but a number of exercise messages had been prepared to stimulate FRMAC play. The exercise control structure made it difficult to coordinate and maximize the consequence play, and the exercise director and senior planners focused on the attack and pursuit portions of the scenario, not realizing that FRMAC activity depends on knowledge about what is happening elsewhere.

The questions about protective action and reentry recommendations arose again. DOE, as the CFA, was responsible for making the federal recommendations to the state. DOE, in its dual role, exercised this responsibility from the FRMAC, without involving FEMA in the discussion. Process became very important, as the state allowed the population to return quickly, but realized during recovery planning that they had essentially accepted higher contamination standards than their own guidelines. Questions arose about the DOE Team Leader’s role, how other groups were involved in decision making, and how the decisions were documented. This situation emphasized the need for DOE as Cognizant Federal Agency to be particularly careful not to overwhelm the state players with technical competence and particularly ensure multiple agency input into these decisions in which DOE may also have a financial interest.

Cosmos 1900

On May 13, 1988, the Soviet Union announced that it had lost radio control of Cosmos 1900, a nuclear-powered satellite. A team, coordinated by the Nevada Operations Office, was directed in August to develop a plan for prompt deployment if the satellite came down in U.S. territory. Their organization chart called for a FRMAC Director to be a designated regional representative when the team moved to the impact zone.

At the national level, the FRS developed “Procedures in Support of the Federal Radiological Emergency Response Plan (FRERP) for Reentry of Cosmos 1900”⁴⁴ in early July. It elaborated on the FRERP assignments, including “pre-reentry, up to 24-hours before reentry,” the pre-accident time period was not covered by the plan. DOD was to monitor the satellite and provide reports, while most agencies were to notify agency personnel who might be activated. An interagency Food and Health Affects Group would be formed to determine uniform contamination guidelines.

The second time phase in the national procedures was the last 24-hours before reentry. FEMA was asked to coordinate the federal response. DOD would continue to monitor and provide information on the satellite. FEMA would establish a Joint Information Center in Washington, D.C. DOE was to identify federal monitoring resources that would be available.

The post-impact response phase was the focus of the FRERP. If the satellite did not impact U.S. territory, FEMA would notify everyone with DOD’s information about time and place of impact. If material impacted U.S. territory, DOE as coordinator of federal monitoring and assessment, would map the location and



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coordinate recovery of radioactive pieces of the satellite. DOE was to have the core of a FRMAC in Las Vegas prior to reentry. After impact, DOE would decide if the FRMAC should be relocated to the field. DOE then had the usual FRMAC duties, although the Washington-based Food and Health Effects Group would review and coordinate any protective action recommendations. EPA would assume the FRMAC coordination after the initial emergency period. DOE had prepared deployment and radiation safety guidelines in preparation for deployment.

On September 30, Cosmos 1900 had used all its altitude control propellant. A safety system accelerated the reactor to a higher storage orbit. The rest of the satellite reentered over the Indian Ocean the next day.⁴⁵

Post-FFE-2 Changes

A Change in FRMAC Coordination

After the FFE-2, DOE reconsidered its assignment of FRMAC responsibilities. There were not enough regional DOE personnel with appropriate background and training to serve as senior FRMAC managers. Duplicating the FRMAC planning and training in each region was inefficient, and there could be differences in the regional plans that the other responders would have to consider.

In 1987, DOE assigned the responsibility for the FRMAC Program to the DOE Nevada Operations Office. The Nevada office had the physical resources used in setting up a FRMAC. It was hoped that giving the FRMAC a programmatic home in one location would provide an instrument for its inclusion in the DOE budget.

The Nevada FRMAC Era Begins

The DOE Nevada Operations Office was established as the programmatic home of FRMAC in 1987. It had the physical resources required to set up a FRMAC and manage the emergency phase. EPA partnered with DOE to manage the late phase of the response.



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FRMAC and NASA

Since the late 1980s, FRMAC has supported the National Aeronautics and Space Administration (NASA) with its deep space launches that have carried radiological devices as part of their payloads.

Galileo

The first NASA mission for which NASA had requested FRMAC's support was Galileo. Galileo was launched into space from the Kennedy Space Center (KSC) on October 18, 1989, aboard the space shuttle Atlantis. Its mission involved a scheduled eight-year, deep-space voyage to the solar system's largest planet, Jupiter, and its four major moons (Figure 10). The spacecraft was to orbit around Jupiter and conduct detailed investigations of this system. The Galileo mission was built around two distinct pieces of spacecraft—an orbiter and a separate atmospheric probe. The Galileo mission involved many challenges, not least of which was meeting the craft's instrument, communications, and other power requirements. Because the journey was far from the sun, solar panels could not supply the necessary electricity to operate the instruments and keep them warm. Without a reliable source of power, the mission's very reason for existing—to provide valuable new information about our solar system—would be jeopardized. The Galileo's mission developers chose to use two radioisotope thermoelectric generators (RTGs) for electric power production and radioisotope heater units (RHU) to provide heat strategic locations within the spacecraft. The compact, light, and long-lasting RTG and RHU units were the only effective power and heat sources for the Galileo mission. Each of the two RTGs contained about 11 kilograms (kg) or 134,000 curies (Ci) of plutonium-238 as the heat source for the conversion of heat energy to electrical energy and each RHU contained an additional 30 Ci of Pu-238.



Figure 10. NASA Galileo Launch 1989

Extensive testing of the RTGs and RHU components had shown that even if an accident occurred, the likelihood of a source release would be small. Any risk was of concern to NASA, the DOE, and the state of Florida. As a result, a comprehensive contingency plan was jointly developed to ensure that any accident, whether it involved a radiological release or not, would be met with a well-developed and tested response.

In addition, in the event of a major radiological accident, the FRERP provided for a FRMAC to be established by the DOE for the purpose of coordinating and managing all of the federal off-site monitoring and assessment activities.



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Ulysses

On October 6, 1990, the Ulysses spacecraft was launched from the KSC on the space shuttle Discovery to begin a five-year mission to observe the polar regions of the sun from out of the elliptic plane in which the earth orbits the sun. By studying the sun from this perspective, scientists hoped to better understand the sun's processes and its effects on the earth.

Because the Ulysses space probe was planned to travel far distances from the sun, a single RTG was used to power the spacecraft. The Ulysses RTG, like those used in Galileo, contained about 137,000 curies of plutonium-238 as the heat source for the conversion of heat energy to electrical energy. Similarly, a comprehensive contingency plan was jointly developed by NASA, DOE, EPA, the state of Florida, and Brevard County to ensure that any accident, whether it involved a radiological release or not, would be met with a well-developed and tested response. In the Ulysses response plan, the state of Florida chose to operate from the FRMAC for their monitoring and assessment activities.

The lessons learned from this event stated that the coordination between federal agencies, particularly DOE and EPA, had vastly improved since the Galileo launch, and that the level of preparedness and pre-deployment for Ulysses was more appropriate than the large-scale effort deployed for Galileo. However, it was also stated that advanced planning was needed for the response of standby teams and that minimum response times and deployment methods needed to be identified. In the future, a contingency plan/procedure should be developed for the deployment of resources to support FRMAC operations in the event of an emergency.

A report⁴⁶ documented the results of the exercise, which met its overall objectives. The initial interactions with the states did not go well; this was complicated by technical problems in the data system. The FRMAC needed to communicate better with the states and follow-up to make sure the state was satisfied with the support. The Manager for Liaison position became a bottleneck for addressing state and local priorities. After a session at the end of the second exercise day (the first day of FRMAC play), the participants gradually worked out many of the difficulties, and interaction and data flow improved. The following lessons learned helped make important changes in FRMAC operation:

- FRMAC and agency representatives must make early contact with the state counterparts to establish a good working relationship.
- The initial monitoring and sampling plan should be developed at the advance party meeting with the state, to get the state decision makers involved.
- FRMAC group managers need knowledgeable deputies to continue work when the managers, state, and LFA representatives attend FRMAC management meetings.
- Early field and laboratory data should be distributed within FRMAC after only cursory checks, as this may be the only information on which the state can base protective action decisions.
- Field sampling plans and protective actions should be based on all predictive models, not just one.



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- FRMAC personnel need more than an occasional large exercise to become familiar with the equipment and procedures.
- FRMAC should provide periodic “all-hands” briefings to ensure everyone gets important safety and status information.
- FRMAC relied too heavily on computer technology and needs ways to manually assess critical data immediately.
- The request tracking system and data flow must be streamlined to avoid bottlenecks. Priority data must be identified and distributed without delay.
- The FRMAC should be laid out as planned. Laboratories must not be too close to sample processing and storage areas, which could elevate the background readings.
- The PAST in the FRMAC was useful to the LFA and the states. Federal guidelines for protective actions could be interpreted based on incoming monitoring results.
- FEMA needs the data from the FRMAC for its risk assessments used to recommend a Presidential Emergency Declaration and may need an expanded role in FRMAC.
- The DOE and EPA draft transfer procedures were successful and should be formalized.

Because of these lessons learned from the exercise, the following changes were made to the FRMAC organization.

- The key state and LFA representatives were co-located with the FRMAC Director to ensure that the decision-making process meets their needs. The Manager of Technical Liaison position was eliminated, so that no one was between the states and the FRMAC Director.
- The FRMAC organization chart in the plan identified the areas of the FRMAC where state representation is required or desired.
- The FRMAC Coordinator became the Assistant Deputy for Operations with the role of providing assistance to the states and LFA in the FRMAC Operations center.
- FRMAC “Chief of Staff” position was renamed “Deputy FRMAC Director” to better describe the second-in-command role of this position.
- A deputy, familiar with FRMAC operations, was assigned to each FRMAC manager and state representatives, when available, in an advisory capacity.
- Special staff positions were reduced. For example, the Meteorological Operations position was reassigned to Atmospheric Predictions under the Evaluation and Assessment group.
- Medical was moved to Health and Safety to better serve the FRMAC’s workers.



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Cassini



Figure 11. NASA Cassini Launch, 1997

At 4:43 a.m. on Wednesday, October 15, 1997, the Cassini spacecraft, mounted atop a powerful Titan IV rocket, was launched from the Cape Canaveral Air Station to begin its journey to Saturn (Figure 11).

The Cassini mission was a joint undertaking by NASA, the European Space Agency, and the Italian Space Agency to perform a four-year study of Saturn and its rings. In addition, it was to deliver a remotely operated probe to Titan, Saturn's largest moon. Titan has an atmosphere believed to contain chemicals similar to those which existed on Earth before life began, making it one of the most intriguing objects in the solar system.

Sunlight at the orbit of Saturn was insufficient to provide enough energy to power the spacecraft using solar cells, thus three RTGs were deployed to provide electrical power for the spacecraft from the heat generated for radioactive decay of plutonium-238 used in the RTGs. The total amount of Pu-238 contained in the three RTGs was about 72 pounds with an activity of about 400,000 curies.

Because there existed a small but finite possibility of an accident, NASA and the state of Florida requested that DOE prepare and be ready to provide offsite surveillance and monitoring support in the event an accident occurred. This support included the participation of the EPA.

The Advance Launch Support Group (ALSG) was the DOE's designation for the support element for the offsite area surrounding the KSC complex. It was housed in the Cocoa National Guard Armory and consisted of the monitoring division, assessment division, health and safety, medical, Geographic Information System, database, radioanalytical laboratory, scientific advisor, and DOE management staff., all from the assets that would comprise a FRMAC. The purpose of the ALSG was to provide radiological monitoring and assessment support in the event of an accident. EPA personnel from Las Vegas and Montgomery staffed the monitoring division and provided one member as the on-scene Senior EPA official.

Pluto New Horizons Launch

NASA launched *New Horizons* on January 19, 2006, on an Atlas V 551 rocket at 1400 EST (Figure 12). The launch, originally scheduled for January 11, 2006, was delayed due to technical concerns. NNSA provided the on-duty CMRT Phase I team from RSL that became part of the off-site Advance Launch Support Group (ALSG), and Aerial Thermal Imaging Team, and additional support personnel, along with a full CMRT Phase II equipment load. Some of the CMRT Phase I personnel were assigned to the on-site support area located in the Radiological Command Center (RADCC). RSL also provided communications support to provide



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connectivity to the following locations: RADCC, Armory (ALSG), Brevard County EOC, and the Public Affairs Radiological Response Team (PARRT).



Figure 12. Pluto New Horizons Launch

Mars Science Laboratory Launch Support

NASA's Mars Science Laboratory (MSL) is the most ambitious effort yet to discern exactly what is on the surface of the Red Planet. The spacecraft launched on November 26, 20011, from Cape Canaveral, Florida, atop an Atlas V rocket at 1002 (EST) carrying a large, mobile laboratory, the rover *Curiosity*. *Curiosity* is equipped with precision landing technology that makes many of Mars' most intriguing regions viable destinations for the first time. It is expected that the spacecraft will not reach Mars until early August 2012. Because of its ambitious mission, the *Curiosity* rover required a more powerful energy source than solar arrays, the technology used on the previous rovers. To meet this requirement, NASA asked the DOE to build a nuclear-powered electrical system called a multi-mission radioisotope thermoelectric generator, or MMRTG. It has no moving parts, but converts heat from a small core of plutonium into about 110 watts of electricity around-the-clock all year for the duration of the mission. It has no moving parts but converts heat from a small core of plutonium into about 110 watts of electricity around-the-clock all year for the duration of the mission. The radioactive material used in the MMRTG is plutonium-238 (^{238}Pu). The material is an alpha emitter, and the exposure pathway of concern was inhalation. When inhaled, ^{238}Pu is deposited primarily in



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the lungs, red blood marrow, bone surface, and liver. Exposure may also occur from ingestion of foodstuffs or water contaminated with ^{238}Pu or from inhalation of particles made airborne from resuspension.

When the rover, *Curiosity*, sets down on Mars, it will be carrying the most advanced payload of scientific gear ever used on Mars' surface. MSL's objective is to search areas of Mars for past or present conditions favorable for life and conditions capable of preserving a record of life. (Figure 13)

The NASA KSC concept of operations for the launch incorporated the idea of pre-staging environmental continuous air monitors (ECAMs) and activating the NNSA Consequence Management Home Team (CMHT), with the NNSA Consequence Management Response Team (CMRT) ready to respond. Given the remote monitoring capability of the ECAM, in 2008 NASA expanded the use of ECAM technology to satisfy their radiological contingency requirements and improve the quality of the immediate response to a launch area accident. In preparation for the MSL launch, NASA/KSC procured and upgraded 30 ECAMs that included satellite-link telemetry.

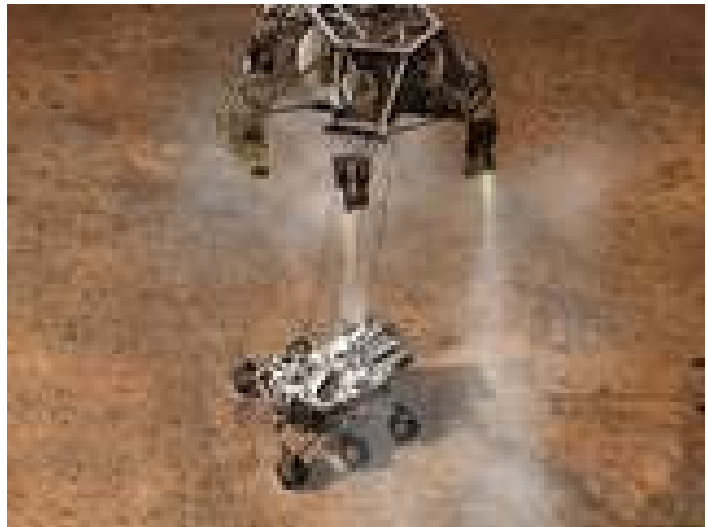


Figure 13. Artist's concept of t Curiosity Touching Down on Mars. (NASA)

For this launch, eFRMAC, the CMRT data acquisition system, was linked with NASA's entire network of ECAMs so that CM assessors on site and with the CMHT could monitor the measurements in real time. Once linked, real time measurements were successfully posted in the Radiological Assessment and Monitoring System (RAMS), eFRMAC's database. This was the first time that tools from the eFRMAC suite were used as one of the response tools for such a mission. In addition, it was the first time that a network of 20 multipath communications devices (MPCDs) designed by RSL, was used to simultaneously transmit monitoring data to the eFRMAC system. A more detailed technical discussion of the capabilities of these technologies may be found in the section titled, *21st Century Technological Advances*.

Other DOE agencies also participated in launch support:

DOE/RAP Region 3: Provided qualified personnel (Radiological Control Technicians) and equipment to support radiological monitoring and related requirements for prelaunch, launch, and post-launch activities.

DOE/REAC/TS: REAC/TS: Provided medical radiological emergency training to the office local hospitals and to medical personnel at KSC. DOE REAC/TS also supported the Radiological Control Center (RADCC) and the monitoring base of operations at the Health Physics Building.

DOE/NARAC: NARAC provided required personnel, equipment, and communications integration for site-specific dispersion and radiological dose projections to include real-time dose

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projection at predetermined time intervals prior to and through launch, to include any post launch accident, as required.

In addition, other FRMAC interagency organization groups provided launch support:

Environmental Protection Agency (EPA) : The EPA provided advice to NASA, the 45th Space Wing, DOE, and state and local health agencies concerning matters of public health in accordance with responsibilities described by the National Response Framework (NRF). They also provided a liaison representative to the Coordinating Agency Management Group (CMG) to maintain communications between EPA support groups and its various offices and provided a Public Affairs representative for the JIC. One role of the EPA is to assume the lead for long-term recovery efforts in the event of an accident causing off-site contamination.

National Oceanographic and Atmospheric Administration (NOAA) : NOAA provided release trajectories using long-range National Weather Service forecast models and consultation on meteorological issues related to atmospheric conditions at Cape Canaveral and along the launch trajectory. In the event of an accident, they would have provided meteorological conditions at potential debris locations from out-of-orbit accidents.



The 1990s

A Decade of Plans and Procedures

During the early 1990s, many of the plans that were developed during the 1980s were formalized or revised. The Stafford Act was amended in 1994; a revised FRERP was published in 1996; EPA published their PAG manual in 1992, and several DOE Orders relating to FRMAC and Emergency Response were issued.

FEMA and the Stafford Act

In 1988, FEMA's disaster response role was solidified by the passage of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. This Act amended the Disaster Relief Act of 1974, PL 93-288, and provided the statutory authority for most federal disaster response activities especially as they pertain to FEMA and FEMA programs.⁴⁷

A Federal Coordinating Officer (FCO) would be appointed to coordinate federal assistance to the state. If the President signs a disaster declaration, federal agencies might be eligible for compensation for some of their response actions. The FRERP had clearly stated that each agency was responsible for its response costs under that plan. Some adjustments would need to be made.

FRMAC Operations Plan

The DOE Nevada Office had published a FRMAC Operations Plan, dated March 1990. The OSTD was now called the FRMAC Director, and DOE's radiological response responsibilities were extracted from the FRERP. The plan listed what the states and CFA might expect from a FRMAC. FRMAC would coordinate offsite federal monitoring and provide the states and CFA the following information in a timely manner:

- Earliest indication of a significant release of radionuclides
- Verification of plume and transport model predictions
- Assistance to state decision-making officials
- Retrievable quality documentation of environmental contamination
- Results of data collection, analysis and evaluation
- As the data are analyzed and provided with subsequent measurements, the FRMAC would provide the states and CFA with the following information:
 - Air concentration in time and space, elevated and near ground, as appropriate
 - Ground concentrations in time and space
 - Concentrations in environmental media in time and space
 - Assurance of quality of data
 - Dose predictions in time and space



The Evolution of FRMAC

DOE's FRMAC organization (Fig. 14) was similar to earlier ones, but the laboratory operations had been put under a Manager for Monitoring and Analysis and a Manager for Radiation Protection created to deal with contamination control and the safety of the FRMAC members. The EPA Senior Official was in a liaison position to the FRMAC Director, so he or she would be well informed when it was time for EPA to assume the leadership role.⁴⁸

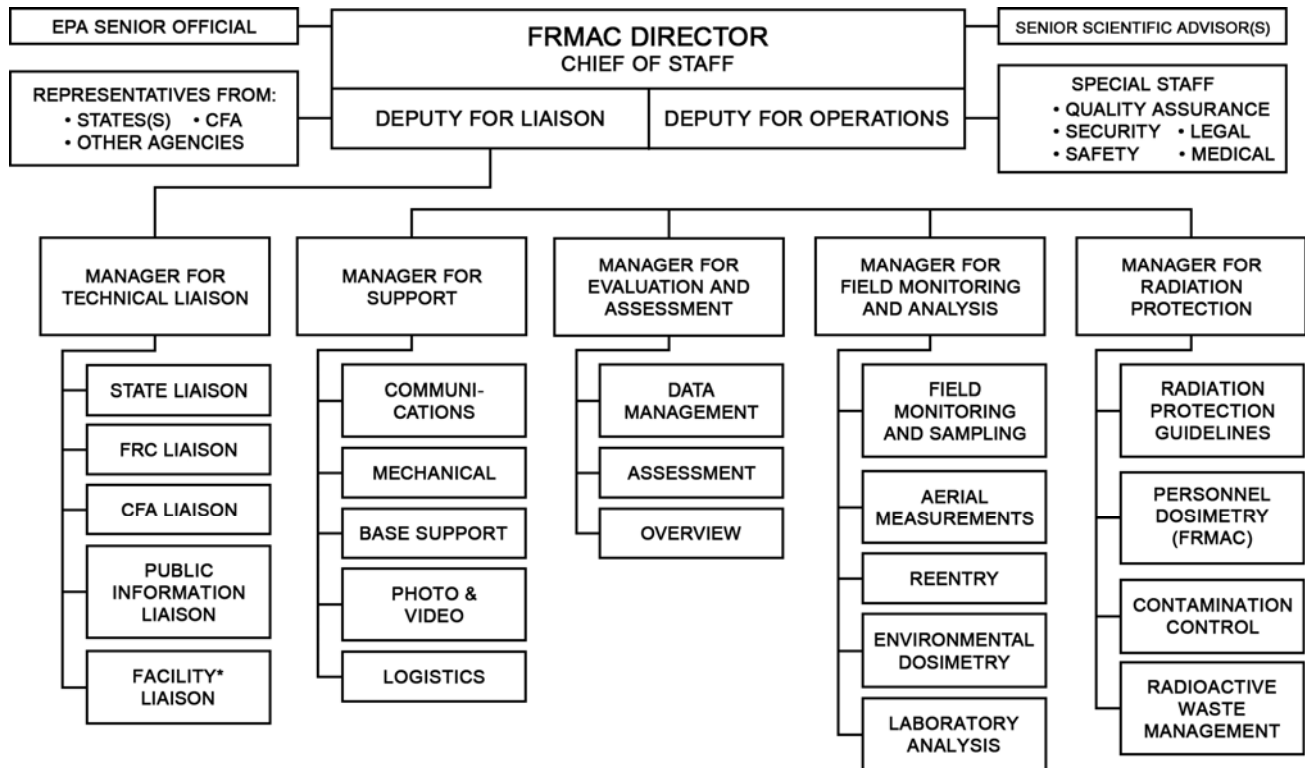


Figure 14. FRMAC Organization Nevada Operations Office (c. 1990)

The flow of information was also charted (Fig. 15). FEMA was still expected to get radiological information from the Cognizant Federal Agency. Information from the offsite authority was to come to the FRMAC Director, which mirrored the DOE responsibilities when DOE was the CFA or had a primary onsite role.

The Federal Response Plan

In 1992, the Federal Response Plan⁴⁹ was published. This plan was a direct result of the Stafford Act and was developed to help states deal with significant disasters. The Plan outlined how federal agencies would provide response assistance to supplement state and local response efforts.



The Evolution of FRMAC

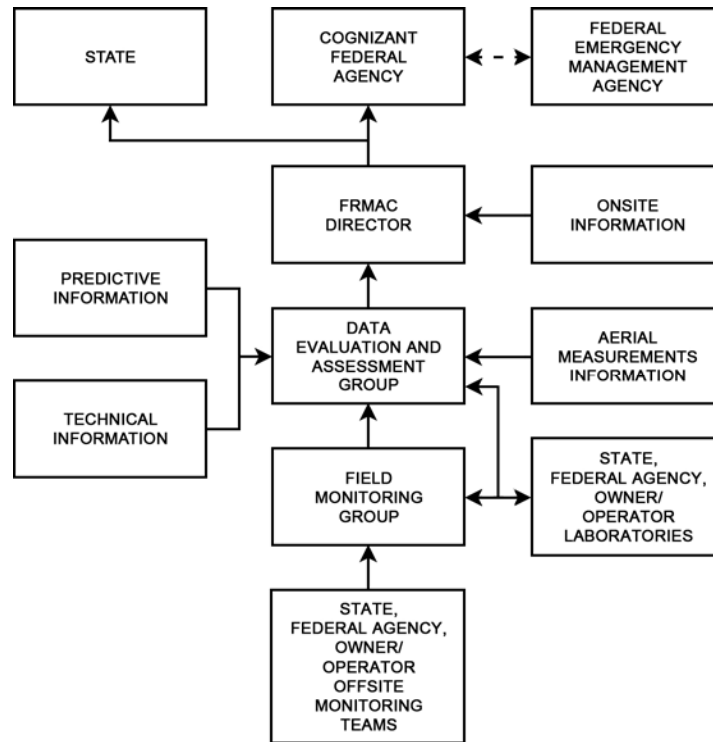


Figure 15. .FRMAC Information Flow Chart from 1990 Plan. Source: Emergency Management Plan, FRMAC Operations Plan, Nevada Operations Office, U.S. Department of Energy, March 1990.

The plan gave the lead responsibility to FEMA. The plan was constructed with a number of annexes—functional annexes and twelve annexes describing Emergency Support Functions: (1) Transportation, (2) Communications, (3) Public Works and Engineering, (4) Firefighting, (6) Mass Care, (7) Resource Support, (8) Health and Medical Services, (9) Urban Search and Rescue, (10) Hazardous Materials, (11) Food, and (12) Energy. The plan focused on the non-radiological response. DOE’s radiological response was a small part of the hazardous materials section.

FRMAC and the Department of Defense

SRFX-90

The FRMAC had big objectives for the June 11–15, 1990, SRFX. This exercise had a nuclear weapon scenario and was conducted at the Seneca Army Depot in New York and extended into site restoration planning. There were seven specific FRMAC objectives:

- Develop and exercise the communications and interfacing of FRMAC management with a Joint Hazard Evaluation Center (JHEC), the DOE Team Leader, and the DoD On-Scene Commander (OSC)
- Exercise notification and activation of a FRMAC
- Exercise FRMAC interfacing with JHEC on a technical basis



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- Exercise the AMS/RAP/DoD/ARG/FRMAC interfaces
- Exercise the transition of FRMAC management from DOE to EPA
- Exercise the FRMAC interfacing with site restoration activities
- Train new FRMAC management team members

The FRMAC played only the management and liaison roles, not internal activities, but appeared fully operational to the Army. Interfaces between agencies and between radiological monitoring groups were tested.

Play continued through the development of a Return and Reentry Plan and negotiation of a FRMAC transfer agreement between DOE and EPA. The conditions specified included the following:

- The source of the accident is stable with no further significant releases of radiation expected.
- The radiological conditions in the off-site area have been defined.
- All major public health protective actions have been completed. No further large-scale public health actions are anticipated.
- DOE and all other involved federal agencies agree to continue to support FRMAC efforts.
- DOE has directed all participating agencies of the FRMAC to prepare a comprehensive summary document of their activities to the date of this transfer of function.
- All the participating agencies were asked to sign, agreeing to commit the required resources, personnel, and funds for the duration of the federal response in the exercise.

Distinct Action

This DoD command post exercise was conducted August 7–10, 1989, at Plattsburg Air Force Base in Plattsburgh, New York. In the exercise scenario, a plane carrying four weapons crashed and burned near Lake Champlain. The high explosives in one weapon detonated, one weapon was damaged, and two fell into Lake Champlain. The crew was killed. Fire fighters and civilians were killed or injured and contaminated. The civilians included both U.S. and Canadian citizens.

One of DoD's goals for the exercise was to test the concept of a JHEC and the draft Nuclear Weapon Accident Response Procedures Manual (NARP), which was to align the DoD response with the FRERP. DOE recognized that the coordination of the FRMAC and the DoD and DOE weapons response teams needed to be improved, especially with the Galileo shuttle mission with its plutonium-238 RTGs and heating units on the horizon. DOE-NV had prepared a new FRMAC organization plan (based somewhat on the NEST response structure).

During this exercise, the DOE FRMAC management began to think of FRMAC as an independent, interagency response, and fought efforts to bury the FRMAC in the JHEC. The FRMAC was identified as a “federal organization.” The DOE maintained the role of the LFA through the emergency phase as opposed to being a DOE organization.⁵⁰



Diamond Flame-92 (SRFX-92)

Diamond Flame combined a national-level exercise with the 1992 Service Response Force Exercise. It was considered an “advanced” field exercise. The exercise took place June 15–19, 1992, at Sierra Army Depot, Herlong, California. The scenario involved a nuclear weapon in Army custody. A FRMAC was established, and the ARG was a key participant.

The Army wanted to ensure that liaisons were established with the supporting federal, state, and local agencies. Figure 16 shows the Army’s concept of the agency interactions during the exercise.

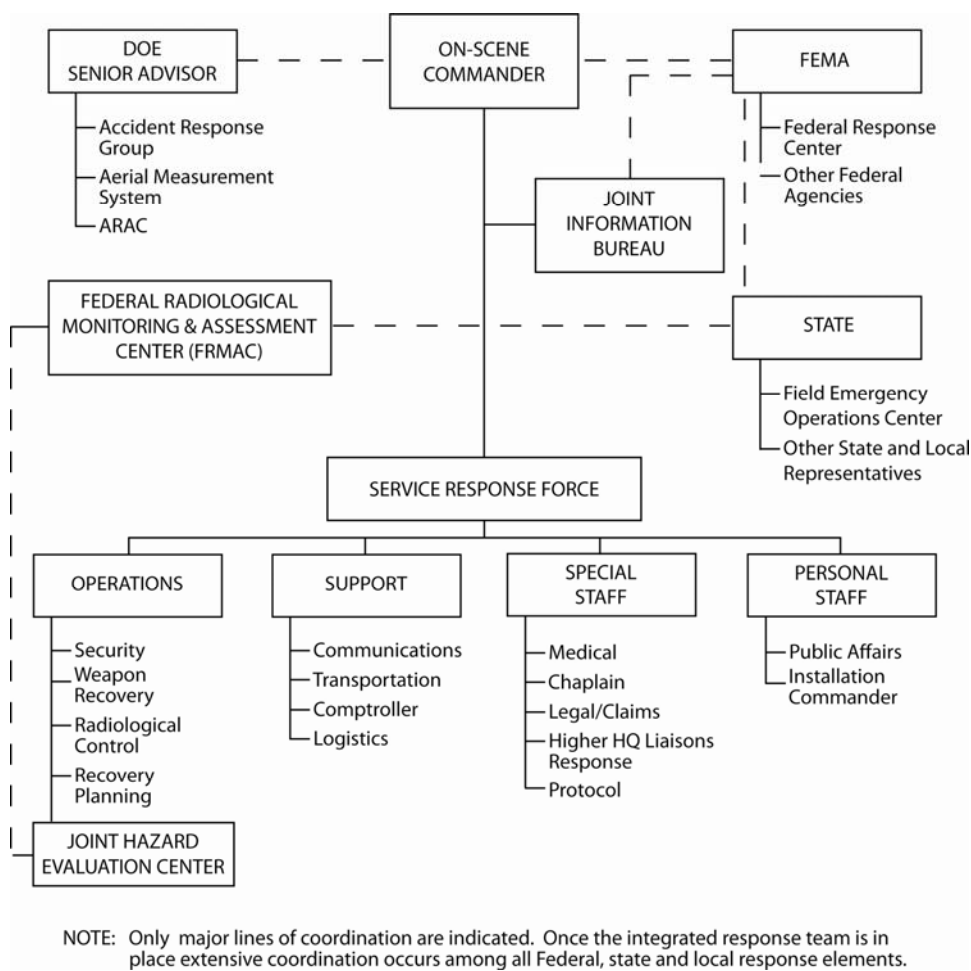


Figure 16. Response Structure from Diamond Flame. Source: Exercise Diamond Flame 92 Procedural Flow Synopsis (Draft), U.S. Army, Sept. 5, 1991.

Plutonium Valley-92

The FRMAC was relatively small, but the Plutonium Valley Training Drill at the Nevada Test Site (NTS) conducted from November 2-6, 1992, gave the participants a chance to practice their monitoring and



The Evolution of FRMAC

assessment activities in a contaminated environment. The DOE ARG and their DOD counterparts in a JHEC participated in the “onsite” monitoring, while the FRMAC was doing offsite monitoring. Command and control were held to a minimum.

Area 11 of the NTS has two areas contaminated with plutonium-239 from previous activities. Using Area 11 gave the participants a chance to measure real radioactive material, work in protective clothing, demonstrate contamination control, and practice as a group. In contrast to the usual radiological simulations, the monitors went to marked stakes to take real radiation readings and were given hypothetical locations for each team to report. The FRMAC collected, accessed, and archived the data from the offsite monitoring. As the plan for the drill stated, “This [would] allow the FRMAC to develop a deposition contour using real measurement in a fictitious land.”⁵¹

Post-Emergency Tabletop Exercise⁵²

The FRS planned a large tabletop exercise of the FRERP in conjunction with the River Bend Nuclear Station at Baton Rouge, LA, in 1990. This exercise was held on two non-consecutive days, August 28 and September 18, to look at the post-emergency roles, responsibilities, and resources of the utility, state, local, federal, and insurance organization in response to a hypothetical accident.

On August 28, the participants explained their roles and resources. This was followed in the afternoon by an examination of events in the plume phase. The September session focused on five areas:

- a) Ingestion pathway response;
- b) Reentry, relocation, and return;
- c) Decontamination and recovery;
- d) Indemnification of financial losses; and
- e) Deactivation of the emergency response.

One concern was that few standards existed for the post-emergency period. The NRC as Lead Federal Agency (LFA) [by this time the “CFA” had been re-titled as the Lead Federal Agency] needed to clarify how federal recommendations would be developed and communicated. Sampling and laboratory methodologies needed standardization. While Area B was the state’s responsibility, the FRMAC had to provide timely and accurate information. There were no cleanup standards for the situation. Funding processes needed clarification, and no responders had criteria for deactivating a response.

Some of the lessons learned that applied to FRMAC were the following:

- State and local governments would exhaust their radiological monitoring resources quickly, so they should identify what they expect to need and inform the federal agencies.
- State decision makers need to work with federal counterparts to ensure response decisions are based on mutually agreeable and sound technical data.



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- The state would initially decide who directs and coordinates field sampling, but they are encouraged to coordinate with the FRMAC.
- State and federal organizations need to standardize the methodology for radiological sampling and analysis.
- FRMAC would establish technical basis for recovery, using both measured data and projections. The state would lead recovery planning.
- The NRC-coordinated federal protective action recommendations for the ingestion pathway are heavily dependent on analysis by EPA, USDA, DOE, and other organizations.
- The states, working with federal technical representatives, would determine acceptable contamination levels.
- The meaning of “damage assessment” after a radiological emergency needs to be developed along with guidelines for performing assessment.
- Any decision by the federal agencies to deactivate need to be made with the LFA in consultation with state and local governments and other federal agencies.

Following the exercise, the NRC and FEMA developed a guide, [*Post-Emergency Response Resources Guide*⁵³] to assist the state and local government in identifying required resources. EPA developed short-term protective action guides (PAGs) for reactor accidents in 1980 after the Three Mile Island Accident. The original PAGs have since been broadened for other accidents and extended into the relocation phases. The drafts of the extended guidance were used during the Baton Rouge exercise. A new version of the PAGs were published in 1991 to include relocation PAGs and reprinted in 1992 to incorporate the Food and Drug Administration’s 1982 recommendations for radiological contamination of food.⁵⁴

Third Federal Field Exercise (FFE-3)

The third field exercise to test the FRERP was planned to be a four-day exercise responding to an accident at the Pennsylvania Power and Light’s Susquehanna Steam Electric Station early in 1993. An interagency committee, chaired by FEMA, was developing the exercise with a preliminary tabletop scheduled for October 29, 1992.

In August 1992, Hurricane Andrew had produced unprecedented economic devastation through southern Florida and south-central Louisiana. Damages were estimated near \$25 billion, with Dade County, Florida, hit especially hard. The storm produced a small number of deaths and left about 250,000 people homeless.⁵⁵ FEMA and other agency response groups were stressed in dealing with the aftermath of the storm. On October 22, one week before the tabletop, FEMA and the NRC announced that the exercise was canceled. The planners summarized their actions and “lessons learned” in the planning effort. The material developed for the planned tabletop⁵⁶ did not go to waste. The NRC adapted it to a guide for a generic nuclear power plant tabletop exercise, focusing on the expected interactions between all the responding parties.

Another change in FRMAC operating strategy also took place. The FRMAC staff had always arrived in one large group. There was no FRMAC presence at the scene until the FRMAC equipment was set-up and operational. For the first time FRMAC deployed an Advance Party before the “main team” arrived. The



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Advance Party included the FRMAC Director; it established communications and met with the other federal, state, and local response organizations to determine what resources were needed. Other members of the Advance Party handled the logistical arrangements for the FRMAC personnel.⁵⁷

FRMAC-93⁵⁸

Because FEMA cancelled FFE-3, DOE and NRC decided to sponsor a FRMAC field exercise. As much of the scenario as possible was taken from that developed for the FFE-3. The Fort Calhoun Nuclear Power Plant, 25 miles north of Omaha, Nebraska, allowed the exercise to be conducted in coordination with, but following, their previously scheduled evaluated exercise. The extended exercise ran from June 30 to July 1, 1993.

FRMAC-93 was designed to determine the effectiveness of a DOE-managed FRMAC, establish appropriate radiological priorities and provide assistance to the states and the NRC as the LFA. Two states, Iowa and Nebraska, were involved. The participation of many non-FRMAC participants was simulated.

On Day 1, the RAP team and the FRMAC Advance Party arrived and met with the states, the utility, and the NRC. Approximately 400 people participated in the FRMAC.

This exercise saw the first use of a Geographic Information System (GIS) in the FRMAC. The concept of a Protective Action Support Team (PAST), located in the FRMAC, was tested for the first time during FRMAC-93. Federal agencies with statutory responsibilities for protective action recommendations (EPA, HHS, and USDA) worked in the PAST to assist the NRC in interpreting the PAGs⁵⁹ for state and local governments and helped the states and NRC relate the FRMAC data to the guidance. The exercise was also used to train additional FRMAC management staff.

As FRMAC's responsibilities increased and more technology was incorporated, the data operations in the FRMAC became more complex. The data center was collecting and assessing environmental radiological data of all types, archiving the database as it developed, and producing information and plots for other groups' use. The center was designed to accomplish the following:

- Archive radiological information to permit reconstruction and reevaluation of the radiological knowledge as a function of time.
- Compile all radiological data for long-term retention and use by EPA.
- Ensure timely retrieval for evaluation and assessment after the accident.
- Provide comprehensive information to the LFA and states in organized, consistent format that preserves data integrity.
- Prepare automated calculations and outputs to produce consistent products.
- Provide a data link to other groups inside the FRMAC.
- Provide a logging facility for environmental radiological data paperwork.
- Establish a checkpoint for completeness of data.
- Provide immediate calculations as needed on results of instrument readings for field teams and data reporting.

Figure 17 shows the plan for data information flow that was developed.

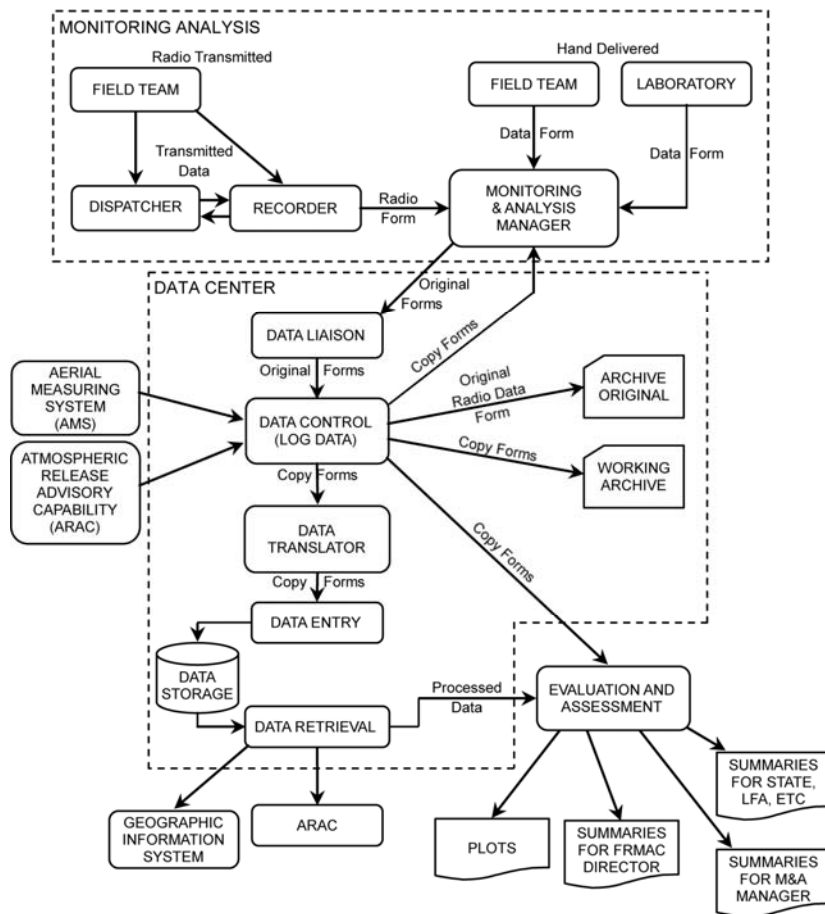


Figure 17. Early FRMAC data information flow. Source: Federal Radiological Monitoring and Assessment Center (FRMAC) Data Center Operations (Working Draft), DOE/NV-XXX, FRMAC -10-92, UC-707, U.S. Department of Energy Nevada Field Office, Las Vegas, March 1993.

Fremont-93

In September 1993, about 150 emergency response personnel took part in the Fremont exercise in Richland, Washington. The exercise involved people from the states of Washington and Oregon and from Westinghouse Hanford Company, the company that operated the Hanford Reservation facilities for the DOE at that time. Participating agencies included EPA, DOE, NRC, and USDA.

The scenario involved an explosion in a propane tank, which caused a major release of radioactive material from an adjacent (fictitious) processing facility. The release prompted a declaration of general emergency. Responders had to shelter the general population living in the down-wind path of the simulated plume. The sensitivity of the local agricultural community to field monitoring teams on the agricultural lands next to the site prompted the hypothetical location of the facility to be changed. In the preparation and aftermath of the exercise, the Hanford Site had to revise many of its procedures for dealing with a FRMAC, recovery measures, other federal agencies, and public relations.⁶⁰



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In this exercise, the FRMAC performed much better, after incorporating the changes inspired by the FRMAC-93 exercise. Among the lessons learned were the importance of the FRMAC Advance Party and the necessity of proactive FRMAC managers. The Advance Party should have a checklist for their meeting, and it would be useful to have a generic monitoring plan already developed that could be tailored to the situation. By being more proactive, the FRMAC managers were able to make the states aware of the FRMAC capabilities, learn their needs and priorities, and develop a coordinated monitoring and sampling effort.

DOE concluded that the interfaces and communications had worked this time. The monitoring and analysis group promptly implemented the monitoring and sampling plan, while responding to changing state priorities. The evaluation and assessment had produced the expected products and transmitted them to the LFA and state by pictures, video, and fax. In this case, the state and LFA representatives worked closely with the FRMAC managers, the state technical personnel provided major assistance, and “raw” data was given promptly to the state and LFA.

Diablo Canyon Ingestion Pathway Exercise

FRMAC personnel participated in an NRC-FEMA required exercise at the Diablo Canyon Nuclear Power Plant near San Luis Obispo, California, October 20–22, 1993. This first stage, an ingestion pathway exercise (IPX), was conducted as a command post exercise to evaluate data flow, radiological evaluation and assessment, protective actions, and the decision-making process. Because the presumed federal support exceeded the state capabilities, federal teams were asked to monitor evacuated areas. The AMS data was most useful for characterizing the plume footprint, as the state used soil samples for determining deposition.

In California, the counties had total authority to act in the early stages of an emergency, without consulting the state. After the emergency phase, the state does the response coordination. This structure emphasized the importance of liaisons and data transfer to the county centers, so early decisions can be made.

A year later, on October 24, 1994, there was a FRMAC/San Luis Obispo County and State of California dispatch exercise in San Luis Obispo to demonstrate field monitoring team command and control, sample collection and handling, contamination control, and decontamination.

The California exercise provided the opportunity for FRMAC staff to work with both state and local responders; responders felt coordination could be improved if the state and FRMAC operations were collocated to avoid delays and miscommunications. The AMS and in-situ gamma spectroscopy were important contributions to the response. Developing the initial FRMAC monitoring plan at the Advance Party meeting helped FRMAC satisfy the state’s requirements. FRMAC needed a policy for incorporating RAP teams when the RAP teams were under state direction and a method for estimating doses to people in contaminated cars.⁶¹

Mile Shakedown

Mile Shakedown was a series of four related exercises that examined the federal capability to deal with domestic nuclear terrorism.⁶² These exercises, which took place between December 1993 and October 1994,



The Evolution of FRMAC

included Mica Dig (a tabletop exercise), an emergency deployment and readiness evaluation (EDRE), Mild Cover (communications), and Mirage Gold (the final field exercise). Mirage Gold took place in New Orleans, Louisiana, with FEMA, DOD, DOE, FBI, and limited state and local involvement. Planning for the final exercise was impacted by the real-world considerations of some of the agencies.

FEMA and portions of DOE expected to use the FRERP and the Federal Response Plan (FRP) for their response to the terrorism incident. The FBI had no policy for transitioning to recovery operations. DOE planned to use its FRMAC structure, while DOD was expecting a Joint Hazard Evaluation Center. The role of the FRMAC in the early stages of a NEST response or the transition to consequence management was unclear. ARAC was producing independent consequence projections. Some scenario details were leaked, and FEMA and other “uncleared” responders were excluded from exercise information they needed.⁶³

While the Mile Shakedown Report was generally positive, the exercise prompted a DOE review of the NEST program.⁶⁴ The after-action report concluded that DOE should review and clarify the NEST/FRMAC relationship in a terrorism response.⁶⁵

Handshake Drills

The “Handshake” drills were conducted by the FRMAC program to train field monitors and data assessors for responding to radiological emergencies. The name, “Handshake,” represented the role that FRMAC played for the federal and state radiological response groups.

Handshake One

FRMAC conducted the Handshake One training drill May 17–19, 1994, on the Nevada Test Site (NTS) near Las Vegas. The portions of NTS used for the drills had above-background levels of gamma radioactivity, but the levels of removable radioactive material were low enough that anti-contamination protection was not necessary.

The scenario was simple, involving a fire in a tanker ship carrying radioactive cargo. The plume crossed into a notional county in an imaginary state, bounded by another state and an Indian reservation. The state governor evacuated the county and asked for federal assistance.

Although the primary objective was to provide monitoring and sampling practice for the 19 field teams, composed of federal and state participants, the evaluation of technical data flow was also important. A FRMAC was established, and several FRMAC data and assessment functions played. Participants practiced hotline procedures, sample control, dose assessment, and radio communications. The participants collected over 600 readings and samples in two days without the aid of data controllers. The AMS helicopter flew in real time.

The drill tested the idea of a forward hotline, about 30 miles north of the FRMAC. A more-distant hotline would reduce the probability of contamination at the FRMAC ,and was found to also reduce the congestion at the FRMAC location.

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The players had a number of practical suggestions for changes in position specific job aids and identified the need for a monitoring and assessment manual.



Figure 18. FIDLER in use at Handshake II

Handshake II

The Handshake II drill took place May 13–17, 1996, on DOE's Savannah River Site, which had some areas with above-background radiation areas. Handshake II included a session on Field Instrument for Detection of Low-Energy Radiation (FIDLER) calibration and some limited monitoring activities in support of the planned 1997 Cassini Space Mission (Fig. 18). This scenario involved a release in conjunction with storms and heavy rain, which resulted in contamination detected in the local waterways.

Most of the participants said this was one of the best drills in which they had ever been involved. The states were

pleased to have been integrated into all the FRMAC functional areas; although some states felt there should be more state involvement in developing the monitoring plans in the Handshake drills. Only state portable laboratories were participating in the exercise. There were problems identified in the set-up of the sample preparation areas. The field monitoring forms needed to correspond better with the data center needs. A new Laboratory Information Management System (LIMS) was introduced, which used bar codes to transfer sample information and provide error checking, security control, and quality control.

The data assessment players were to test the FRMAC assessment manual. The FRMAC program also used the exercise to test the data center and the use of default GIS and database products. The data center was barely adequate and would need more equipment, room, people, and support during a real emergency. The database application needed further development, but the sharing of data between the database and the GIS system assisted in prompt data flow. The GIS system worked well, but the assessors needed more training to take advantage of its capabilities.

Handshake III

The Handshake drill was to return to the Nevada Test Site in the late summer of 2001. The drill was postponed after the September 11 terrorist attack that year and was never rescheduled.

Diagram Jump 94

The Diagram Jump exercise was held in between Handshake I and Handshake II. It was conducted in two phases—emergency response phase (August 17–20, 1994) and site restoration phase, (September 20–22, 1994). Phase II started on Day 8 of the original scenario. Held at the Naval Submarine Base Bangor, Washington, the exercise simulated the response to an explosion on base and resulted in a damaged U.S. Navy nuclear weapon, military and civilian casualties, and contamination on and off base. The exercise provided an



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opportunity to test a recently developed draft Defense Nuclear Agency guide, *On-Scene Commander's Guide to Site Restoration*.

Diagram Jump Phase I was a command post exercise, located completely on the base; the Naval Service Response Force (SRF) had modified field participation. There was participation from the state and county agencies, and DOE's ARG in addition to the FRMAC. The advance party meetings between FRMAC and the other response groups did not take place until the second day, which caused some confusion in the chain of command and delayed the assignments of liaisons. Actions were not fully coordinated by the end of the exercise, although coordination was much improved.

The naval base personnel had little knowledge or interest in the civilian federal response. Data flow between the response centers was poor after the SRF arrived. The FRMAC Director was not able to meet with the On Scene Commander. Although the proposed revision of the FRERP, published earlier that month⁶⁶, formalized the Advisory Team for Environment, Food, and Health, the On Scene Commander did not take advantage of their expertise. The FRMAC was not given a chance to participate in the protective action recommendations and did not agree with the action taken.

A number of problems surfaced during Phase II. While the play of the FRMAC was somewhat limited, the Advisory Team for Environment, Food, and Health made valuable and informed recommendations. The FRMAC helped develop a clean-up plan early in the exercise, but its implementation was delayed. FRMAC's role in site restoration was not clear and hampered by the communications delays with the On-Scene Commander. The interface of the FRERP and FRP needed to be clarified.

Display Select



Figure 19. Briefing at Display Select

Display Select was the largest nuclear weapon exercise held in the U.S. up to that time, with over 2,000 participants from federal, state, local, and private organizations. The exercise was conducted September 18–27, 1995, near Yorktown, VA, where the hypothetical accident took place. The exercise was designed to be a full-field exercise that would focus on the integration of local, state, and federal assets. Figure 19 shows Display Select participants in an exercise briefing. There was 24-hour participation by some groups, but budgetary considerations limited the hours of play for other responders. The response began under the FRERP and continued under the FRP.



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The extreme scenario involved a civilian jet crashing into the pier during the non-routine movement of nuclear weapons. The fire and explosions from the crash caused damage or destruction of the weapons, death and injury to nearby people, and the atmospheric release of radioactive contamination.



Figure 20. GIS Maps

The participation of the FRMAC was important to the exercise. One new technology used to provide more realistic data to the field monitoring teams was the “Plume-in-a-Box”. This technology involved combining calculated plume dispersion and a GPS unit. When field teams reached a monitoring point, they entered some information about the location, and the programmed device gave them an appropriate hypothetical reading for the time, location, characteristics of the area, and the instrument being used.

Although there were still some problems getting onsite data from the JHEC, the FRMAC got to practice using the monitoring, assessment, and other manuals that had been developed

A GIS capability was in heavy demand, and a number of practical lessons were learned regarding labeling, categorizing, and cataloging the plots (Fig. 20). Some problems with transferring AMS data were flagged for immediate correction. However, the FRERP/FRP transition still raised some questions.

Dial Flinty

Dial Flinty was another nuclear weapons exercise, although it may be best remembered by the blizzard (Fig. 21). The weekend before the command post exercise was scheduled at Minot Air Force Base, near Minot, North Dakota, there was a major blizzard. The storm occurred as the facility on base was being set up for the exercise. Airports closed and participants were stranded on the way; however, the exercise started on Tuesday, March 26, 1996, as planned. Another snowstorm hit on Wednesday, and the participants endured low temperatures and snow drifts for the rest of their stay.



Figure 21. Working conditions at Dial Flinty

The scenario simulated a collision between a small civilian aircraft and a U.S. Air Force plane transporting nuclear weapons. The crash caused deaths and injuries to the crews of both aircraft and spread radioactive contamination on the local area. In addition to DOD and DOE, FEMA and local and state players were



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involved. While command post exercises always require much simulation, this response was assumed to take place July 26–29 to allow more agricultural and tourism play; this was quite a contrast to the white world outside.

The FRMAC initiated an excellent interaction with the North Dakota State Health Department Liaison, but the state radiological representative was not able to interact much with the FRMAC because he also was trying to do the press conferences and answer citizen questions. The state needed larger representation. The ARAC plots faxed to the Joint Operations Center were not readable and thus not usable. The often-problematic interaction between the JHEC and the FRMAC was significantly better this time, possibly due to the physical proximity of the two groups.

Digit Pace

Digit Pace was composed of a command post exercise, Digit Pace I, held in Albuquerque, November 5–8, 1996, and a large field exercise, Digit Pace II, May 19–23, 1997. Digit Pace II involved multiple locations, including Kirtland Air Force Base, the Albuquerque Operations Office, and DOE headquarters. The scenario involved a severe, offsite transportation accident—a large propane tanker that crashed into a convoy transporting multiple nuclear weapons. The damaged tanker undergoes a boiling liquid expanding vapor explosion, which detonates the high explosive in one weapon. The weapons were in DOE custody, making DOE the lead federal agency under the FRERP.

DOE did its own evaluation of the exercise. The DOE officials were unaccustomed to coordinating the actions of the other agencies, state, and local government. The FRMAC struggled again as it produced large amounts of data, but observers felt the output was not exactly what the state needed for protective action decisions. The need for urgent results should get higher priority. While each group may come up with a different approach to collecting data, the initial pre-FRMAC measurements needed to be in a form the FRMAC could use.

Changes in Organization and Operations

As the FRMAC matured, gained broader acceptance, and was asked to do different things, the organization had to learn to work with non-FRMAC entities.

Advisory Group for Environment, Food, and Health

The Advisory Group for Environment, Food, and Health, was never part of the FRMAC organization, but it became increasingly associated with FRMAC. The predecessor of the group had developed as part of the agency planning for the reentry of Cosmos 1900 in 1988. The special procedures developed by the federal agencies, called for a Washington Advisory Group, chaired by the Department of Health and Human Services, to develop recommendations to protect the public from direct exposure to radiation or exposure through ingestion of contaminated food and food products. This concept was based on the ad hoc group formed as part of the U.S. response to the Chernobyl Nuclear Power Plant accident. Additional participants were to be representatives of the USDA, FEMA, DoD, the Conference of Radiation Control Program Directors, the



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National Emergency Management Association, and the National Governors' Association. After reentry, the group could be joined by representatives from the "heavily impacted" states. DOE decided it would have a staff member also attend the meetings.⁶⁷

The need for some kind of group had also become apparent to the NRC. The NRC had defended its right and responsibility to issue federal protective action recommendations when a nuclear power plant was involved. The first FRERP had clearly stated that the FRMAC did not provide protective action recommendations. This had not caused any particular problems when the first exercises focused on the early response to a reactor accident. As the period of exercise play started extending to ingestion pathways, return, relocation, and recovery, the NRC had less expertise and other agencies had statutory responsibilities.

In 1982, the Food and Drug Administration had developed guidelines for radioactive contamination levels in food that would trigger protective actions and was in the process of revising them based on experience gained from the Chernobyl reactor accident in 1996. As part of its Federal Guidance function, EPA continued to revise and update its recommendations on protective actions.

The NRC had formed an advisory structure. At one time, representatives of EPA, FDA, and USDA were to report to the NRC Washington Emergency Operations Center and deploy to the field with the NRC team. Keeping the advisory group with the LFA and not collocated within the FRMAC was problematic—the data the team needed was in the FRMAC. By the time the first major revision to the FRERP was published in 1994,⁶⁸ the Advisory Team for Environment, Food, and Health had been formalized in the plan. The team was to consist of representatives from EPA, HHS, and USDA, supported by other federal agencies if the circumstances warranted. The team supported the LFA. Because it had no independent authority it would not release information or recommendations unless authorized to do so by the LFA. The Advisory Team would normally collocate with the FRMAC because FRMAC was the source of monitoring and assessment data. This change was included when the FRERP revision was published in 1996.⁶⁹

With time, the Advisory Team has played a greater role in helping to set the FRMAC's monitoring priorities, in order to ensure that they get the data they need.

Improved State and Local Integration

With time, and by utilizing lessons learned from exercises, the FRMAC organization improved its interagency nature. From the early concept of states and federal agencies being connected to the FRMAC through liaisons, the states and federal agencies became more integrated into the FRMAC management, monitoring, and assessment. A typical FRMAC structure by the mid-90s would look somewhat like Fig. 23. It was becoming common for the state and federal monitoring teams to both operate out of the FRMAC. (The new FRMAC organizational structure is illustrated in Figure 22.) However, each state has its own requirements, so the FRMAC had to be flexible enough to collocate or be able to maintain coordination through different areas.

A new operations manual⁷⁰ was published in May 1997, and a revision of the *Overview of FRMAC Operations*⁷¹ followed in 1998. Much effort went to standardizing the FRMAC interface with the states and



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Lead Federal Agency and defining a standard set of FRMAC “products,” with GIS-produced maps displaying radiation levels, contours reflecting EPA PAGs, and other features of the impacted area.

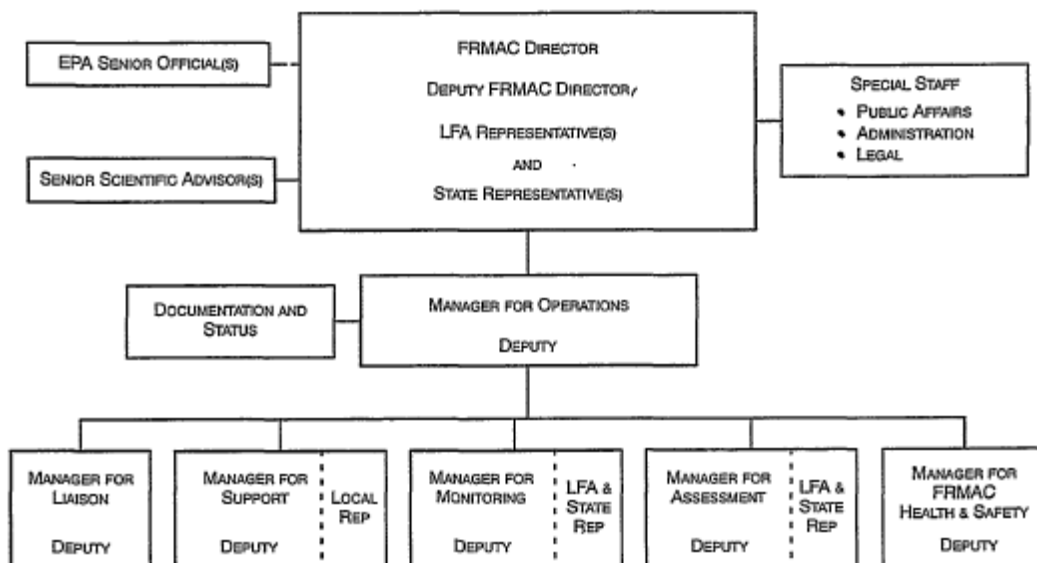


Figure 22. Typical FRMAC organization for large radiological emergency. Source: Overview of FRMAC Operations, DOE/NV-358, Rev. 3, UC-707, U.S. Department of Energy, Nevada Operations Office, February 1996

Phased Response

To become more responsive and efficient, in 1999, DOE switched to a “phased response” deployment of its assets. A Phase I response was designed for an initial rapid response to an incident in the United States when more than a RAP response was required. The 15 team members and equipment were to be prepared to deploy in four hours. Phase I differed from the Advance Party previously used, in that it included monitoring and assessment resources in addition to the management and logistics staff. Phase I would provide minimal staffing for one-shift operations.

Phase II represented an augmentation to the deployed Phase I team. With the 45 additional Phase II staff, 24-hour extended operation was possible. Phase I and Phase II would be the DOE element of an established FRMAC. The classic FRMAC response was called Phase III. The Phase I and Phase II teams together would form the standard response to a foreign incident.^{72,73}

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Ingestion Pathway Exercises

Ingestion Pathway Exercises (IPXs) were designed for state, local, and tribal authorities along with nuclear power plant licensees to demonstrate their ability to protect the public in the event of a nuclear emergency. Following the incident at Three Mile Island nuclear power station, it was determined that a more deliberate and detailed assessment of the capabilities of state, local, and licensee authorities should be conducted. Therefore, in December 1979 President Carter issued Executive Order 12148 that directed FEMA to take the lead in evaluating emergency plans and procedures of state agencies, local organizations, and the licensee. Meanwhile, Congress passed laws providing the means for the NRC to add an additional criterion to the license required by nuclear power utilities that required an element of emergency preparedness. In 1980, a joint committee of the U.S. Nuclear Regulatory Commission (NRC) and FEMA representatives met and created “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” NUREG-0654. This document along with its subsequent addenda and supplements form the basis upon which state, local, and licensee organizations are evaluated. According to NRC and FEMA regulations, there are two required exercise types: plume phase and post-plume, or ingestion phase exercises. These exercises are conducted on an eight-year planning cycles along with an additional “off year” industry-suggested exercise called a Hostile Action-Based (HAB) drill. The HAB drill was required by the NRC after September 11, 2001, to ensure that the Licensees provide additional measures in their emergency preparedness procedures to address situations where hostile actions were taken against the generating station (Figure 23).

While it is not common for the DOE (CMHT and RAP) to be involved in Plume Phase or HAB drills, DOE typically supports the states with an IPX. This is due to the much larger scope of the ingestion phase (this phase is usually conducted over a two-day period). Typically, on the second day FRMAC maps are released to the players and briefed by the FRMAC representatives. At some point, lab analysis data generated by FRMAC will be provided to the state and/or local dose assessors. State and local decision makers and even dose assessment personnel will often ask for FRMAC’s opinion about a decision they are making. FRMAC does not deviate from the standard practice of not providing recommendations. However, they may ask a member of the Advisory Team to join the discussion and discuss the data together.

FRMAC participates in an average of 6–10 Ingestion Pathway exercises each year, utilizing a small number



Figure 23. EOC at Clinton NPP 2001 IPX (2001)



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of dedicated personnel who participate in planning conference calls and meetings with the organizations involved depending on the level of support requested.

Consequence Management

Prime Mover

This no-notice exercise was staged to test the deployment readiness of the FRMAC Phases I and II, RSL's Executive Planning Team, the Home Support Team, and the NEST Search Response Team. The exercise took place on April 24, 2000.

While the drill was considered a successful test of the objectives, a variety of problems was identified. There were problems in the speed and accuracy of the notification from the DOE Nevada Emergency Operations Center. The majority of the Executive Planning Team was unavailable, demonstrating the need for substitutes and cross-training. After the search team and the Phase I positions were filled, it was difficult to find enough people to staff the Phase II responder positions. Personnel from outside RSL needed to be identified. Developing the Operations Plan should be a group effort to speed up the process. The transition from Phase I FRMAC to Phase II did not go as smoothly as desired.



Figure 24. A huge forest fire threatens the Los Alamos National Laboratory as high winds sweep the northern New Mexico area. (Rick Wilking/Reuters)

Los Alamos/Cerro Grande Fire Response

After a forest fire had burned much of the area around Los Alamos National Laboratory (Figure 24), there was public concern as to whether the fire had caused resuspension of radioactive particles from contaminated soil and vegetation in parts of the site. On May 11, 2000, the DOE assets that would normally be part of the FRMAC program were deployed to the area.

After the response, the participants suggested that the DOE component of the FRMAC should be renamed the Consequence Management Response Team (CMRT) and include a Consequence Management Planning Team (CMPT). To avoid confusion with the federal FRMAC, the resources were called the Consequence

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Management Support Team (CMST). The staggered deployment did not follow the systematic deployment planned for Phase I and Phase II (CMPT) as one of its components. The multispectral AMS capabilities would have been useful in planning the response, but many people were not aware of them. The past AMS surveys, along with the multispectral photography showed that the most contaminated areas were not burned, supporting the findings of the radiation monitoring. The responders identified some areas that needed strengthening for a non-FRMAC response and recognized the importance of the GIS home team support early in the response.



Into the 21st Century

The terrorist attacks of September 11, 2001, prompted a number of changes in the national emergency planning. The Homeland Security Act of 2002,⁷⁴ which took effect 60 days after November 25, 2002, when the legislation was passed, created the U.S. Department of Homeland Security. Shortly afterward, President George W. Bush issued Homeland Security Presidential Directive (HSPD)-5,⁷⁵ “Management of Domestic Incidents.”

This directive recognized the responsibilities of states and local authorities for domestic incident management and the federal obligation to help when state resources were overwhelmed or federal interests were involved. The Secretary of Homeland Security was required to develop an initial National Response Plan (NRP) and implementation plan by April 1, 2003, and develop a National Incident Management System (NIMS) by June 1, 2003. Federal agencies were to adopt the new plan and implement NIMS. States had to adopt NIMS to continue to qualify for preparedness assistance grants.

NIMS was released on March 1, 2004, to provide a nationwide standard for federal, state, local, and tribal governments to work together to prepare for and respond to various types of domestic incidents of significant national interest. NIMS is a multiagency implementation of the Incident Command System (ICS), based on the National Interagency Incident Management System (NIIMS), adopted by the Coast Guard in 2001.⁷⁶

As the initial plan described itself, “The NRP integrates existing Federal domestic awareness, prevention, preparedness, response, and recovery plans into one base plan, addressing functional areas common to most contingencies, with annexes to describe unique procedures required under special circumstances.”⁷⁷ It was an “all-hazards/all disciplines” plan that emphasized a unified response and treated crisis management and consequence management as an integrated function.

The NRP was structured in much the same way as the FRP had been (see Figure 25), but there was a significant difference. In December 2004, a Nuclear/Radiological Incident Annex was added to the plan.⁷⁸ With this addition, the NRP superseded the FRERP as the guide for dealing with radiological emergencies and incidents. Radiological response capabilities cited include the following:

- Interagency Modeling and Atmospheric Assessment Center (IMAAC), responsible for production, coordination, and dissemination of consequence predictions for an airborne hazardous material release
- FRMAC established to coordinate radiological assessment and monitoring
- Advisory Team for Environment, Food, and Health, which provides expert recommendations on protective action guidance

DHS was to maintain the annex through the Federal Radiological Preparedness Coordinating Committee. Most of the provisions of the FRERP were incorporated into the annex.

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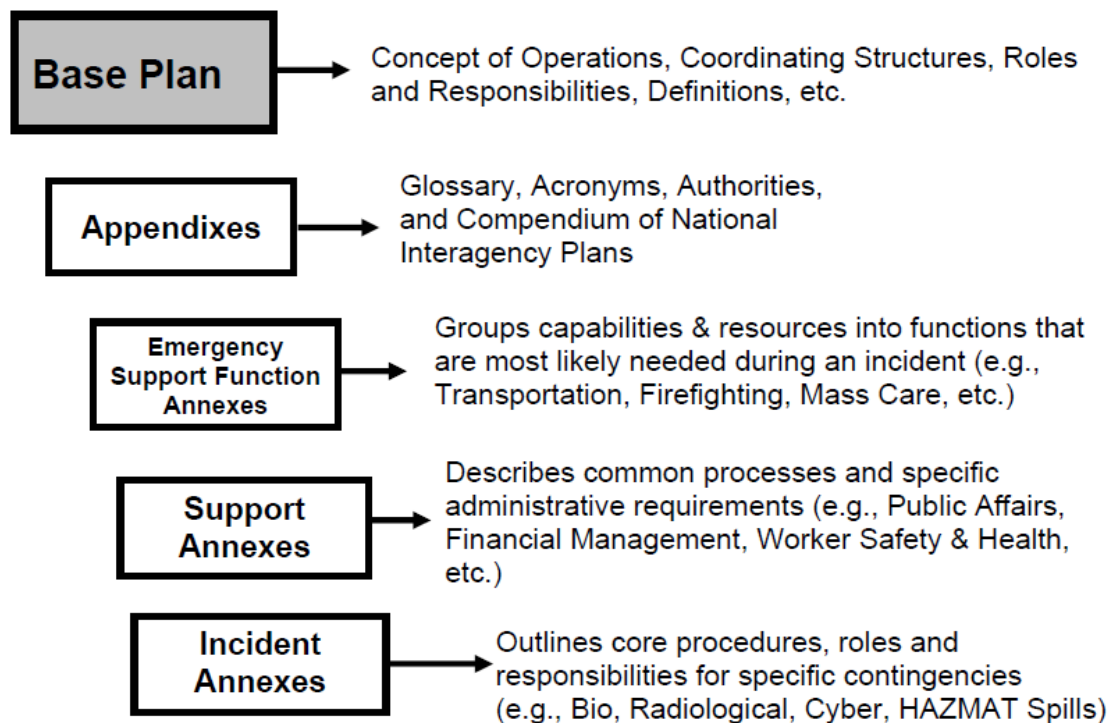


Figure 25. Organization of the National Response Plan

FRMAC Implements NRP and NIMS

The Nuclear/Radiological Incident Annex to the NRP describes the response to nuclear or radiological incident of national significance. One of the premises of incident command (and NIMS) is that the response can be scaled to the incident. The FRMAC response structure will remain the same. If the incident does not reach the level of national significance, the FRMAC will report to the Senior Federal Official of the coordinating agency (formerly the Lead Federal Agency). When FRMAC operates under NIMS, a DOE Senior Federal Official will represent DOE in the Joint Field Office, while a Senior Energy Official represents the DOE assets in Unified Command.⁷⁹ DOE's concept of the FRMAC branch and unit structure is shown in Figure 26.

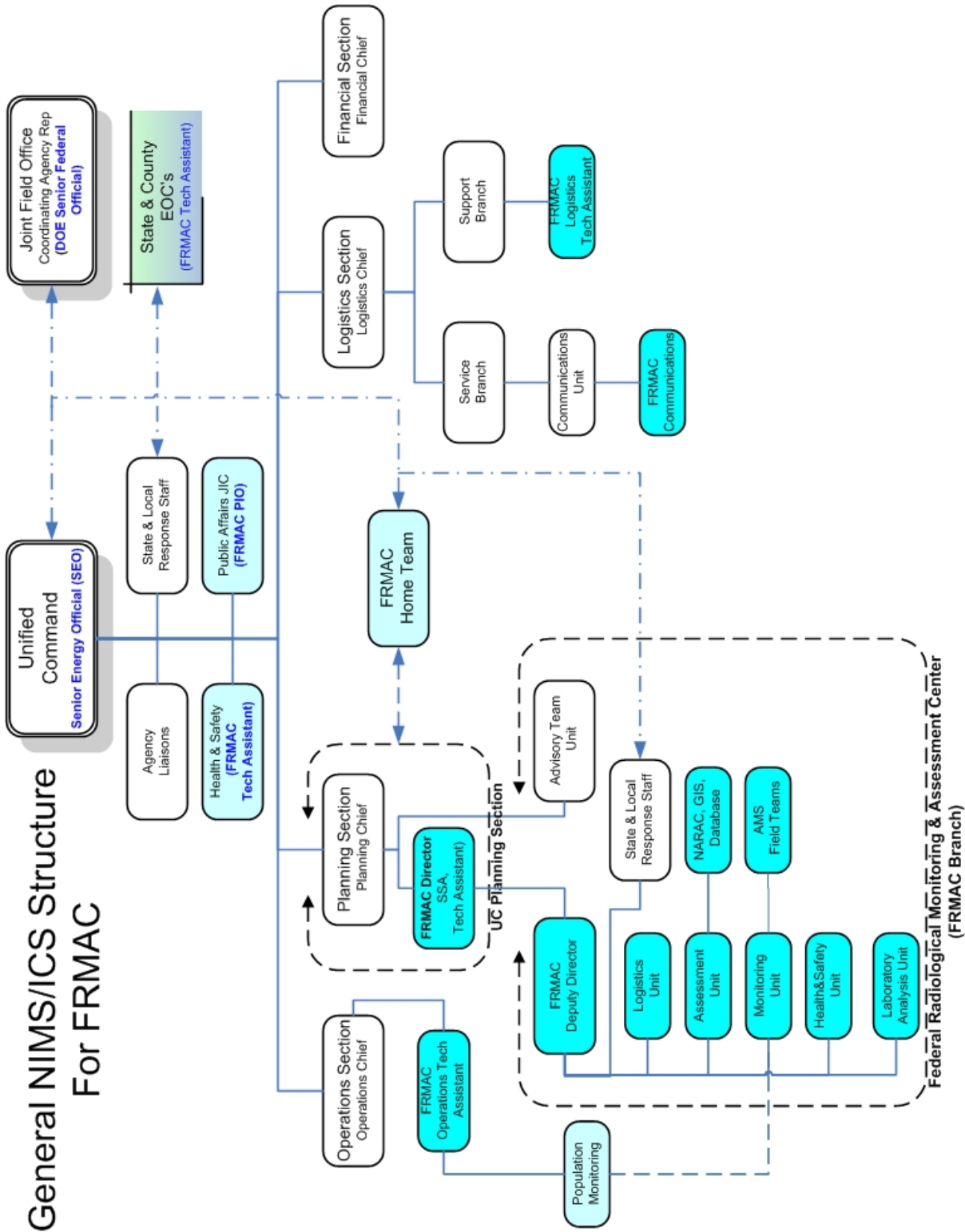


Figure 26. Basic FRMAC Branch/Unit Structure.

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National Response Framework

After dealing with large disasters like hurricanes Katrina and Rita in 2005, the NRP was replaced by the National Response Framework (NRF). The NRF is a guide to an all-hazards response, from response to a serious, but local incident to a large terrorist attack or catastrophic natural disaster. Here, “response” includes immediate actions to save lives, protect property and the environment, and meet basic human needs. The NRF explains the common discipline and structures that have developed at different governmental levels and builds on NIMS, which provides the template for managing incidents.⁸⁰

Like its predecessor, the NRF consists of the core document and annexes. The NRF core document covers the following: [13](#)

- Roles and responsibilities at the individual, organizational and private sector level as well as local, state, and federal government levels
- Response actions
- Staffing and organization
- Planning and the National Preparedness Architecture
- NRF implementation, Resource Center, and other supporting documents incorporated by reference

The core document is supplemented by 15 Emergency Support Function (ESF) Annexes: (1) Transportation; (2) Communications ; (3) Public Works and Engineering; (4) Firefighting; (5) Emergency Management; (6) Mass Care, Emergency Assistance, Housing, and Human Services; (7) Logistics Management and Resource Support; (8) Public Health and Medical Services; (9) Search and Rescue; (10) Oil and Hazardous Materials Response; (11) Agriculture and Natural Resources; (12) Energy; (13) Public Safety and Security; (14) Long-Term Community Recovery; and (15) External Affairs.

The Support Annexes include (1) Critical Infrastructure and Key Resources (CIKR) , (2) Financial Management, (3) International Coordination; (4) Private-Sector Coordination, (5) Public Affairs, (6) Tribal Relations, (7) Volunteer and Donations Management, and (8) Worker Safety and Health.

The FRMAC response was still included in the incident annexes: (1) Incident Annex Introduction; (2) Biological Incident; (3) Catastrophic Incident; (4) Cyber Incident; (5) Food and Agriculture Incident; (6) Mass Evacuation Incident; (7) Nuclear/Radiological Incident; and (8) Terrorism Incident Law Enforcement and Investigation. The Oil and Hazardous Materials Annex in the FRP was superseded by ESF #10.⁸¹



Joint Venture 2002

Joint Venture 02 was a field training exercise conducted at the Savannah River Site in Aiken, South Carolina, from April 22-26, 2002 (Figure 28). This exercise was designed to provide a realistic observation of DOE-emergency response Consequence Management (CM) assets in support of a national response to a consequence management incident at the Savannah River Site (SRS) and surrounding area resulting from an earthquake at the facility (Figure 27). The exercise provided a vehicle to assess readiness and explore and refine operational procedures between DOE Headquarters and DOE emergency response field assets, Interagency and state CM partners (Figure 28). The event took place at various sites in the Aiken area. Alert, mobilization, and deployment of DOE assets was executed within the constraints of real-world logistics and deployment factors.



Figure 27. Savannah River Site, Aiken, SC

Lessons learned from the exercise focused on the need for improvement in the leadership of the analytical laboratory assets. This observation resulted in the established of a Laboratory Analysis Section as part of the FRMAC organization, which would be responsible for tracking samples and data. Other outcomes from the exercise included revisions to Monitoring and Analysis Manual sampling procedures.



Figure 28. Working through plans at Joint Venture



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TOPOFF II⁸²

On May 12–14, 2003, FRMAC participated in the full-field exercise, TOPOFF II in Seattle, Washington. RSL-Nellis provided exercise controllers, photo support, the AMS Incident Response team, and a CMRT team that became part of the FRMAC. The AMS Incident Response Home Team also participated in the exercise from its response center at RSL-Nellis. All mission personnel and equipment were pre-deployed.

The exercise scenario focused on the explosion of a large truck south of downtown Seattle (Figure 29). Early responders reported that the crater's location suggested that the truck was in motion at the time of the explosion. Within 12 minutes of the explosion, Seattle Police and Fire authorities detected gamma radiation in the vicinity of the crater. Precautions were immediately put in place to respond to a radiological dispersion device (RDD).

Two of the major DOE objectives for the exercise were to: 1) Exercise NNSA command and control policies and procedures with regional counterpart, and 2) Evaluate the CMRT monitoring process, the input of field data into the Emergency Response Data System (ERDS), and 3) Transfer data to the GIS for the development of field measurement maps.

One of the significant lessons learned from the exercise was the need to standardize the format of map products so that when maps are distributed electronically they display accurate data which is consistently interpreted. This observation was to become one of the motivators for the standardized briefing products. These products are now part of the FRMAC tool box. In addition, the FRMAC and the state radiological resources were on opposite sides of the explosion site, which hindered FRMAC in its interaction with the state. The state personnel were too busy to meet with FRMAC advance party. This made the FRMAC less effective in supporting the state needs. This reinforced the importance of having the advance party meeting to insure that FRMAC and state monitoring and sampling priorities are properly aligned.



Figure 29. Staged exercise incident scene at TOPOFF II



Operation Synergy

Operation Synergy was a joint NNSA / state of California drill conducted in Los Alamitos, California, from March 5–11, 2004. RSL deployed the Search Response Team (SRT), the Aerial Measuring System (AMS) capability, a Consequence Measurement Planning Team (CMPT), a CMRT Phase II, and provided RSL Home Team Geographic Information System (GIS) support. The purpose of Operation Synergy was to conduct training of federal personnel in the disciplines of radiological search and radiological consequence management, and interface and coordinate with the state of California personnel as well as the counties of Los Angeles and Orange.

The scenario involved a hypothetical report from the Secretary of Homeland Security and the Federal Bureau of Investigation (FBI) that an unknown terrorist group had targeted the Los Angeles area for an attack. The Los Angeles office of the FBI had intelligence that an unknown terrorist group had been working out of the

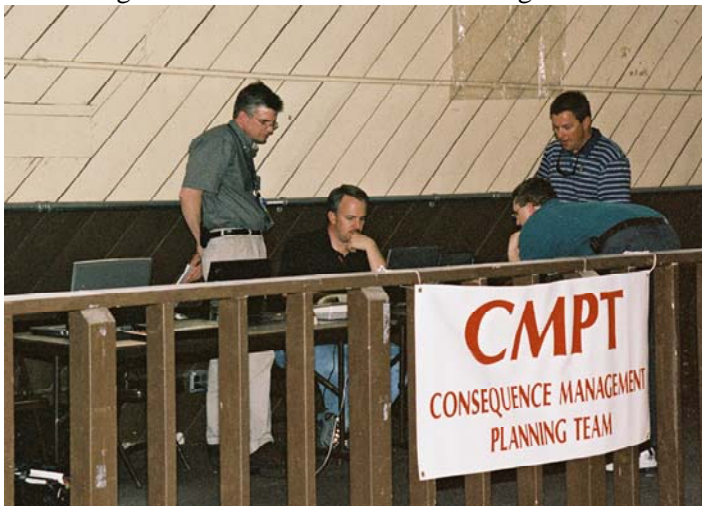


Figure 30. CMPT at Operation Synergy

Los Alamitos and Long Beach area. The FBI requested NNSA support.

In addition to training federal responders, one of the major mission objectives was to demonstrate the integration and interaction of federal, state, and local response management to a nuclear/radiological emergency response. Another goal was to exercise the transition procedures of the FRMAC management from the DOE to the EPA.

The major exercise objectives were met and it effectively provided the opportunity for Crisis and Consequence assets to deploy together and

integrate and operate with federal, state, and local, agencies. As a result of evaluations from the exercise the CMPT was restructured and eventually absorbed into the CMRT I (Figure 30). Also, although the DHS National Response Plan was in force at this time, the ICS/NIMS was not implemented by FRMAC. This resulted in a lack of coordination in the integration of the FRMAC and the State Data Assessment Center.

Dingo King

Dingo King was a DTRA-hosted, national level NUWAX exercise conducted at the Naval Submarine Base (NSB) in Kings Bay, Georgia, from August 22 thru August 25, 2005. RSL deployed the CMRT I team which became part of the FRMAC. The ARG team also participated in the exercise and one of the objectives for the exercise was the successful integration of the FRMAC and the ARG.

The scenario involved an accident in which the pilot of a single-engine aircraft suffered a heart attack and crashed in to the NSB Explosives Handling Wharf-2. An ensuing fire engulfed one weapon and the



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subsequent deflagration of the missile's fuel cell propelled the other weapon into the sea. The initial DOE response was to include a RAP team, the NARAC, ARG, and various liaison officials. The CMRT deployed at 1100 PDT on August 22 and arrived in Jacksonville, Florida, at 1900 EDT. Once cleared through security, the team was escorted to the FRMAC area where they participated in an Advance Party meeting and setup the FRMAC.

Southern Crossing

Southern Crossing Full-Scale Exercise 2006 (SC-06) was a DOE-led exercise that encompassed the deployment and integration of local, state, and federal resources and focused on command and control, data flow, and coordination. The FSE was conducted from August 14–18, 2006, at the Houston County Farm Center located in Dothan, Alabama. Primary exercise activities occurred at the Farm Center, although notification processes, reach-back capabilities, and monitoring and sampling teams were exercised beyond the center. Field play incorporated real-time deployment, as much as the exercise design and exercise management allowed, and 24-hour operations in a radiological dispersal device (RDD) scenario. This was the first major FRMAC RDD-based scenario to bring extensive interagency federal, state, and local resources to bear within the tri-state region of Alabama, Florida, and Georgia. The scenario centered on a van with two unknown individuals transporting a 5,000 curie Cs-137 source of unknown origin (presumably smuggled into the country and intended for an unknown location). The van was involved in a traffic accident at the intersection of route US 84 and County Road 55.

As a result of the accident, explosives around the source detonated. Two individuals were in the vehicles transporting the source and the driver of the second vehicle was killed. The second vehicle was destroyed and the van, virtually unrecognizable, was slowly burning from the resulting rupture of its fuel tank. The explosion from the collision severely damaged the roadbed and resulted in a 20-ft blast-like crater. Another truck approaching the scene overturned in the east-bound lane of US 84 trying to avoid the explosion. This caused the roadway to become impassable and traffic approaching the scene became blocked.

To accommodate the scope and scale of this exercise, DOE facilitated a seven-module Tabletop Exercise (TTX) to resolve any policy-level issues that would hinder field play during the FSE. Topics for this discussion included: incident to Day 30 considerations, Day 31 onward considerations, FRMAC Transfer, and Coordinating Agency Transfer. The TTX was conducted from April 25–26, 2006, also at the Houston Farm Center.

A cooperative partnership was established between Alabama, Georgia, and Florida emergency management and radiation control agencies and FRMAC and participants of all agencies at the state and local levels demonstrated excellent teamwork. Exercise design presented real-world problems and invaluable comprehensive training opportunities evidenced by having initial plume projections not match ground truth. This created realistic conditions to test decision-making and place stress on command and control.

The importance of the Consequence Management Home Team was validated. This exercise was the first time that this relatively new concept had been tested. The asset provided interagency reach-back support, forward



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concept planning, and in-depth problem solving, particularly in light of logistical complications. The CMHT including NARAC/IMAAC resources, the RSL Home Team and Assessment Scientists from Sandia National Laboratories were active and on the bridge line within two hours of the call with the parties communicating necessary information.

The exercise participants demonstrated a positive attitude and ability to respond to the 17-hour delay in the arrival of the Consequence Management Phase I team due to a DOE-chartered aircraft malfunction. The aircraft transporting the CMRT Phase I team was forced to land at Longview, Texas. Once it was determined that the aircraft could not be repaired in a timely manner a bus was contracted to drive the team over night from Texas to Alabama. This resulted in the CRMT II team, which was on a different aircraft, arriving in advance of CMRT I. This unfortunate occurrence serendipitously paralleled a potential real-world situation. The challenge it presented was a valuable lesson learned for future planning and communications. Stories of the “bus ride” have become urban legend in the CM community to this day.

One important lesson was the need for a DOE federal official to be part of CMRT II to interact with other federal agencies and state officials.

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21st Century Technological Advances

FRMAC Moves into the Electronic Age

Over time, the focus in response operations has grown away from leaving a big footprint on the ground and relying more on technological innovations and communications enhancements to provide a quicker, more reliable, and coordinated response.

The eFRMAC enterprise and CM Home Team have been established to provide faster and more reliable access to FRMAC capabilities and data products by states and locals even before field teams arrive. eFRMAC uses data telemetry and computer networking to gather, move, and archive data. The CM Home Team decreases the size of the deployed footprint and can remain active to also assist EPA after they have taken over management of the FRMAC in the late phase of the response.

eFRMAC

The eFRMAC enterprise is a broad initiative to move data faster, farther, and better through telemetry, automation, and networking. The eFRMAC schema is illustrated in Figure 31. Appreciable time was required for field measurements to find their way on to maps and in to models using a paper-based process. Therefore, the eFRMAC enterprise was conceived to eliminate paper handling and avoid data re-entry as much as possible throughout the process of monitoring, assessment, and data product distribution. In eFRMAC data are moved, managed, and manipulated electronically all the way from the instrument in the field to the final map product on the decision maker's desk. Measurements can now be viewed on a map and used for computations within seconds of acquisition. Special access is provided for direct upload of early data acquired by first responders.

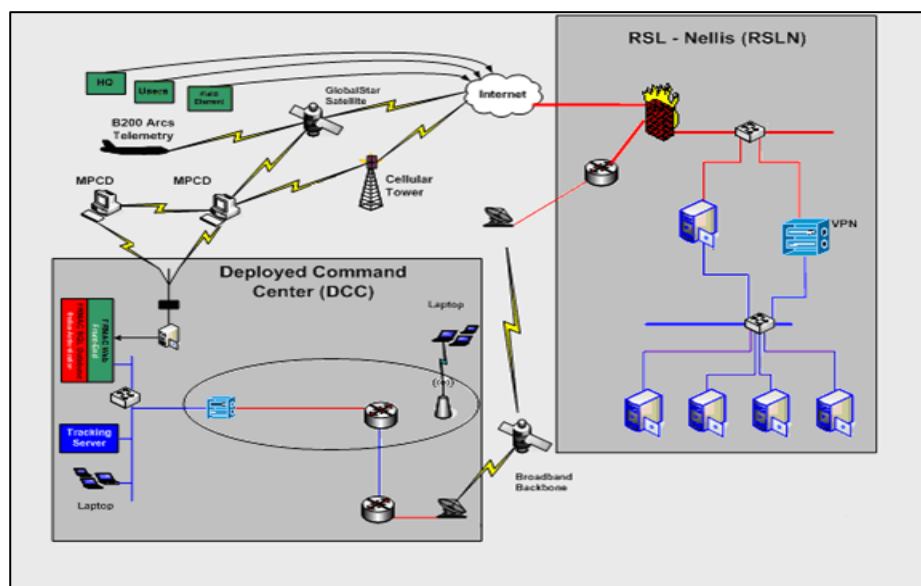


Figure 31. eFRMAC Schema



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CM Home Team

The Consequence Management Home Team (CMHT) plays an essential role in the FRMAC, and it is anticipated that the role of CMHT will continue to expand with the continuing process improvement efforts that include improved automation of telecommunications capabilities, the necessity to decrease the size of the deployed footprint, and the support of additional non-consequence management assets.

The primary role of the CMHT is to support the FRMAC event response while CMRT I is en route to the event scene and to provide support to RAP or ARG teams. It will continue to support the deployed CM teams after they arrive in the field. In the Japan deployment in 2011, the CMHT was critical in balancing the requests for data from Washington, D.C. and the field. CMHT support includes collecting and analyzing data, evaluating hazards, and providing event information and data products to protective action decision makers. The DOE's Remote Sensing Laboratory (RSL) serves as the headquarters for the CMHT, but assessment scientists and NARAC scientists who are also team members operate out of Sandia National Laboratories and Lawrence Livermore National Laboratory. The CMHT establishes a bridge line for decision makers, scientists, state authorities, and other assets to discuss the situation and any available data before CMRT I has set up a FRMAC, or in the event a FRMAC is not requested. The CMHT will continue to support the event for as long as necessary.

The CMHT is activated when a requestor (state, local, tribal, or agency official) contacts the DOE's National Incident Team (NIT) who, in turn, notifies the RSL duty manager that an event has occurred with requires Consequence Management support.

The CMHT has the capability to respond to several types of radiological emergency situations and can tailor itself to meet the needs of the event.

Diablo Bravo

Exercise Diablo Bravo 2008 (DB 08) was a National Exercise Program Tier II nuclear weapons incident exercise sponsored by the NNSA. The primary exercise activity took place from July 28 to August 1, 2008, in Kitsap County, Washington. DB 08 involved a comprehensive interagency response at the federal, state, and local levels. DOE/NNSA participants included the ARG and RAP groups, the CMRT, AMS, NARAC, and the Emergency Management Team and Nuclear Incident Team (NIT) from DOE/Headquarters. Diablo Bravo was significant because it was the first inter-agency U.S. nuclear weapons incident exercise to test the response activities to a terrorist attack on nuclear weapons. It was also the first real-time deployment of response assets and the first exercise in which weapons were in DOE custody under the NRF. The scenario was also intended to drive interaction between all participating departments and agencies responding to the incident and to establish and coordinate a National Security Area (NSA).

The exercise planning process identified several additional areas of emphasis for exercise design that became significant during the conduct of the exercise.



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- Examine interagency coordination inside and outside the National Security Area, with emphasis on the crime scene investigation
- Evaluate the nature and extent of DoD support to the DOE
- Coordinate an effective and consistent public affairs message in response to a terrorist attack on a DOE nuclear convoy
- Examine emergency response activities within the constraints of a crime scene/evidence collection activity

The exercise after action report indicated that all the goals were met; however, there were some opportunities for improvement in the area of data collection flow to Incident Command and decision makers and effective use of available personnel by the Incident Management Team. In addition, interagency coordination within the NSA needed to be solidified and assessed further.

Empire 09

Exercise Empire 2009 was the first exercise in which the eFRMAC was employed for data management. Empire 09 was a DOE/NNSA-sponsored full-scale exercise hosted by the state of New York to demonstrate effective management of a response to a domestic RDD incident. It was conducted in three phases: Phase I (Table Top Exercise) was conducted May 14–15, 2009; Phase II (Full-Field Exercise) was June 1–5, 2009; and Phase III was conducted on June 16–17, 2009 (Figure 32).

While previous exercises had focused solely on the *immediate response* to an RDD incident, the exercise goals for Empire 09 were to address the Consequence Management process. Empire 09 had the following three goals:

- Demonstrate a coordinated response to a radiological incident in an urban environment.
- Emphasize the interagency coordination necessary for the deployment of the FRMAC, including full integration of state and local entities. Address response- and resource-related policy issues that develop during an RDD incident after initial life-saving operations. While Empire 09 was designed to be as realistic as possible, several artificialities were necessary in order to achieve the exercise goals and objectives.



Figure 32. Admiral Joseph Krol, Associate Administrator for NNSA's Office of Emergency Operations and Colleen O'Laughlin, FRMAC Program Manager at FRMAC established for Empire 09

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Figure 33. Generating FRMAC Data Products at Empire 09

The exercise planners chose to conduct the exercise in three phases in order to meet all the objectives from detonation through day 45 (recovery). Phase I allowed players to discuss all immediate response actions and make decisions for the initial 48 hours. Phase II included the response to the incident starting on day three and ending on day five. From then a “time jump” extended to 45 days to discuss recovery and transition of the FRMAC from DOE to EPA as Phase II.

The major strengths identified during this exercise include an unprecedented level of interagency collaboration at the federal, state, and local levels and significant state and local participation. Population monitoring activities were led by New York DOH, and a large volume and variety of FRMAC data and products to support federal, state, and local decision makers were created (Figure 33).

The major strengths identified during this exercise include an unprecedented level of interagency collaboration at the federal, state,

Another critical issue identified at the end of the exercise was that the “stage” was not appropriately set for the start of Phase II to ensure all players understood the starting conditions and rules of engagement. This issue was addressed to the exercise planners. In future exercises the planners must ensure that sufficient background information is provided to controllers/evaluators and players to create a clear operating picture prior of the entire full-scale exercise prior to STARTEX.

The seamless integration of agencies into the FRMAC operations was noted as being a best practice in the Exercise After-Action Report. This shows the progress made in the time since FRMAC-93 at Ft. Calhoun, Nebraska, when the communication between the states and the FRMAC was poor.

Liberty Radex

Exercise Liberty Radex was conducted April 26–30, 2010, and was an EPA-led exercise that was designed to explore the late phase activities, such as cleanup and recovery. The exercise scenario was a continuation of the Empire 09 scenario, transplanted to Philadelphia, PA and beginning 30–90 days after the detonation. FRMAC management had been transitioned to EPA, but DOE staff continued to provide support as they are committed to do in the FRMAC transfer agreement. This was the first large scale test of late phase activities, and one of the few exercises conducted in the downtown area of a large city. Alternative assessment computer codes and methods were brought into the assessment group, to answer questions unique to the cleanup and recovery actions. This gave the exercise a different character. Because FRMAC was being managed by EPA, some of the administrative practices followed in a FRMAC established for early and intermediate phase activities were not followed. The exercise showed that FRMAC was a flexible, adaptable organization.



Fukushima Daiichi Nuclear Power Plant Response

On March 11, 2011, at 2:46 PM, Japan time, (March 10, 1:46 AM EST) a 9.0 magnitude earthquake occurred off the northeast coast of Japan. This earthquake generated a large tsunami that devastated the northeast coast of Honshu. At 3:41 PM, the tsunami struck the Fukushima Daiichi nuclear power plant complex with a wave that exceeded design criterion by several meters. The power plants survived the earthquake with little damage, but all power was shut off, and the tsunami damaged the back-up power generators. The reactors shut down, and the emergency cooling began on battery power.

Unfortunately, the batteries died before emergency power could be restored, and heat began to build up in the reactor cores. Within hours the fuel rods began to heat sufficiently to cause the zirconium cladding to oxidize, releasing hydrogen gas. This gas and associated fission products were released into secondary containment, where hydrogen explosions destroyed the containment and released radiation into the atmosphere.

On Friday, March 11, in the U.S. (the early morning hours of March 12 in Japan), the NNSA Administrator, Tom D'Agostino, agreed that NNSA, through the Secretary of Energy, would offer the assistance of the NA-42 Aerial Measuring System. The Consequence Management group at the Las Vegas Remote Sensing Laboratory (RSL), at the request of NA-42, put together a plan to send equipment and four personnel to Hawaii to be staged to continue to Japan when invited. This was put on hold through Saturday and into Sunday.

Throughout this time, the National Atmospheric Release Advisory Center at Lawrence Livermore National Laboratory began performing atmospheric dispersion modeling calculations to assess potential impacts to U.S. personnel in Japan as well as to the U.S. territories and mainland. These modeling efforts continued throughout the ensuing response.

On Sunday, March 13, NA-40 asked NA-42 to put together a plan to deploy a more robust CMRT if the situation required. In the mean time, Alan Remick from NA-42 traveled to Japan on Sunday to be a DOE liaison to the U.S. Embassy in Tokyo. Dan Blumenthal traveled to Las Vegas to help coordinate the CM assets and lead the team ultimately to Japan.

On Monday, March 14, at 1PM EST, the decision was given to deploy a full CMRT directly to Japan. An Air Force C-17 arrived at Nellis AFB at 3PM PST for loading and transport. The operations plan stressed that the deployment was directed for the safety of U.S. citizens and would do monitoring of U.S. bases and consulates in Japan.

The C-17, loaded with 17,000 pounds of equipment and 34 personnel, departed Nellis AFB at 6:20 PM PST. It refueled at Elmendorf AFB, Alaska, and continued to Japan, landing at Yokota Air Base just to the west of Tokyo. The personnel checked into their base housing at 5 am JST on March 16 and immediately went to their assigned work location, Hanger 1503, for equipment setup and preparation for the first AMS flights. By

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midnight the next day the first AMS data were sent to the U.S. giving everyone the first indications of the impact of the deposition of radioactivity from the damaged nuclear plants.

Activities in Japan

When the team arrived in Japan, they were met with confusion. There was a lack of knowledge and communication concerning what was happening to the reactors. Hydrogen explosions and release of radioactivity occurred just hours before the arrival of the CM team on March 16. No one knew the extent of the spread of the radiation from the leaking reactors. The U.S. Ambassador to Japan was considering the evacuation of all U.S. citizens from the country, and the U.S. Forces Japan had executed the voluntary evacuation of military dependents that first week.

There was airborne ^{131}I in Tokyo sufficient to make HPGe measurements of air filters difficult, but it was clear that there was no present danger to one's health from the radioactivity. What was unclear was what the potential releases might be. There was a great deal of tension among U.S. Embassy personnel, military personnel, and government agencies in Washington about the situation.



Figure 34. CM personnel, US military and Japanese military personnel work together

On the day of arrival, March 16, DOE negotiated the use of an Air Force C-12 fixed wing plane and a helicopter for aerial surveillance. The first airborne measurements by the DOE team were analyzed during the evening of March 17 and did much to provide a basis for rational decision making by the U.S. government.

There were three primary customers at the beginning of the deployment: the U.S. Embassy in Japan, the U.S. military forces in Japan, and the White House staff in Washington D.C.

(Figure 34). After the first week and after the radiation products were seen, the Japanese government agencies became interested in the CM data and requested the support of the DOE assets. The most difficult task became coordinating the priorities of the three U.S. customers. In particular, the requests from the White House tended to drive the actions of the DOE team in a strong manner.

The Consequence Management Home Team (CMHT) was a new concept that had been developed to support the deployed team. The CMHT had dedicated space and communications at the RSL in Las Vegas, but consisted of scientists at LLNL, LANL, and SNL, and RSL at Nellis and Andrews. This group became the center of coordination for all requests for information. They bore the stress of balancing the demands of Washington and the field assets in Japan and in a number of instances found it impossible to make everyone



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happy. The pressure from Washington for data had always been expected in large, high-profile incidents, but this was the first time it had been experienced to this extent.

The newness of the organizational structure of the CMHT was apparent, and the NNSA/NSO federal personnel, who were the federal team leads, were helped and augmented by Headquarters and Albuquerque federal personnel.

The monitoring in Japan continued with daily flights of the fixed wing and helicopter and with trips by automobile for ground monitors taking soil and air samples. The mapping of the radiological deposition became clear over time, and it was seen that no significant ground deposition had occurred after the first week when the hydrogen explosions were occurring in the reactors. The U.S. surveys continued until the third week of May. During this time, the Japanese expressed an interest in borrowing our RSL detection equipment and in performing aerial surveillance identical to ours after we returned to the U.S. The DOE scientists spent several weeks during the last of May training the Japanese scientists.



Figure 35. Japanese installing RSI equipment

The U.S. wanted to have a ring of detectors reporting back in real time around the reactor site to give early warning if there were additional major releases of radiation. DOE had the Infield detectors used in search sent to Japan and set them up to transmit data back through cell phone connections. An array of eight detectors was placed around the reactor site at a distance of about 25 miles. The data were continuously posted to the internet with a GIS map posted on the CMHT video wall (Figure 35).

The Japanese had a number of radiation sensors deployed around their country and were posting these data on the internet. The CMHT at RSL-Andrews was responsible for collating these data and watching for trends. All of the data, including the aerial surveillance maps, have been posted to the FRMAC web site for permanent access.

Ambassador Roos, the U.S. Ambassador to Japan, appreciated the information provided by the DOE assets. He had been particularly concerned about the safety of U.S. citizens in Japan. On the DOE departure at the end of May, there was an agreement to place a radiation sensor on the roof of the U.S. Embassy to give immediate warning of future radiological releases. This was coordinated by NA-46, which had done similar emplacements on U.S. Embassies around the world.

The last of the deployed DOE team returned to the U.S. on May 28, 2011.

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Although the U.S. response was never an official FRMAC given the overseas nature of the incident, many key operational elements performed tasks they would normally do during a comparable nuclear accident in the U.S.

Several Department of Defense teams provided field support as well as reachback support as the CMHT did for DOE. The Air Force Radiation Assessment Team (AFRAT) worked closely with the DOE team conducting monitoring and sampling both on and off U.S. military bases and also provided dosimetry support to the U.S. military personnel in Japan. The Defense threat Reduction Agency (DTRA) Consequence Management Advisory Team (CMAT) provided modeling support to the military with reachback to the DTRA operations center.

The Nuclear Regulatory Commission (NRC) provided atmospheric dispersion modeling support through its Protective Measures Team (PMT) at the NRC Operations Center. The PMT worked closely with the DOE modelers at NARAC. NRC also had a team at the U.S. embassy in Tokyo to help the Department of State interpret information related to the reactor status as well as the environmental conditions.

The Environmental Protection Agency was responsible for assessing potential impacts to U.S. territories. Its RadNet system was a key part of a nationwide environmental monitoring effort that included the rapid deployment of additional sensors to the U.S. west coast, Alaska, and Pacific territories as well as enhanced sampling frequencies, 24/7 analysis by EPA's National Air and Radiation Environmental Laboratory (NAREL) and more rapid public release of data. Sharing RadNet data was just one component of a broader communication strategy coordinated by EPA within the U.S.

The interagency Advisory Team for Environment, Food, and Health (A-Team) was formally activated; it provided consensus recommendations to both the U.S. embassy in Japan and to federal agencies and states in the U.S.



Appendix A—25 Years of FRMAC

Year	Key Real-World Events in Evolution of FRMAC	Exercises with FRMAC Participation	Major Documents, Statutes, and Federal Plans
1978	Cosmos 954 (Operation Morning Light)		
1979	Three Mile Island		1) DOE develops Federal Monitoring and Assessment Plan (FRMAP) 2) E.O. 12148 Federal Emergency Management 3) PL 96-295 NRC Appropriation Authorization
1980	Co-60 Incident, Juarez, Mexico		1) E.O. 12241 National Contingency Plan 2) NRC NUREG 0654 Criteria for Prep. And Eval. Of Rad ER Plans in support of NPPs
1983	Cosmos 1402 (Bright Light)		
1984		FFE-1 St. Lucie, FL	Draft FRERP Published
1986	Chernobyl Disaster	Humble Servant Mighty Derringer, Indianapolis, IN and NTS	
1987	Cesium-137 Incident, Goiânia, Brazil	FFE-2 Zion, IL Busy Force, Salina, KS	1) FRMAC Program assigned to Nevada Ops Office 2) EPA RERP Published
1988	Cosmos 1900	Compass Rose, Camp Pendleton, CA	1) Stafford Act Signed 2) E.O. 12656 Assignment of Emergency Preparedness Responsibilities
1989	NASA Galileo Launch	Distinct Action, Plattsburg, NY Plume-In-A-Box 2	
1990	NASA Ulysses Launch First NREP Conference	Digit Prime (SRFX-90), Seneca, NY River Bend, Baton Rouge, LA	1) Revision to FRERP Begun 2) Nuclear Accident Response Procedures (NARP Manual)
1992		PU Valley NTS Diamond Flame, CA Sierra Army Depot	1) DOE Order 5530.5 FRMAC 2) EPA-400 (Manual of PAGs and Protective Actions for Nuclear Incidents)
1993		FRMAC 93 Ft. Calhoun, NE Freemont DOE/Hanford	
1994		Handshake NTS Pantex Facility, Amarillo, TX Diagram Jump, Bangor, WA Mirage Gold, New Orleans, LA	Stafford Act Amendment
1995		Display Select, Yorktown, VA Agile Lion (Lithuania)	DOE Order 157-1 Comprehensive Emergency Management System
1996		Handshake II, SRS, SC Dial Flinty, Minot AFB, ND Digit Pace I, Albuquerque, NM	1) Revised FRERP Published 2) A-Team Incorporated into FRERP
1997	NASA Cassini Launch	Surry, Newport News, VA Bold Endeavor, San Antonio, TX Digit Pace II, Albuquerque, NM	First Edition of FRMAC Operations Manual
1998		Ventex 98, NTS	FDA Human Food and Animal Feed PAGs

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Year	Key Real-World Events in Evolution of FRMAC	Exercises with FRMAC Participation	Major Documents, Statutes, and Federal Plans
1999	Nuclear Criticality Accident, Tokaimura, Japan	Vigilant Lion, Annville, PA SONGS, San Clemente, CA Calling Birds, Hanford, WA	DOE Phased Approach adopted for CM responses
2000	Cerro Grande Fire, LANL, NM	Dingo Dawn, Seattle, WA Prime Mover, RSL-Nellis	
2001	World Trade Center Attack		CM Leadership Symposium held at RSL
2002		Diligent Warrior 02, Camp Guernsey, WY Joint Venture 02, Aiken, SC	Homeland Security Act passed
2003	NASA Mars Experimental Rover Launch	TOPOFF II, Seattle, WA	1) EPA's OEM established 2) NIMS final 3) DHS established 4) HSPD-5 issued
2004		Diligent Warrior 04, Great Falls, MT Operation Synergy, Los Alamos, CA	Initial NRP and Nuc/Rad Incident Annex published (these documents superseded the FRERP and the FRP)
2005		Dingo King, Kings Bay, GA Pinnacle 05, Washington, DC Diamond Dragon, Las Vegas, NV	1) CM Home Team established 2) CM Augmentation implemented
2006	NASA Pluto Launch	Southern Crossing, Dothan, AL CAPEX 06, Cheyenne, WY Vigilant Shield, Davis Montham AFB, Tucson, AZ	Turbo FRMAC V.2 released
2007		TOPOFF 4, Portland, OR NNX-3 07 Albuquerque, NM & Las Vegas, NV ARG/CM TTX Las Vegas, NV Ardent Sentry, Indianapolis, IN	1) DOE Order 153.1 Dept. Rad ER Assets 2) Revision of EPA PAG Manual in progress 3) CDC Population Monitoring Guidelines released
2008		Diablo Bravo, Bremerton, WA	1) National Response Framework published (replaces NRP) 2) Nuc/Rad Annex revised 3) CM Web on-line
2009		Empire 09, Albany, NY NUWAIX 09 F.E. Warren AFB, WY	Turbo FRMAC 2009 released
2010		Liberty Rad Ex, Philadelphia, PA International Search & CM Workshop, Las Vegas, NV	1) FRMAC Operations Manual revised and published 2) FRMAC Assessment Manual (Vols. 1-3) Revised and Published
2011	Fukushima NPP Incident, Japan NASA Mars Rover Launch		



Appendix B—FRMAC IPX Support and Outreach Summary

Year	IPXs	Outreaches
1986		FRMAC/FEMA Outreach, Philadelphia, PA
1990		First NREP Conference, Chicago, IL
1993	Diablo Canyon, San Luis Obispo, CA	
1996	Arkansas Nuclear One Duane Arnold, Cedar Rapids, IA Point Beach	Mirrored Image CPX, Atlanta, GA
1997	Kewaunee, Green Bay, WI Callaway, Jefferson City, MO Robinson, Columbia, SC	H.B. Robinson CPX, Hartsville, SC
1998	Prairie Island, Minn. MO Peach Bottom, Lancaster, PA Hatch, Baxley, GA Salem, Wilmington, DE Palo Verde, Phoenix, AZ River Bend, Baton Rouge, LA	
1999	Palo Verde, Phoenix, AZ Indian Point, New York Vermont Yankee, Brattleboro, VT Comanche Peak, Glen Rose, TX Sequoyah, Chattanooga, TN Browns Ferry, Athens, AL Limerick, Philadelphia, PA Grand Gulf, Vicksburg, MS McGuire, Charlotte, NC Dresden, Channahon, IL Calvert Cliffs, Annapolis, MD	Indian Point TTX, New York City Comanche Point Outreach, Glen Rose, TX
2000	Seabrook, Portsmouth, NH Robinson, Florence, SC Palisades, South Have, MI	
2001	Clinton, Clinton, IL	
2002	Duane Arnold, Cedar Rapids, IA Crystal River, Crystal River, FL Oconee, Greenville, SC Wolf Creek, Burlington, KS Davis Bessie, Toledo, OH Arkansas Nuclear One, Russellville, AR	FRMAC Technical Outreach, Augusta, GA

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Year	IPXs	Outreaches
2003	Monticello, Minneapolis, MN Watts Bar, Spring City, TN Surry, Newport News, VA Duane Arnold, Cedar Rapids, IA Ft. Calhoun, Omaha, NB Kewaunee, Green Bay, WI Millstone, Waterford, CT Oyster Creek, Toms River, NJ Salem, Wilmington, DE	
2004	Waterford, New Orleans, La South Texas Project, Bay City, TX Millstone, Waterford, CT Monticello, Minneapolis, MN Susquehanna, Berwick, PA Watts Bar, Spring City, TX	
2005	Ginna, Rochester, NY Vermont Yankee, Brattleboro, VT Grand Gulf, Vicksburg, MS Vogtle, Augusta, GA Hanford, Richland, WA Plant Farley, Dothan, AL	Palo Verde REP-05, Phoenix, AZ
2006	Palo Verde, Phoenix, AZ Braidwood, Joliet, IL Oconee, Clemson, SC Beaver Valley, McCandless, PA Fermi II, Toledo, OH Seabrook, Portsmouth, NH	EPA Table Top
2007	Wolf Creek, Burlington, KS McGuire, Charlotte, NC Harris, Raleigh, NC	FRMAC Technical Outreach, Kettle Point, RI Capitol Bridge, EPA TTX, Washington, DC Hanford 07, Richland, WA
2008	Point Beach, Manitowoc, WI Duane Arnold, Cedar Rapids, IA Sequoyah, Chattanooga, TN Columbia, Richland, WA Catawba, Rock Hill, SC North Anna, Richmond, VA Arkansas One, Russeleville, AR St. Lucie, Ft. Pierce, FL	ORNL TTX, Oak Ridge, TN RAP 3, Prairie Island, Minneapolis, MN
2009	Callaway, Jefferson City, MO Calvert Cliffs, Annapolis, MD Monticello, Monticello, MN Point Beach, Manitowoc, WI Comanche Peak, Glen Rose, TX Turkey Point, Miami, FL	NNX 1-09, Riverside, CA



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Year	IPXs	Outreaches
2010	Hope Creek/Salem NPP, NJ and Delaware Riverbend, Baton Rouge, LA Vermont Yankee, Brattleboro, VT Millstone, Waterford, CT Wolf Creek, Burlington, KS Pilgrim NPP,	Salem/Hope Creek Planning Meeting Palo Verde NPP Assessment & Outreach VT Yankee FRMAC training
2011	Palo Verde, Phoenix, AZ Fitzpatrick, Oswega, NY	Planning Meetings for San Onofre IPX (SONGS) scheduled for May 2011



Acronyms

AEC	Atomic Energy Commission
ALSG	Advance Launch Support Group
AMS	Aerial Measuring System
ARAC	Atmospheric Release Advisory Capability
ARG	Accident Response Group
ARMS	Aerial Radiation Measuring System (precursor to the AMS)
A-Team	Advisory Team for Environment, Food, and Health
CA	Coordinating Agency
CFA	Cognizant Federal Agency
CMHT	Consequence Management Home Team
CMPT	Consequence Management Planning Team
CMRT	Consequence Management Response Team
CMST	Consequence Management Support Team
DHEW	Department of Health, Education, and Welfare
DHS	Department of Homeland Security
DOC	Department of Commerce
DoD	Department of Defense
DOE	U.S. Department of Energy
DOT	Department of Transportation
DTRA	Defense Threat Reduction Agency
ECAM	Environmental Continuous Air Monitoring System
EDRE	Emergency Deployment and Readiness Evaluation
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ERDA	Emergency Research and Development Agency
FEMA	Federal Emergency Management Agency
FFE	Federal Field Exercise
FPA	Federal Preparedness Agency
FRERP	Federal Radiological Emergency Response Plan
FRMAC	Federal Radiological Monitoring and Assessment Center



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FRMAP	Federal Radiological Monitoring and Assessment Plan
FRP	Federal Response Plan
FRPCC	Federal Radiological Preparedness Coordinating Committee
GIS	geographical information system
HHS	Department of Health and Human Services
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IPX	Ingestion Pathway Exercise
IRAP	Interagency Radiological Assistance Plan
JHEC	Joint Hazard Evaluation Center
JNACC	Joint Nuclear Accident Coordinating Center
JRCC	Joint Radiological Control Center
KSC	Kennedy Space Center
LFA	Lead Federal Agency
LIMS	Laboratory Information Management System
MPCD	Multipath Communication Device
NARAC	National Atmospheric Release Advisory Center
NARP	Nuclear Accident Response Plan
NASA	North American Space Administration
NEST	Nuclear Emergency Search Team
NIMS	National Incident Management System
NIT	National Incident Team
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRP	National Response Plan
NSB	Naval Submarine Base
NSC	National Security Council
NTS	Nevada Test Site
NUWAX	Nuclear Weapons Accident Exercise
OSTD	Offsite Technical Director
PAG	protective action guide
PAR	protective action recommendation
PAST	Protective Action Support Team
RAMS	Radiological and Assessment Monitoring System

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RAP	Radiological Assistance Program
RAT	Radiological Assistance Team
RCT	Radiological Control Technician
RDD	radiological dispersion device
RHU	radio-isotope heater unit
RTG	radio-isotope thermoelectric generator
SRFX	Service Response Force Exercise
SRT	Search Response Team
TMI	Three Mile Island
TTX	table top exercise
USDA	Department of Agriculture



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