2. Proposal Description

This proposal describes a plan for a new collaboration between Dr. Al Robbat (Chemistry), Dr. John Durant (Civil and Environmental Engineering), and Dr. Doug Brugge in (Public Health and Community Medicine) to study organic and inorganic pollutants in urban air using a novel mobile monitoring platform equipped with rapid-response instruments.

A. Background

Exposure to traffic-related air pollution is a concern in the US where ~10% of the population lives within 300 m of major roadways (>20,000 vehicles per day) [1-7]. In 2008, for example, 1,300 coronary heart disease deaths were attributable to traffic density and 430 deaths to residential proximity to a major road in southern California [8]. These numbers are expected to increase as our population ages despite predicted improvements in air quality. Key research questions related to traffic pollution exposures include: (1) elucidating the most toxic pollutants in the mixture of gases and particles in vehicle exhaust; (2) determining if exhaust gases and particles work together (additively, synergistically) to impact human health; (3) measuring the extent to which gases and particles are transformed during atmospheric transport between busy roadways and downwind residential areas; (4) estimating the effectiveness of programs aimed at mitigating exposure and reducing risks from exposure to traffic-related air pollutants.

In 2007, Dr. Durant and Dr. Doug Brugge (Tufts School of Medicine), along with other Tufts colleagues and community partners, received a grant from the National Institute of Environmental Health Sciences (NIEHS) to support the Community Assessment of Freeway Exposure and Health (CAFEH) study. The goal of CAFEH is to study the association between exposure to air pollutants from highway traffic and indicators of cardiovascular health risk in near-highways communities. To obtain air pollution monitoring data we used funds from CAFEH to purchase and equip the first mobile Tufts Air Pollution Monitoring Laboratory (TAPL 1.0). TAPL 1.0 is a recreational vehicle that we converted into a mobile monitoring platform that contains rapid-response instruments to measure both gases and particles in motor vehicle exhaust (**Figure 1a**). An example of the kind of data we have collected is show in **Figure 2** for the Big Dig Tunnel in downtown Boston. Our data collection efforts with the TAPL have supported four PhD theses, four MS theses, four senior honors theses, seven referreed journal articles [9-15] (with several more in progress (e.g., references 16, 17)), and it has helped to leverage over $6 million in funding from federal agencies and foundations.

B. Tufts Collaborates Project Goals

The goal of our Tufts Collaborates! project is build upon the success we have had with TAPL 1.0 by adding to the team Dr. Robbat and his substantial expertise in organic pollutant analysis. Dr. Robbat is a pioneer in the development of field-transportable instruments (i.e., gas chromatographs and mass spectrometers) and software that allow rapid, on-site characterization of organic pollutants in air. The collaboration with Dr. Robbat will allow us to refine our analysis of health risks related to organic pollutant exposures and gas-to-particle transformations that we were unable too characterize with TAPL 1.0. This new capacity would position us to contribute to near-roadway environmental science and epidemiology in ways that few other investigators can.

C. Activities and Experiments

During the Tufts Collaborates! project we will perform the following three activities. First, we will purchase and equip a new mobile monitoring vehicle. This step is necessary because TAPL 1.0 is nearing the end of its useful life (it is 15 years old) and it was not designed to perform organic analysis. Specifically, because we plan to measure organic fuel-constituents and organic combustion byproducts in air, many of which are present in the exhaust produced by the gasoline-burning TAPL 1.0 and its electricity generators, we must take steps to avoid self-monitoring of our own exhaust emissions. To do this we will purchase a pre-owned Toyota RAV4 electric-powered SUV (**Figure 1b**). We will also purchase and install batteries and a DC-to-AC inverter to power the instruments in TAPL 2.0. We will then move our existing suite of air monitoring instruments and inlet lines from TAPL 1.0 and install them in TAPL 2.0 along with Dr. Robbat's field-portable mass spectrometer. Second, using the new TAPL 2.0 we will conduct experiments to characterize organic pollutants including polycyclic aromatic hydrocarbons, known carcinogens and mutagens, in residential areas downwind of the Big Dig Tunnel exits in South Boston and the North End under different weather and traffic conditions. Based on our measurements with TAPL 1.0 we know that the tunnel is a significant (huge!) source of inorganic pollutants to the air in these communities (**Figure 2**); however, no work has been done to actually measure pollutants from the tunnel in these communities. Third, we will use our preliminary data from South Boston and the North End to design a hypothesis-driven study to characterize human exposures and test associations with cardiovascular health effects. We will submit this proposal at the end of the Tufts Collaborates! funding period as an R01 application to the National Institutes of Environmental Health Sciences (NIEHS). We will be assisted in this effort by Dr. Brugge who, as a public health researcher, has had considerable success in writing proposals to NIH. Also, since the start of CAFEH we have partnered with Chinatown community organizations, and we see great potential for new partnerships with community organizations

in South Boston and the North End; therefore, during the preliminary data collect period, we will actively seek out new partner organizations in these communities.

Figure 1. (a) the Tufts Air Pollution Monitoring Laboratory (TAPL 1.0); (b) the proposed new TAPL 2.0.

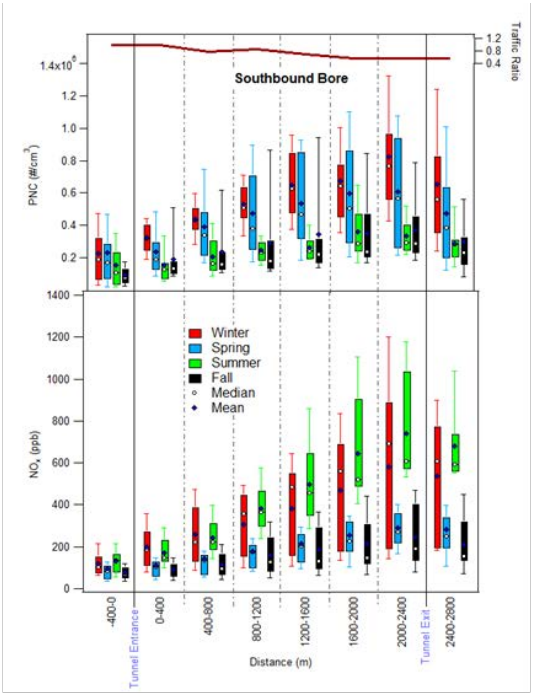

Figure 2. Particle number concentration and nitrogen oxide measurements made with the TAPL 1.0 in the Big Dig Tunnel in Boston [9].

D. Expected Outcomes

Short-term outcomes: The proposed Tufts Collaborates! project will help generate preliminary data and establish a multidisciplinary team of Tufts scientists and engineers to design new, cutting-edge traffic-related air pollution health studies. The PI, Dr. Durant, has worked with Dr. Brugge on the CAFEH study for many years. The addition of Dr. Robbat, a chemist who has considerable expertise in designing and using field-transportable instrumentation to measure organic pollutants in air, will enhance the ability of the team to test hypotheses related to air pollution exposures. Drs. Durant and Brugge have not worked together with Dr. Robbat prior to this study. Collaborates! funding will support a three-school project and provide an opportunity for the three groups to work with together to address a critically important global problem. In addition, it is expected that by the end of our Tufts Collaborates! project (July 1, 2017) we will have successfully developed TAPL 2.0, collected sufficient air pollution measurements in residential areas of South Boston and the North End (downwind of the Big Dig Tunnel exits) to support development of an R01 proposal to NIEHS, and made substantial progress on preparing the proposal for submission to NIEHS in October 2017. Also, by the end of the Collaborates! funding period we expect to have made substantial progress identifying and communicating with potential community-partner organizations in South Boston and the North End.

Long-term outcomes: Based on our track record in CAFEH with TAPL 1.0, we expect similar measures of productivity as a result of the proposed Tufts Collaborates! study. Specifically, it is anticipated that investment in TAPL 2.0 and the collaboration of Drs. Durant, Robbat and Brugge and will – during the 6-7 year expected lifetime of TAPL 2.0 – yield 2-3 major proposals per year (e.g., NIEHS, HUD, EPA, NSF), 2-4 PhD students, and 8-10 articles in peer-reviewed journals.

E. Timeline

Activity	Months 1-3	Months 3-6	Months 6-9	Months 9-12
1. Purchase vehicle				
2. Purchase and install electrical system in TAPL 2.0				
3. Install air monitoring equipment in TAPL 2.0				
4. Collect preliminary measurements				
5. Grant proposal to NIEHS				

3. Additional Proposal Information

The proposed Tufts Collaborates! project will help establish a multidisciplinary team of scientists and engineers that will design studies to assess the effects of traffic-related air pollution exposures on cardiovascular health, and write a competitive proposal to the National Institute of Environmental Health Sciences (NIEHS). The mission of the NIEHS is to "discover how the environment affects people in order to promote healthier lives" (http://www.niehs.nih.gov/about/). The NIEHS supports a wide variety of research including air pollution toxicology and epidemiology. The key collaborative multidisciplinary team members are:

Dr. John Durant is a registered professional engineer and also a faculty member in the Department of Civil and Environmental Engineering. His research interests are in the characterization of effected environments, and in the development and implementation of engineering solutions to mitigate public health impacts. In this Tufts Collaborates! project Dr. Durant has the opportunity to partner with established researchers in chemistry and epidemiology to help discover how air pollution impacts cardiovascular health.

Dr. Al Robbat is on the faculty in the Department of Chemistry. He is an analytical chemist with more than two decades of experience designing and building complex instruments for remote monitoring applications. Dr. Robbat designed the first mobile GC/MS, and he developed the first adaptive sampling and analysis plan used to expedite hazardous waste site investigations, which became the foundation for EPA's TRIAD strategy for analyzing hazardous compounds in the field.

Dr. Zinoviy Kataenko is a technician Department of Chemistry who has worked in the Robbat lab for 20 years. Dr. Kataenko built the mobile GC/MS instrument and air sampling probes.

Dr. Doug Brugge is the PI of the Community Assessment of Freeway Exposure and Health Study (CAFEH) and a faculty member in the Department of Public Health and Community Medicine. CAFEH is a series of studies looking at the relationship between traffic-related pollution and cardiovascular health in the Boston area. Thus, Dr. Brugge brings extensive experience with epidemiological studies on pollution and health to this project.

Additional Methodologies: Dr. Robbat has already developed a sampling probe for his GC/MS, that can collect both volatile and semivolatile organic chemicals present in soil vapor. An example of the kind of data that can be obtained with this system is shown **Figure 3** for soil gas beneath a coal-tar contaminated site. Each peak in the chromatogram represents a different volatile or semivolalite polycyclic aromatic hydrocarbon (PAH). Many of these same PAH are present in traffic exhaust and are detectable in urban air. In the proposed project, Drs. Robbat and Kataenko will modify the sampling probe so that it can be used for air pollution monitoring. In addition, Drs. Robbat and Kataenko will modify the original data aquistion software (developed for soil gases) to produce quantitative data for toxic pollutants in air. Dr. Kataenko will perform the majority of this work, with Dr. Robbat acting as his supervisor. Because Dr. Kataenko built the first soil gas sampling probe and he is very qualified to perform the required modifications.

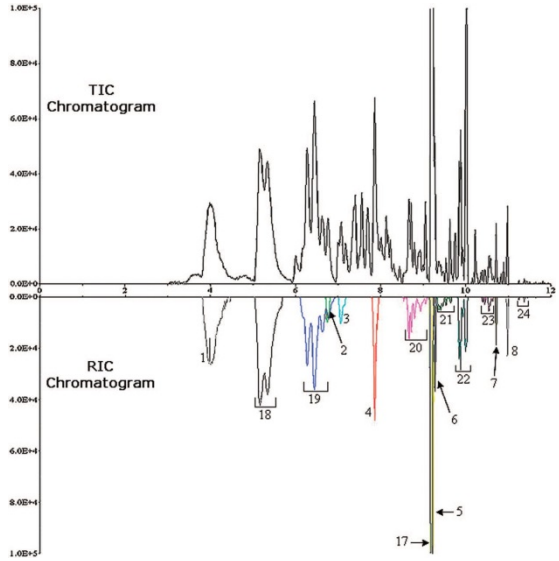

Figure 3. Total ion chromatogram (TIC) and reconstructed ion chromatogram (RIC) for a soil gas sample [18].

Once the TAPL 2.0 has been built and tested locally (Tufts parking lots), it will be deployed in South Boston and the North End to monitor emissions from the Big Dig Tunnel. The TAPL will be driven 1-2 km downwind of the tunnel to measure the extent to which pollutant concentrations decrease with distance from the tunnel exit. To measure how far the plume spreads as it moves downwind, we will drive the TAPL back and forth perpendicular to the plume direction through the study neighborhoods. Measurements of gases (NO/NO_x, CO) and particles (number concentration, black carbon, PM2.5) will be collected using our conventional instruments; measurements of organic compounds (e.g., gasoline and diesel fuel constituents, PAHs) will be collected using the GC/MS. We plan to drive this circuit 2-3 times per day on at least three week days per neighborhood in winter and in spring to characterize different temporal scales of varition in air pollution concentrations. This study design is very similar to what used in CAFEH, and we are confident that it will yield an excellent preliminary dataset that can be used to support our R01 application to NIEHS.

The electric vehicle will be recharged using the Tufts electric vehicle charging stations in the Aidekman Arts Center parking lot and in the Dowling Hall parking garage (http://www.plugshare.com). It is expected that TAPL 2.0 will be supported by Public Safety at Tufts in the same manner that TAPL 1.0 is currently being supported (e.g., annual inspections, registration, routine maintenance). The vehicle will be insured by the university.