containing perfluorocarbon tracers every 5 minutes. It can detect perfluorocarbon tracers at their ambient levels with 15 percent accuracy essentially in real time.

The third prototype sampler is a real-time continuous monitor intended primarily for use in aircraft sampling. Air is drawn through a catalytic reactor that removes the oxygen and other electron absorbers, leaving the perfluorocarbons and nitrogen in the remaining air. This air is passed directly to an electron-capture detector that provides continuous readout of perfluorocarbon concentration with only a 3-second delay. When completed, this sampler should yield accuracies of 0.1 parts/trillion in measuring perfluorocarbon traces.

History In the early 1970's, the only available atmospheric tracer with acceptable physical properties was SF_6. The difficulty in measuring trace amounts of SF_6 against natural and man-made backgrounds limited its usefulness to a range of about 150 kilometers. Recognizing the need for longer-range tracers, OHER initiated research into two tracer types:

1. *Perfluorocarbon tracer.* Investigations reported by 1974 indicated that a perfluorocarbon tracer system could be developed that would be ideal for long-range dispersion studies. The NOAA Air Resources Laboratories contracted with Lovelock to develop the three different samplers as the first step in the development of the new tracer system. Prototype instruments were delivered by Lovelock in 1976. Since then the laboratory has been working closely with DOE's Environmental Measurements Laboratory (EML) and BNL in a cooperative effort to develop a practical perfluorocarbon system.
2. *Heavy methane tracer.* Following the observation that air contained an insignificant number of atoms with an atomic mass of 21, Los Alamos initiated work in 1973 to develop a tracer with that atomic mass by synthesizing carbon-13 and deuterium into heavy methane, CD_4. Both carbon-13 and deuterium are available from other Los Alamos programs. Concurrently, scintillation techniques for detecting single ions using mass spectrometry were being developed at the Atomic Weapons Research Establishment (AWRE), United Kingdom. After the initial tests of heavy methane tracers at AWRE were completed, OHER funded the development of a mass spectrometer analytical capability at Los Alamos to measure the tracer levels in ecological samples.

Several field experiments have been conducted to test the perfluorocarbon and heavy methane tracer systems. The most important of these were two demonstrations conducted in July 1980. In the first demonstration, SF_6 perfluorocarbons and heavy methane tracers were released and sampled at distances of 100 and 600 kilometers. The second trial used only perfluorocarbons and SF_6 with sampling only at 100 kilometers.

The key issue to be resolved by the experiments was whether the tracers and the analysis systems were similar; that is, if equal amounts of the two perfluorocarbons were released, would equal amounts be detected at every location? Even more crucial were the direct comparisons of different tracers, such as the perfluorocarbons and the heavy methanes.

The experiments proved that the perfluorocarbon and methane tracers behaved the same in the atmosphere, faithfully following the air motions and remaining in the air streams out to 600 kilometers from the source. Considering that the heavy methane and perfluorocarbon determinations are conducted by totally different analysis techniques (mass spectrometry for the methane and gas chromatography followed by electron-capture detection for the perfluorocarbons), these results inspired confidence in both tracer systems.

Benefits Atmospheric tracers are a recent development that may find applications in several research areas. These tracers allow the validation of computerized models to describe atmospheric transport and dispersion, as well as the investigation of fundamental aspects of dispersion or dynamic meteorology not accessible by other means.

These tracers will find applications in facility siting and empirical studies of specific situations where there is no adequate model of the dispersion of emissions or when existing models are inadequate because of the complexity of the terrain. For example, in a recent DOE study of drainage winds in complex terrain, the tracers were used to determine the capability of existing wind patterns to remove pollutants vented from geothermal wells.

Aerosol Instrumentation, Dry Deposition, and Resuspension In an effort to predict the fallout of minute particles of radioactive debris from weapons tests, research was undertaken in the science and technology of aerosols. Subjects studied include particle behavior in the stratospheric air, tropospheric interactions with rain and snow, and deposition in lungs from inhalation.

Dry deposition is the process by which particles and gases are transferred to the earth's surface from the air. Research into dry deposition has made possible the development of predictive models that relate deposition velocity to particle diameter. Although these models still contain considerable predictive error, the results are typically an order-of-magnitude improvement over earlier practice.

Resuspension is the process by which particles and gases become reintroduced into the air from the earth's surface. Research into particle resuspension has made possible the development of models to predict resuspension rates, which are used as boundary conditions in air transport models needed to reliably predict what will occur downwind.