# What's in your air?

May 9 2014, by Denise Brehm

Katie Spies works on the internal wiring on a CLAIRITY node. Credit: Eben Cross

Every senior at MIT has come to know the campus in a personal way, having established favorite haunts for studying, eating, resting, and playing during their four years at the Institute. But the Course 1 Class of 2014 is getting to know the campus on an even more intimate level, and wants to share that with others.

These students in the MIT Department of Civil and Environmental

Engineering (CEE) just completed deployment of a highly sophisticated air-quality monitoring network that covers most of the 0.25-square-mile campus. The network, called CLAIRITY, has 24 indoor and outdoor sensor nodes that continuously measure gases and the small particles found in air pollution and send these data via wireless to a central computer. They formally launched the network and its web portal in a public presentation May 6 in Room 46-3002.

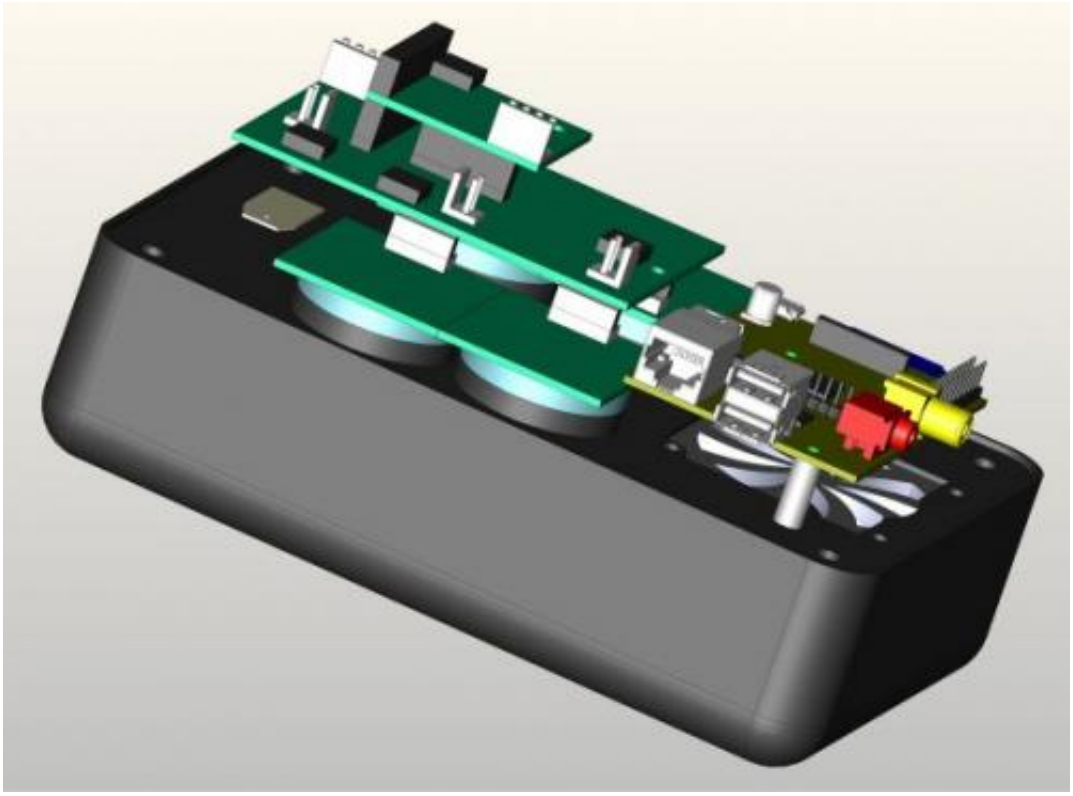
The network represents two semesters of work for the students, who designed, built, and deployed the network as the capstone project in the CEE engineering design subject. They worked at Beaver Works, a joint facility of MIT Lincoln Lab and MIT's School of Engineering, located in Technology Square.

Air-quality networks like CLAIRITY, and other new types of innovative infrastructure, provide information essential to the design of smarter cities, a major goal of civil and environmental engineers.

"This project exemplifies the very best in our students, to take a project from an idea, to a plan, to implementation," says CEE department head Markus Buehler, a professor of civil and environmental engineering. "I congratulate the Class of 2014 on this major accomplishment, and am excited about the potential impact of this new technology."

## Smart cities need better air-quality monitoring

Air pollution is the leading environmental cause of premature death and a major contributor to chronic illness like asthma, particularly in congested urban areas with dense vehicle traffic. This is true in U.S. cities and even more so in many developing countries where the rapid rise in automobile use is leading to dangerously high levels of airborne particles and gases.



Graphic showing a CLAIRITY node without the 3-D printed casing.Credit: CLAIRITY Hardware Team

In the United States, the Environmental Protection Agency (EPA) monitors air quality by measuring levels of particulate matter and gases defined by the Clean Air Act. In Massachusetts, the Department of Environmental Protection (DEP), following EPA protocols, has deployed sensors at 28 monitoring stations strategically placed across the commonwealth. Five of these monitoring stations are in Boston. Most cities, including Cambridge, have no DEP monitoring stations.

Thanks to the CEE students, the MIT campus now has its own network that provides extremely high-resolution, precise data—each sensor is calibrated using a state-of-the-art lab system—on par with the DEP

monitoring stations. But a monitoring station in the DEP's statewide network is more than 50 times as expensive as nodes in the CLAIRITY system, each of which cost only $1,500 to build.

The MIT network measures ozone, carbon monoxide, nitric oxide, nitrogen dioxide, and small particles like soot, dust, and pollen that can increase risk of lung and heart disease. The web portal shows a map indicating air health at each node, and displays data from one or more sensor nodes as a graph, in time intervals of the user's choice, and makes these data downloadable as a CSV file. The site automatically refreshes every 10 seconds.

CLAIRITY reports that air on the Cambridge campus is relatively clean. The network picked up the occasional blast of gas and particles related to heavy vehicle traffic at certain points in the day – events that standard hourly monitors tend to average out, rather than report. It also recorded bursts of pollution at some indoor nodes, as well as outdoor pollution events that affected the entire Boston area.

The inexpensive network—now operational—could serve as a template for air-quality monitoring in other cities, even the more polluted cities throughout the developing world.


A CLAIRITY node deployed at the Kresge parking lot. Credit: Eben Cross

## Hands-on project from start to finish

The students conceived of the project, created the initial design, and built the first prototype of their sensor node in the fall 2013 semester. This spring they fine-tuned the design, purchased the parts, assembled the gas sensors, placed a commercial laser particle sensor and microprocessor on each node, and then 3-D printed the housing for the sensors, as well as the weather-protection casing that covers the entire node.

"The seniors really rose to the challenge of this class, dedicating

extensive time and energy to learning new skills and working through a problem from design to implementation and all the hiccups along the way," says associate professor Colette Heald, who taught the class with lecturer Eben Cross and associate professor Jesse Kroll. "This network is a tremendous accomplishment, and something that we hope will be a part of the legacy of the CEE Class of 2014."

The class divided into five teams, each with primary responsibility for one aspect of the project. The hardware team selected, purchased, designed and 3-D printed, and assembled the sensor nodes. The software team wrote the code used by each Raspberry Pi microprocessor to decipher data and forward it to the central computer. The calibration team translated voltage into concentration volumes, and then calibrated the continuous sensor data against high-fidelity instruments. Students on the deployment team installed all 24 nodes, and wired them to power connections. The communications team built and populated the web portal and translated data into easily understandable formats.

Daphne Basangwa, a member of the hardware team, says that "seeing the different teams' representatives working together to reach a common goal" and "knowing this is how it will work in real life" injected the project with a sense of reality.

"Just keeping track of the email threads from all the people involved" in installing the 24 nodes was a challenge, says Linda Seymour, a member of the deployment team. "But the people we're working with on installation are great. We're meeting some of the people who make MIT function, like the electricians and the people who run the Tech shuttle."

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