J4.8 MAPIT: AN AIRBORNE SYSTEM FOR URBAN ENVIRONMENTAL MONITORING

Randolph J. Evans*, Joseph Dreher, John Manobianco, and Mark Adams
ENSCO, Inc., Melbourne, FL

1. INTRODUCTION

Integrating real-time sensor data to analyze and predict chemical and biological (CB) threat clouds using existing transport and dispersion models is a challenging problem especially when the location and amount of CB releases are unknown. We describe a new paradigm for observing and predicting threat clouds using large numbers of low-cost, disposable probes for maximum detection capabilities in a system called Mobile Airborne Probes for Identification and Tracking (MAPIT).

Three-dimensional meteorological and air quality data are essential for accurate mapping and modeling of transport and dispersion of pollutants and toxic materials within the urban-scale environment. Collecting the three-dimensional data, especially above the ground, can require extensive resources and sampling networks that may not be feasible for certain urban areas. The Joint Action Group for Atmospheric Transport and Diffusion (ATD) Modeling (OFCM 2004) recommended improvements for data collection such as:

- Some sensing systems must be mobile, rather than fixed at one location.
- Measurement capabilities are needed at or below the scales of interest for model predictions.
- Instrumentation is needed that can measure concentrations as a function of time and distance from a release point, as well as measuring air transport and diffusion parameters.

Dabberdt et al. (2004) state that “more extensive measurements of meteorological parameters and chemical composition are needed to support data assimilation, air quality forecasting and air quality forecast model evaluation. Data on winds and turbulence, air temperature, and concentration would be the most valuable.”

*Corresponding author address: Randolph Evans, ENSCO, Inc., 4849 N. Wickham Rd., Melbourne, FL 32940. e-mail: evans.randy@ensco.com

2. CONCEPT DESCRIPTION

The MAPIT concept is an offshoot of a new observing system called Global Environmental Micro Sensors (GEMS) (Manobianco 2002; Manobianco et al. 2003, Manobianco et al. 2004, Evans et al 2004, Dreher, 2006).

The MAPIT system features wireless, in situ, buoyant airborne probes designed for urban-scale environmental monitoring. The constant altitude probes will likely be spherical or disk shaped and filled with lighter-than-air gas, such as helium, to provide buoyancy. Initial prototypes assembled with commercial-off-the-shelf components will have a total mass of approximately 70 gm and diameter of 50 cm. The probes will measure pressure, temperature, humidity, wind velocity, and possibly ozone, carbon dioxide, or other trace gases. While MAPIT will likely complement current and even next-generation in situ sensors and remote sensing platforms, the system has the capability to provide a 100-fold increase in three-dimensional planetary boundary layer observations especially in urban environments. An artist’s conception of the MAPIT probes and their deployment is shown in Figure 1.

3. RELEASE LOCATION DETECTION SIMULATION

A simulation experiment was conducted to determine the location of a chemical release of unknown origin. The experiment was conducted by releasing a simulated chemical within the city of Atlanta and simulated probes upwind of the city (Figure 2). The probes were assumed to have chemical sensors to simulate atmospheric concentration measurements. The chemical release was modeled using the Short-range Layered Atmospheric Model (SLAM) (Atchison and Kienzle 2002). This simulation of the MAPIT system is described in the following section.

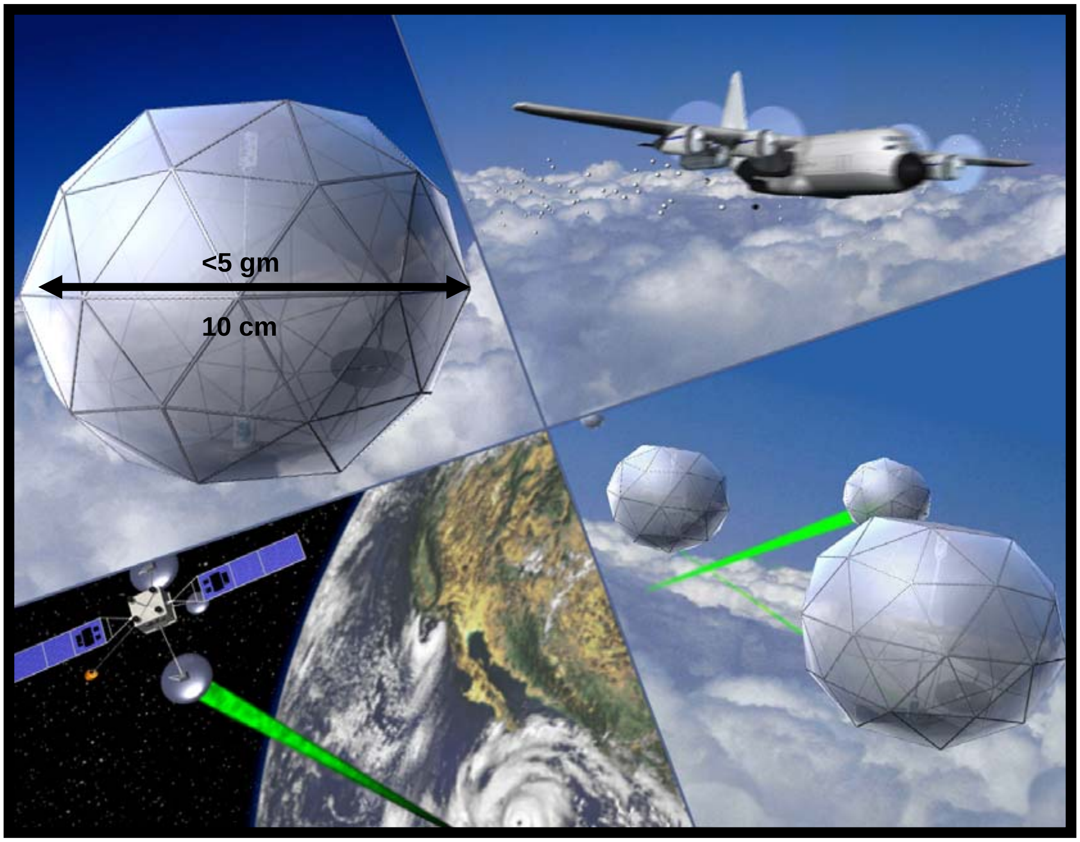

Figure 1. Conceptualization of GEMS illustrating both global and local distribution of probes with communication and networking between probes and data collectors.

The first step in the experiment was to simulate the chemical release from a location in downtown Atlanta with SLAM. The release time was set at 1500 UTC on 4 July 2000 (Fig. 2a). Meteorological data for the simulation was provided by the Regional Atmospheric Modeling System (RAMS) (Pielke et al. 1992). Low-level northwesterly winds of ~10 m s^{-1} transported the threat cloud southeast as shown by the instantaneous concentration isopleths at 15-minute intervals from 1515 – 1615 UTC (Fig. 2a). For the simulation, three fixed samplers were located approximately 35 km southeast of the source (red triangles; Figs. 2a, b). With this scenario, the threat cloud was detected 75 minutes after release.

Without knowing the exact release point, it would be possible to estimate the source somewhere within a ~6400 km^2 area upwind of the samplers (green shading; Fig. 6b) using data collected at the three fixed samplers. However, estimating the precise release time or the amount of the release would be a considerable challenge with data from only the three samplers.

The second step in the experiment was to simulate the release of MAPIT probes in a scenario that would mimic how probes might be deployed in an operational scenario. By using the MAPIT system, four probe deployment locations were placed upwind of Atlanta and released beginning at 1300 UTC (squares; Fig. 2b). The probe releases were simulated using the HYbrid Particle And Concentration Transport (HYPACT) model (Walko et al. 2001). The low-level winds transported and dispersed the probes to yield significant areal coverage by 1615 UTC (black dots; Fig. 2b). At the time of the chemical release (1500 UTC), probes moving over the source region provided data to estimate the release time to within 15 minutes and the source location to within ~ 30 km^2 (blue area; Fig 2b). These estimates were derived from the time and location when the network first detected the presence of a chemical agent. Once the threat cloud was detected, the subsequent observations were used to characterize the dispersion and fate of the plume (black outlines; Fig. 2a).

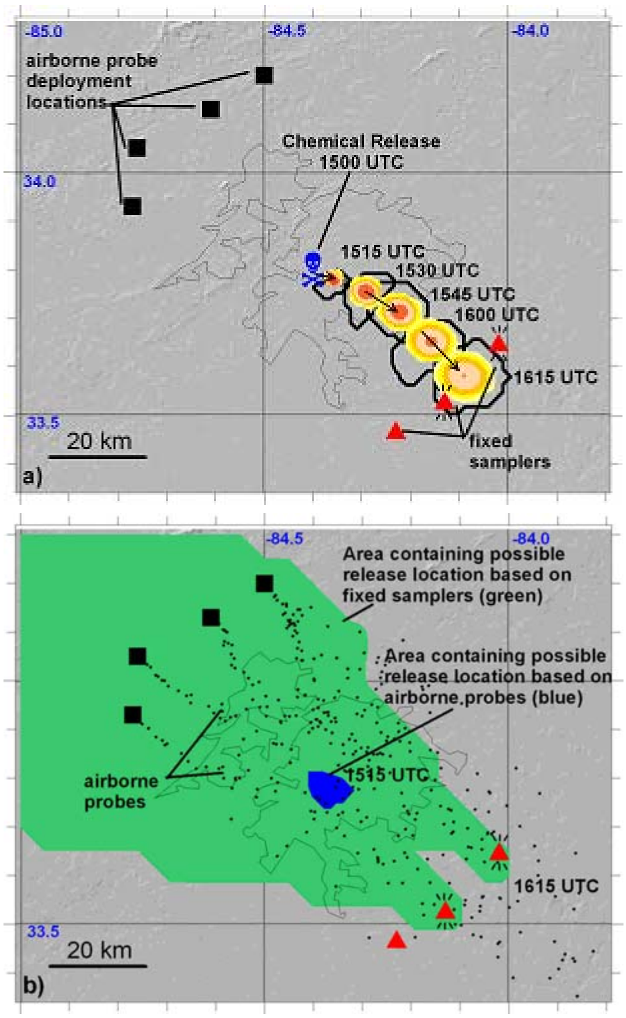

Figure 2. Maps showing: a) chemical release and transport/dispersion of cloud toward fixed samplers, and b) areas containing possible release location based on fixed samplers (green) and airborne probes (blue).

4. CONCLUSIONS

This paper described an application of the MAPIT system for urban-scale environmental monitoring. Simulations were conducted to determine the feasibility of using the probes equipped with chemical-measuring sensors to locate the origin of an unknown source. The results of the simulations showed that if the probes were deployed in optimum configuration and were equipped with chemical-measuring sensors, they could be used to detect the location of a chemical release when that location was not known.

Future work will focus on combining the meteorological and chemical data from MAPIT to identify the source and to visualized four-dimensional evolution of chemical threat clouds in real-time. Additional examinations in the future will focus on determining the sensitivities to data density and assimilation strategies including the use of different mesoscale models to generate the wind field for the threat cloud dispersion and the probe deployment simulation. Prototype probes will be built and tested as MAPIT progresses.

5. REFERENCES

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