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ATMOSPHERIC RELEASE ADVISORY CAPABILITY (ARAC) RESPONSE TO THE THREE MILE ISLAND ACCIDENT

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ATMOSPHERIC RELEASE ADVISORY CAPABILITY (ARAC) RESPONSE TO THE THREE MILE ISLAND ACCIDENT

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Summary

This paper discusses the three general classes of support provided by the Atmospheric Release Advisory Capability (ARAC)[1,2] and describes the role played by ARAC in support of DOE during the Three Mile Island accident in March and April of 1979.

Introduction

In 1972, the AEC perceived that emergeney response to nuclear accidents could be improved by developing better communications, dispersion modeling, modeling of regional-scale flow systems, and pathway modeling. Lawrence Livermore Laboratory was requested to review these areas of research and develop a concept for an improved advisory service.

Since the adoption of ARAC in 1973 after a thorough technical and scientific review, LLL has directed the research, development and implementation of the ARAC advisory service as part of the DOE Emergency Response Capability. The DOE Office of Health and Environmental Research and its predecessors have sponsored the research base and the Office of Environmental Compliance and Overview provided most of the operational funds for the project.

Classes of Support

DOE Facilities

For either production or research DOE sites, data bases are developed that include geography, topography, and location of meteorological measurement stations at each facility. Population distribution and possibly land use will be included in the future. These permanent data bases are stored in the computers and are updated periodically as appropriate. Meteorological data from the Air Force Global Weather Control and the site are stored in model input format. In addition, data from each site describing potential source terms, locations of potential releases, and other information are received and catalogued in notebooks, to provide the ARAC staff with substantial detail for each site.

Presently the Savannah River Plant, Rocky Flats Plant, Mound Facility and Lawrence Livermore Laboratory/Sandia Laboratory are routinely receiving the ARAC service. Each of these DOE-serviced facilities has a minicomputer called the site-facility computer.[3] The ARAC site facilities perform several specific functions:

- Multiplex the environmental sensors.
- Provide local data quality control.
- Continuously calculate and display Gaussian diffusion estimates for close-in distances (out to approximately 10 km), using latest local meteorological data.
- Transmit local environmental measurements to the ARAC central facility.
- Receive and display regional MATHEW[4]/ADPIC[5] calculations from the central facility.

The site facilities perform the following functions without a direct data link to the central facility (in the stand-alone mode):

- Display the listing of last four hours (15-minute averages) of wind and temperature measurements for each sensor.
- Display the wind rose of latest two hours (eight 15-minute averages) of wind speed and direction measurements for each sensor.
- Calculate and display Gaussian diffusion-concentration estimates.

Interaction between personnel in the ARAC center and at the site depends on the local capabilities at each site. For the Savannah River Plant, the Atmospheric Science Group at the Savannah River Laboratory (SRL) provides excellent support for local consequences within and around the plant boundaries. In this case, the Gaussian calculation provided by the ARAC site facility backs up the SRL local capability, which also provides an initial estimate of the regional consequences with a trajectory-puff calculation on their minicomputer. The ARAC regional model calculations are used to extend and provide more detail to the trajectory-puff calculations.

At Rocky Flats and Mound Facility, which have neither an atmospheric sciences group nor an inhouse minicomputer capability, greater dependence is placed on the local capability of the ARAC site facility and the weather forecasts from the ARAC center. The regional model calculations serve essentially the same functions as at SRL.

Off-Site Incidents

Off-site responses — i.e., nuclear weapon accidents, nuclear extortion threats, or incidents at facilities not regularly serviced by ARAC — require a different method of operation, especially in the data collection for model input files and source term definitions. The Air Force Global Weather Central (AFGWC) computer link is used to obtain surface and upper-air observational data; it is also used to forecast and analyze on a global or regional basis. Within minutes, AFGWC provides access to measurements routinely collected and centrally stored for approximately 12,000 locations. With the possible exception of wind speed and direction measurements at the incident location, the input meteorological data for an off-site response are similar to those for a DOE-serviced facility. The major difference is that input files and measur ment locations must be established.

The ARAC center has on file a complete set of USGS 1:250000 global topographic maps, which are presently used to define the major geographical and topographical features of a given area. From these maps, a digitized geographical background for the computer products is generated and the major topographical features of the area are defined to calculate a crude topographical input file for the MATHEW and ADPIC computer codes. For the continental U.S., USGS tapes of terrain data are on file in the ARAC center and can be used to extact regional terrain data within a couple of hours after notification. Input terrain data will be more readily available for the MATHEW and ADPIC calculations when these data are eventually stored on disks in the ARAC center.

FAA Support

The FAA has requested that DOE provide ARAC support whenever aircraft could potentially intercept debris clouds

from Chinese atmospheric nuclear tests. Since 1976, ARAC has calculated and provided estimates to the FAA on the dose to passengers and crews of aircraft that might intercept these radioactive clouds. These calculations are now based on the 2BPUFF[6] long-range transport and diffusion computer code, using input data from AFGWC. Every 12 hours, calculations based on analyzed and forecast winds at the appropriate levels in the troposphere and/or stratosphere are sent to FAA headquarters by telecopier. The FAA uses these calculations to determine whether any deviations from normal flight operations are required to minimize the dose to passengers and crew.

Response to TMI Accident

At 0820 PST on March 28, the DOE Emergency Operation Center alerted ARAC to the fact that the Three Mile Island Unit No. 2 in Harrisburg, Pa., had had a release some four hours previously in the form of steam and an unknown level of radioactivity and total heat content. The center was asked by DOE to respond with regional calculations of the temporal distribution of the radioactivity since the inception of the incident, and to come up to real-time simulation as quickly as possible. Because the alert was late, and because Middletown, Pa. is not a normally serviced ARAC site, meteorological and terrain information were not available immediately. After three hours we produced the past and currently projected temporal distributions of the released radioactivity out to a range of some 60 km.

Some 12 to 18 hours into this event, the ARAC staff had processed detailed topographic data for the Harrisburg region. These data were then input as boundary conditions to both the regional flow model and the transport-diffusion model for all calculations of temporal radionuclide distribution for the next 20 days.

By the morning of March 29, an LLL ARAC field representative was at Harrisburg to interpret the ARAC results and to advise the DOE emergency response site commander. On March 31, a second LLL ARAC representative was sent to Harrisburg. These individuals played a role in designing suitable and effective deployment of the environmental monitoring systems that became available during the course of the incident. After one week, representatives from National Oceanic and Atmospheric Administration, Idaho Falls, Id., and SRL were called on to support the DOE on-scene commander.

Figures 1 through 6 illustrate typical calculations provided to the ARAC representatives at Harrisburg. Figure 1 is a x-y view looking down on the ADPIC marker particle distribution produced by the ADPIC transport and diffusion model using transport wind fields provided by the MATHEW mass-consistent wind field model. This view shows the particle locations at 1400 hrs EDT on April 1 based on meteorological data observed through 1200 hrs. Figure 2 shows the instantaneous air concentration, 65m above the terrain, calculated from the marker particle distribution shown in Fig. 1 and based on a normalized continuous unit rate release. Other calculations (not shown) available to the field representatives were integrated concentrations at 2m above terrain and instantaneous concentrations 150m above terrain. Figures 3-6 are similar to Figs. 1 and 2 except they are valid for 1500 hrs. and 1600 hrs. EDT respectively.

Calculations like those shown in Figs. 1-6 were produced each hour from approximately 0800 hrs. EDT to approximately 2000 hrs. EDT each day until the intensity began to diminish in accordance with operational requirements. These calculations were available to the ARAC field representative within 50 minutes to 1 hour after the meteorological data observation time. During the remaining 12 hours of the day meteorological data were collected and stored in model input format so that calculations could have been made in a timely manner if required.

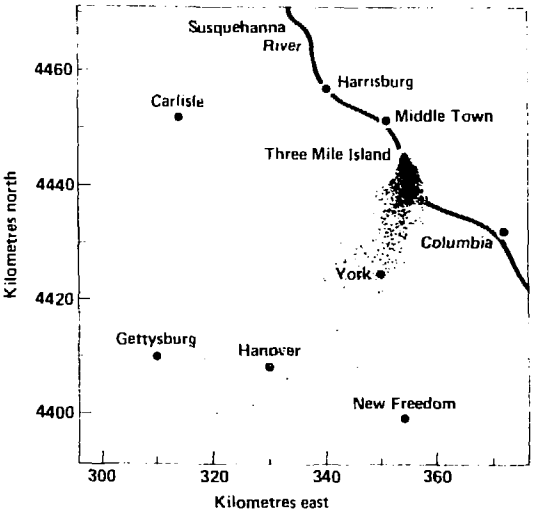

Fig. 1. ADPIC marker particle locations for a continum unit rate release viewed in the x- , y-plane for April 1, 1400 EST, based on meteorological data observed through 1200 hrs.

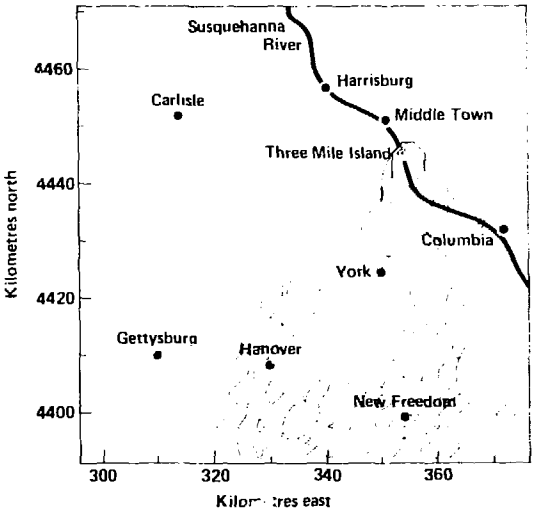

Fig. 2. Instantaneous air concentration (s/m^3) contours, 65 m above terrain, calculated from the marker particle locations for the continous unit rate release shown in Fig. 1.

Services provided by ARAC during and after the TMI accident fall into the following five categories:

- Provide guidance on the deployment of ground and to some extent air monitoring resources.
- Estimate of source term.
- Advise FAA with respect to air corridor safety.
- Screening of data for consistency.

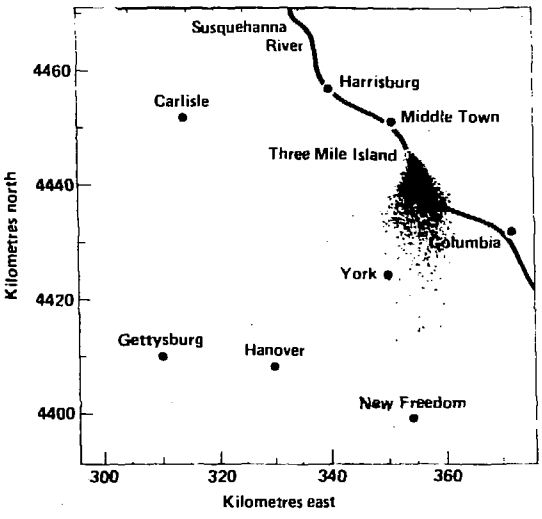

Fig. 3. Same as Fig. 1 except for April 1, 1500 hrs. EST.

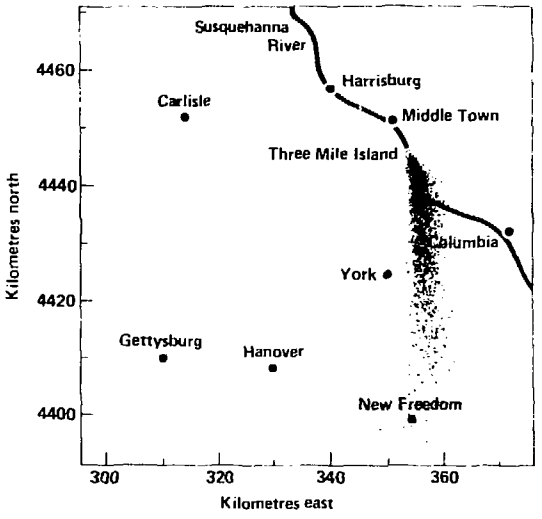

Fig. 5. Same as Fig. 1 except for April 1, 1600 hrs. EST.

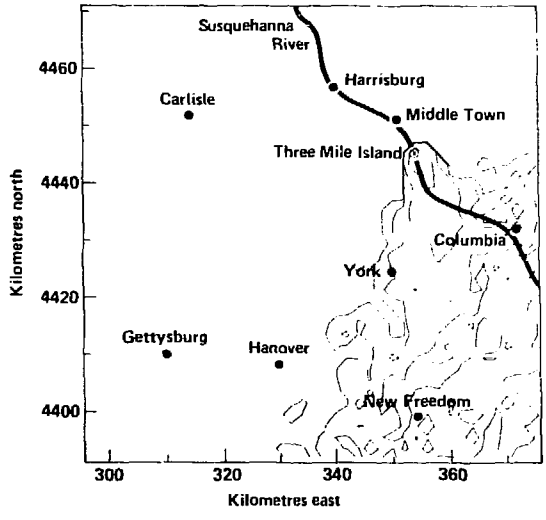

Fig. 4. Same as Fig. 2 except based on Fig. 3.

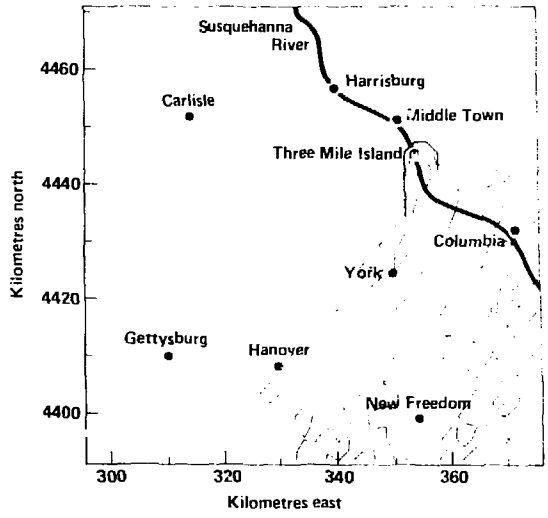

Fig. 6. Same as Fig. 2 except based on Fig. 5.

- Detailed person-rem calculations several months after the accident.

Each morning the ARAC calculations coupled with the National Weather Service forecasts were used to deploy monitoring teams to areas covered by the plume during the previous night and to deploy teams scheduled to make measurements during the day. As the day progressed forecast and observed changes in meteorological conditions were relayed to the field.

Airborne measurements were used in conjunction with model output data shown in Figs. 1, 3, and 5 to quantitatively compare the location of the radioactive material to the model predictions.

The model calculations, shown in Fig. 2, 4, 6, were used in conjunction with the airborne measurements to estimate the average source term over a period of several hours. These estimates were factored into the integrated air concentration calculations to estimate the dose for 12 hour periods.

The FAA used ARAC calculations during this time to determine if low-level flight plans of aircraft in the vicinity of Harrisburg should be modified to minimize exposure to passengers and crews. For this purpose, the FAA was in direct contact with the ARAC center for the required information and guidance.

Each afternoon the DOE and several other agencies making radiological measurements in the area would meet to

discuss the day's activities. At this time the data taken in the field and model calculations were discussed and carefully checked for consistency.

Recently the MATHEW/ADPIC models have been used to carefully estimate the population dose resulting from the TMI accident. Results of these calculations should be available later this year.

Conclusion

Since the TMI accident the DOE ARAC service has received considerable interest from Federal Agencies, State and Local Officals and private utilities. Although no definite plans have been formulated at this time, the experience at TMI has shown that the concept of a real-time advisory service for nuclear incidents is viable. Perhaps all or part of this technology, developed under DOE sponsorship, can be applied to the private sector.

Acknowledgments

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References

1. M. H. Dickerson and R. C. Orphan, "Atmospheric Release Advisory Capability," Nuclear Safety 17, 281-289 (1976).

2. M. H. Dickerson and R. C. Orphan, "Atmospheric Release Advisory Capability," Nuclear Safety 17, 281-289 (1976).

3. B. S. Lawver and R. C. Orphan, Operators Guide: Atmospheric Release Advisory Capability (ARAC) Site Facility, Lawrence Livermore Laboratory, Rept. UCID-17490 (1977).

4. C. A. Sherman, "A Mass-Consistent Model for Wind Fields Over Complex Terrain," J. Appl. Meteor. 17, 312-319 (1978).

5. R. Lange, "ADPIC—A Three-Dimensional Particle-in-Cell Model for the Dispersal of Atmospheric Pollutants and Its Comparison to Regional Tracer Studies," J. Appl. Meteor 17, 320-329 (1978).

6. T. V. Crawford, A Computer Program for Calculating the Atmosphe. Dispersion of Large Clouds, Lawrence Livermore Laboratory, Rept. UCRL-50179 (1966).