The Array of Things

Pete Beckman, Rajesh Sankaran, Kathleen Cagney, Mike Papka, Rob Jacob, David Carhart, Douglas Pancoast, Brenna Berman, Daniel Work, Kate Kusiak Galvin...

A collaborative project: Argonne National Laboratory, the University of Chicago, and the City of Chicago

Supported by collaborating institutions and the U.S. National Science Foundation.

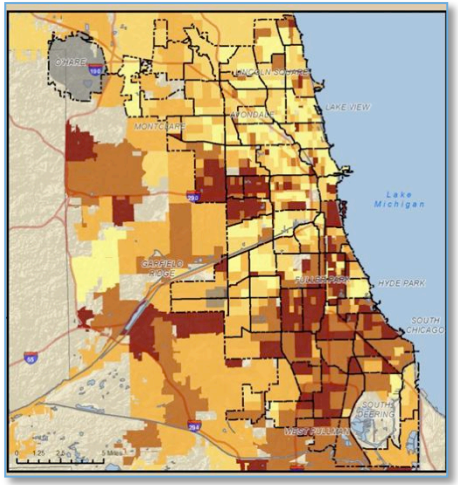
Industry In-Kind partners: AT&T, Cisco, Intel, Microsoft, Motorola Solutions, Schneider Electric, Zebra

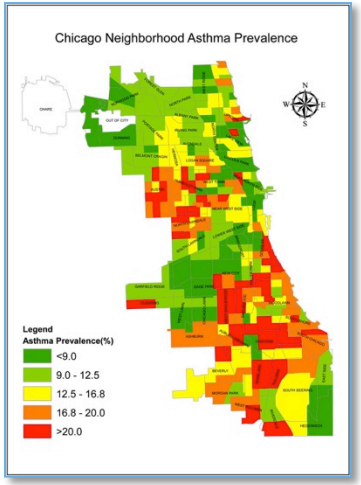
UrbanCCD (Computation Institute of the University of Chicago and Argonne National Lab)

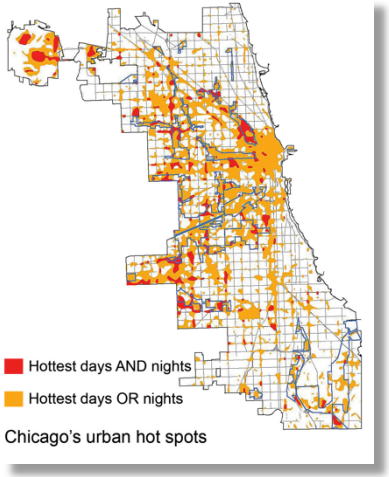
Why measure cities?

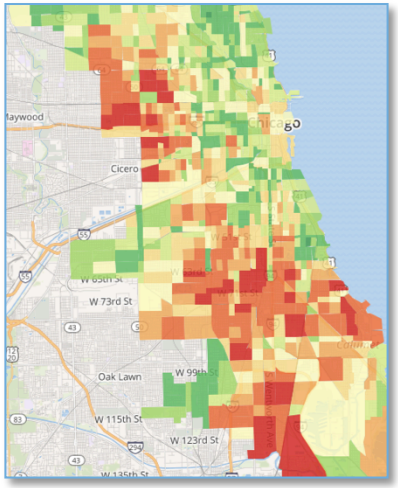
THE UNIVERSITY OF CHICAGO

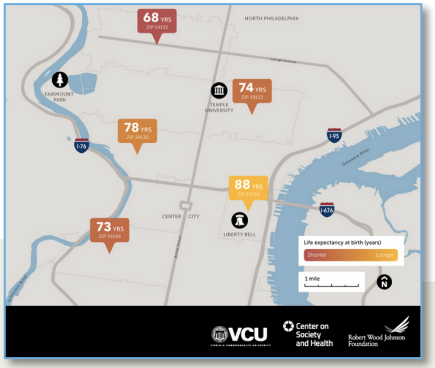
Argonne NATIONAL LABORATORY

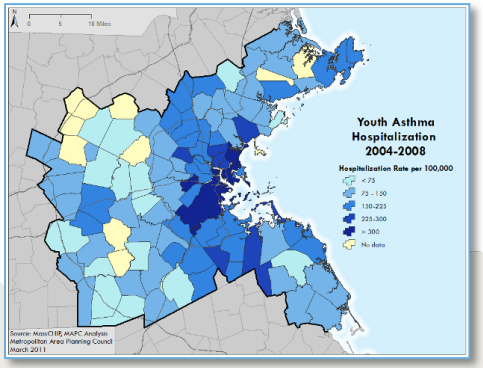






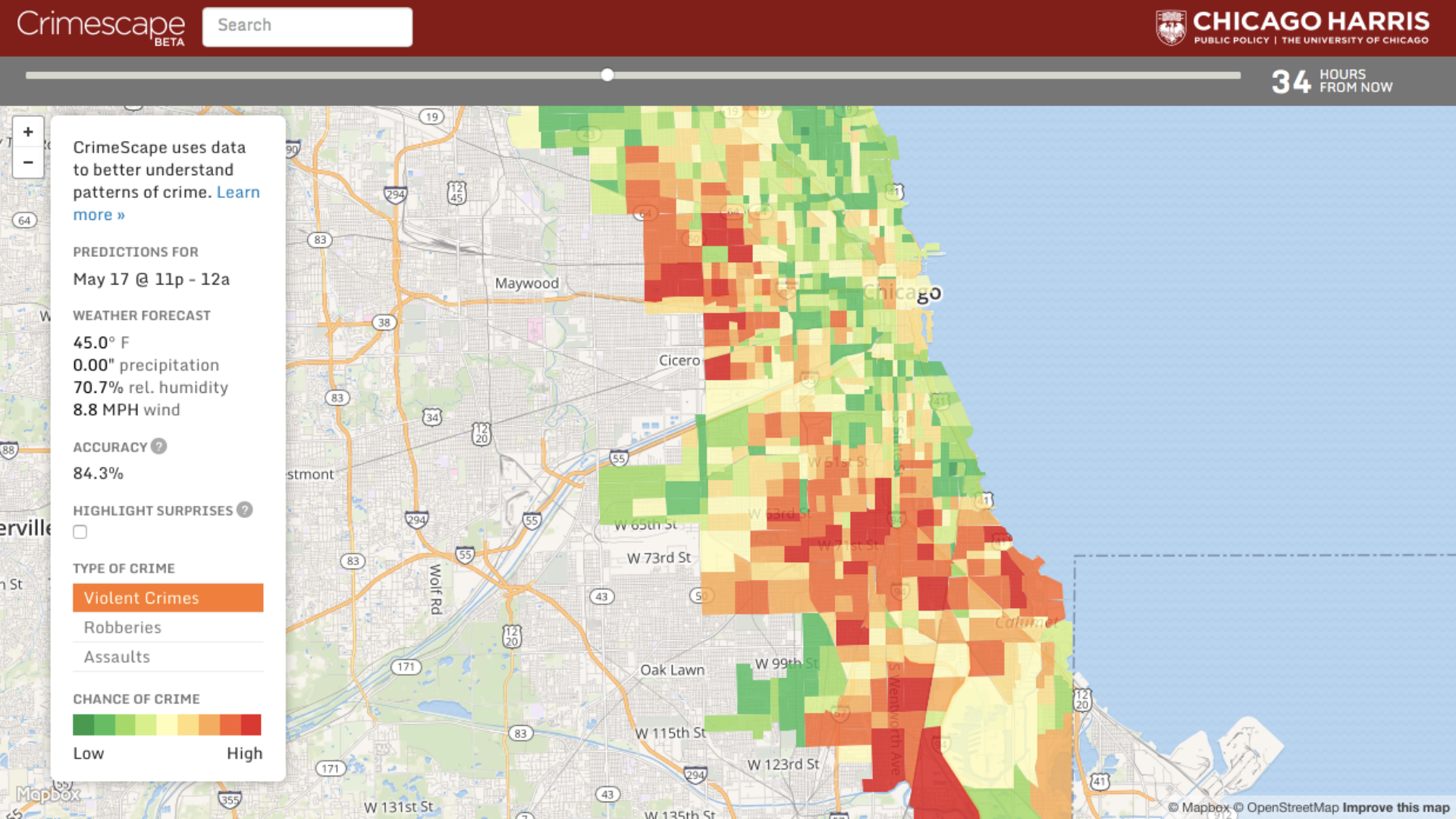


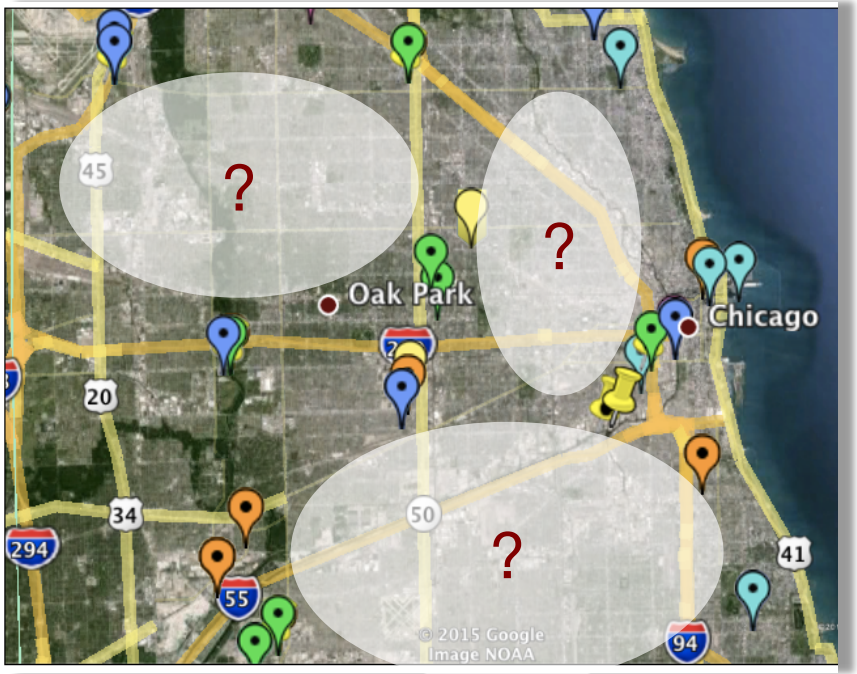


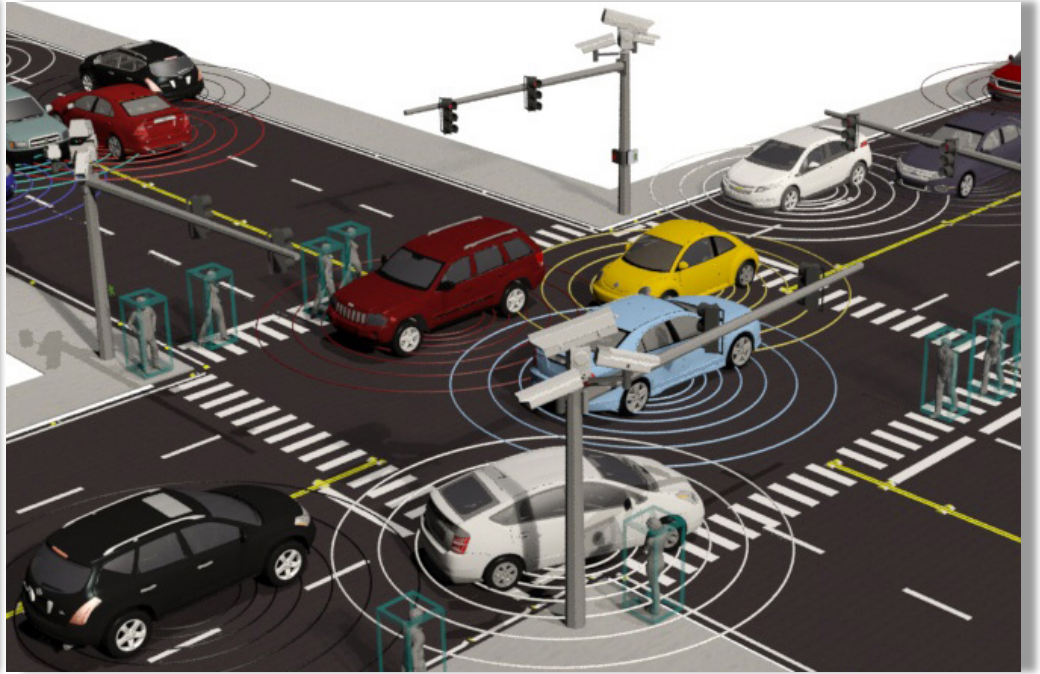


NSF

CITY OF CHICAGO INCORPORATED 4th MARCH 1837


Crimescape BETA
Search
CHICAGO HARRIS
PUBLIC POLICY | THE UNIVERSITY OF CHICAGO
34 HOURS FROM NOW
CrimeScape uses data to better understand patterns of crime. Learn more »
PREDICTIONS FOR
May 17 @ 11p - 12a
WEATHER FORECAST
45.0° F
0.00" precipitation
70.7% rel. humidity
8.8 MPH wind
ACCURACY
84.3%
HIGHLIGHT SURPRISES
TYPE OF CRIME
Violent Crimes
Robberies
Assaults
CHANCE OF CRIME
Low
High
Maywood
Cicero
W 73rd St
Oak Lawn
W 99th St
W 115th St
W 123rd St
W 131st St
Wolf Rd
S Wentworth Ave
Mapbox
© Mapbox © OpenStreetMap Improve this map





- Sensor selection from three years of workshops.
  - Environment/Atmosphere
  - Engineering/Transportation/Cities
  - Information Sciences
  - Social Sciences

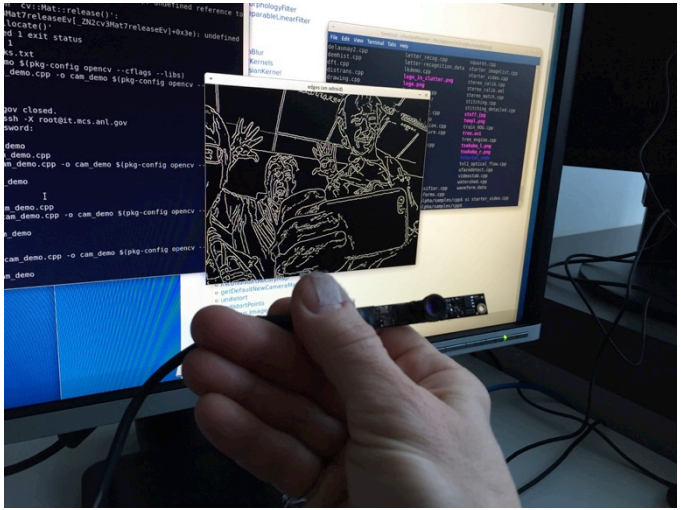
VISION 4.0

FOCUS CITIES

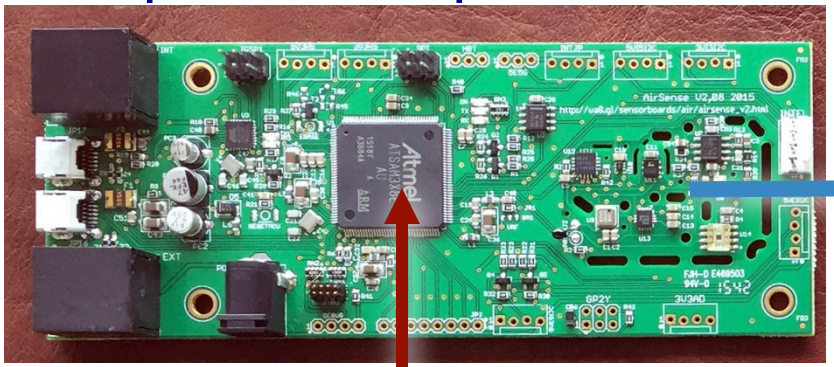
Austin | Boston | Chicago | DC | Fort Lauderdale | LA | NYC | Portland | San Francisco | Seattle

In-Situ/Edge Computing
Analysis and Feature Recognition

- Parallel Computing
- Open Platform
- Deep Learning



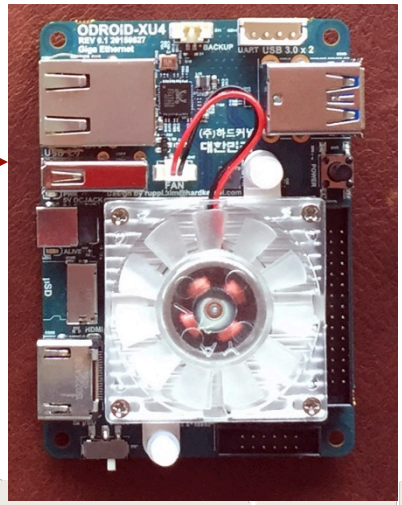
Sample and Report



data

EASY: Simple. Reliable.[1]

HARD: Programmable.
Not Reliable.[2]

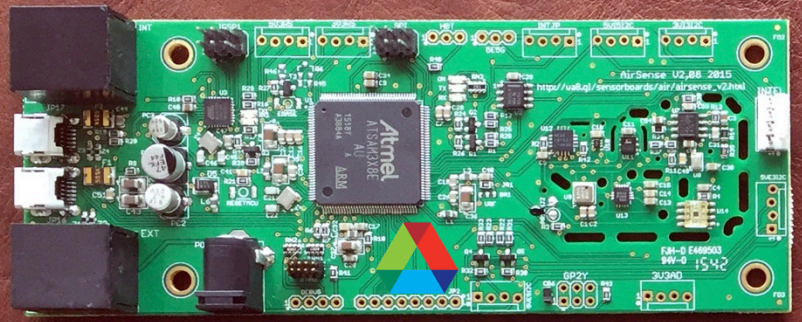


Linux with
OpenCV, Caffe

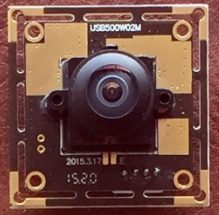
[1] Can it run untouched for 2 years?

[2] Especially if remotely programmable…

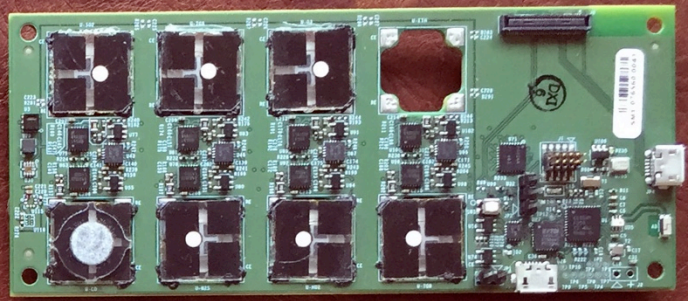
AirSense Board

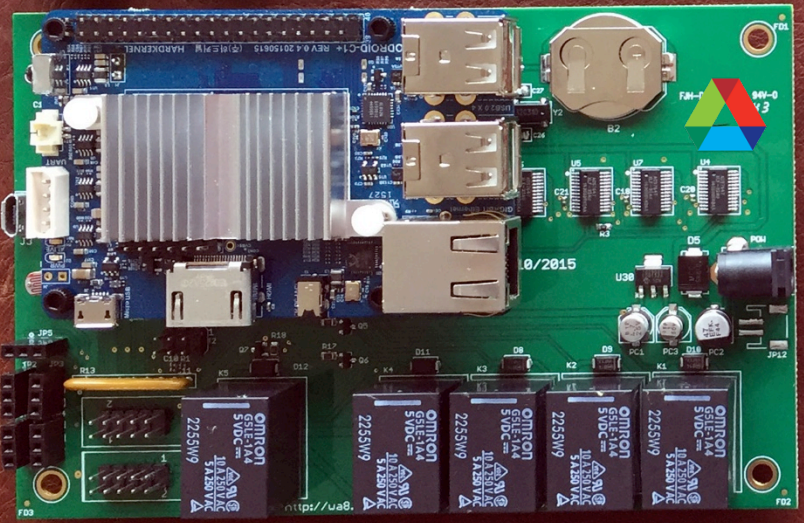


Camera

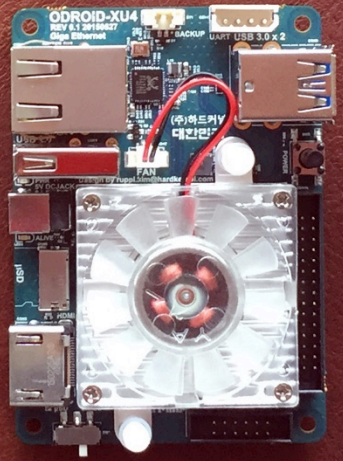


ChemSense Board

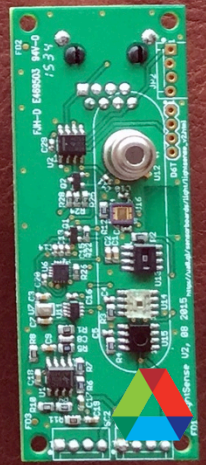




WagMan Board + ODROID
(Amlogic quad ARM A7)



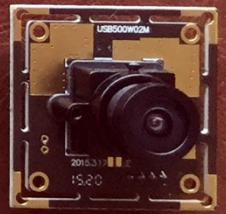
ODRIOD
(Samsung Exynos5422, A15 & A7)



LightSense Board

IR Temp

Camera



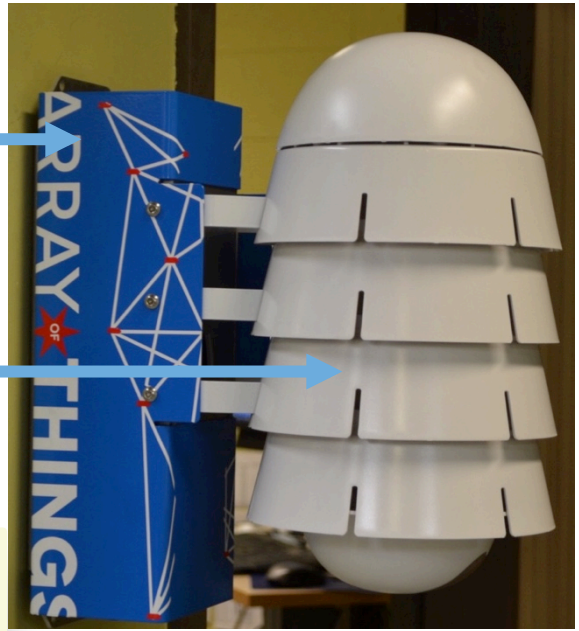
Control Platform

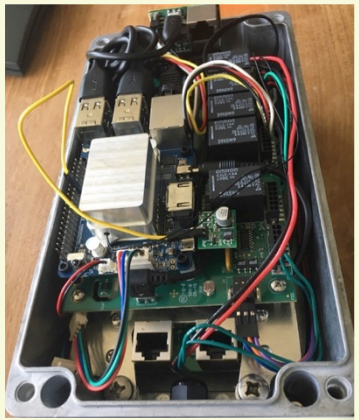
- Processors
- Communications
- Fault detection/recovery

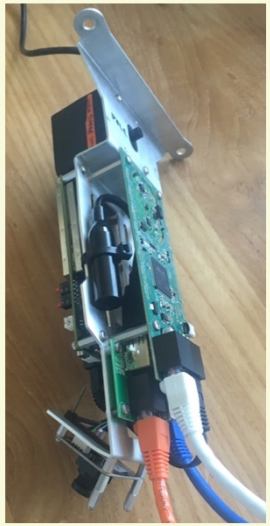
Sensors

- Air Quality
- Weather
- Street/Air Activity

  (via on-board image processing with upward and downward facing cameras)







- Aesthetics
- Quick-Replace
- Resilient

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KOHLER
PLUMBING
PRODUCTS


CDOT


CDOT

City of Chicago

Pilot Agreement

This Agreement (the "Agreement") is entered into as of the date of last sign
("**Effective Date**") by and between the University of Chicago (**"UChicago"** or "**Contr**
the City of Chicago, a municipal corporation and home rule unit of local government
under the Constitution of the State of Illinois, acting through its Department of Inno
Technology ("**City**"), at Chicago, Illinois.

Whereas, the Commissioner of the Department of Innovation and Technology ("Cor
is authorized by MCC 2-68-30 to enter into agreements with information technology
for the testing and pilot application of hardware, software, peripherals, technology
any combination of them, in order to determine suitability for use by the City;

Whereas, the Commissioner wishes to enter into such an agreement with UChicago
testing and pilot application of certain environmental sensing technology, containec
platforms, or, "nodes," to be installed on City traffic signal poles as described in Exh
"Pilot") for the one year period after installation as described in this Agreement;

Whereas, one of the purposes of the Pilot is to help the Commissioner assess wheth
proceed with a broader program, which would begin after the termination of the pi
which broader program would be called "Array of Things" or "AoT," an outline of th
of which (which would be subject to negotiation if the City decides to proceed with

EXHIBIT 1

Description of Pilot

Overvie
Array o
modula
activity

Nodes
Interne
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and vel
directly
provide
below)
obtaine

No PII
person
images
transm
"Calibr

EXHIBIT 2
PRIVACY POLICY

1 Purpose and Scope

The Array
support re
limited to
cloud cove
data will c

The purpo
Things pro
document
policy sets
some of w
The opera
National L

2 Guiding

We value

EXHIBIT 3
GOVERNANCE POLICY & PROCESSES

***1** Purpose and Scope*

This document provides a framework within which the University of Chicago and Argonne National Labs (program operators) and the City of Chicago will implement and manage the Array of Things (AoT) in Chicago by 1) defining the initial scope of the program, 2) establishing the roles and responsibilities of program partners; and, 3) describing the process by which decisions about the program will be made.

This document is complimented by the AoT Privacy Policy, which sets forth requirements regarding Personally Identifiable Information (PII).

1.1 Guiding Principle

We value privacy, transparency, and openness.

1.2 Program Overview

The AoT program operators aim to build an urban-scale research instrument comprising a network of at least 500 Internet-connected "nodes," each supporting multiple environmental and air quality sensors. As a first of its kind public sensor utility, AoT will produce an open and freely available source of urban sensor measurements to support research, development, education, prototyping, and demonstration. The program operators have designed AoT to

Technology

Accountability

Transparency

URBAN CENTER FOR COMPUTATION AND DATA

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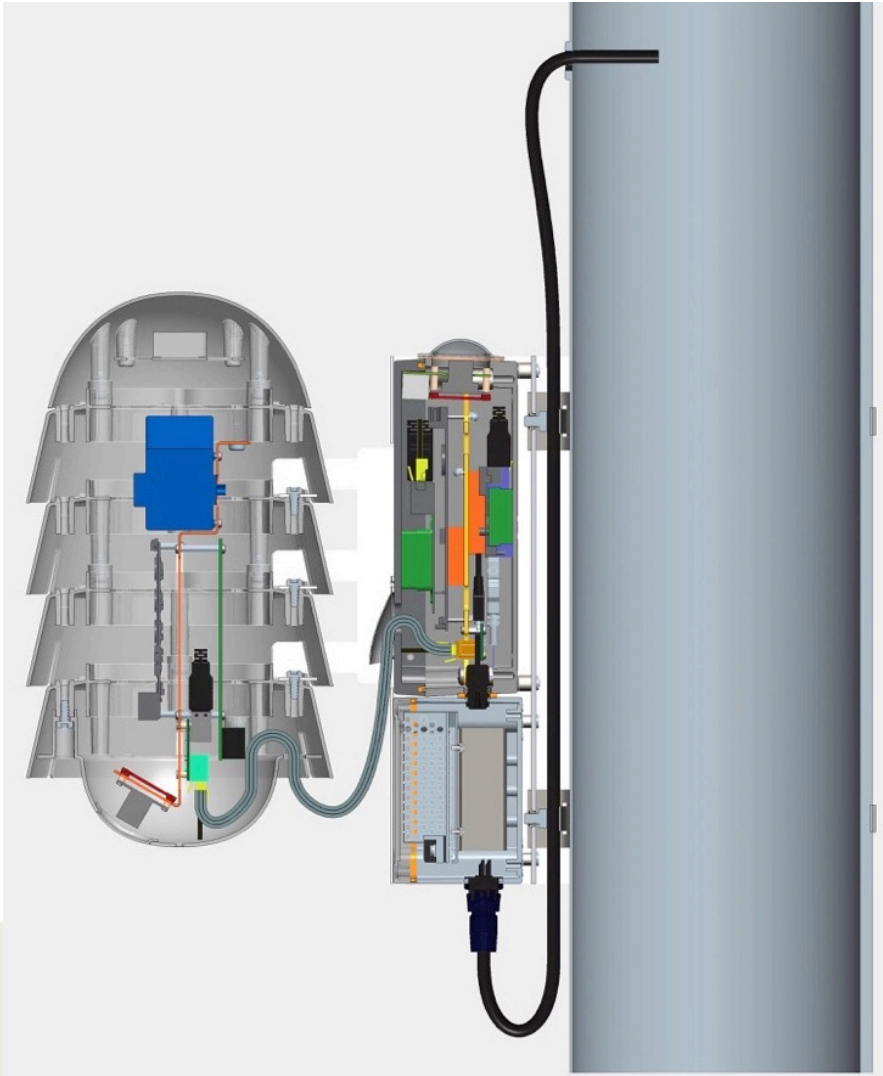
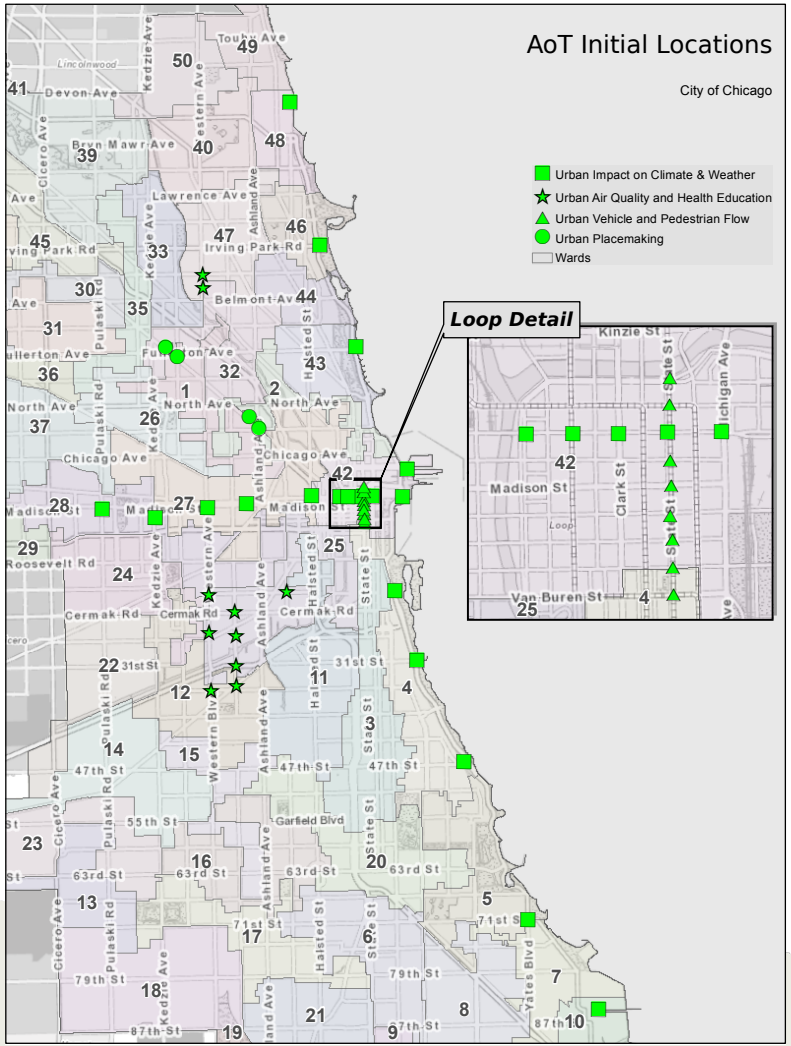
Privacy

Central to the privacy policy are secure design, transparent policies and actions, and accountability via an independent external privacy review process.

Privacy and governance policies released for public comment in June 2016. Initial public "town hall" meetings were held June 14 and June 22 to engage hundreds of residents prior to the first installations scheduled for July 2016.





Sites planned for Fall 2016

ARRAY THINGS

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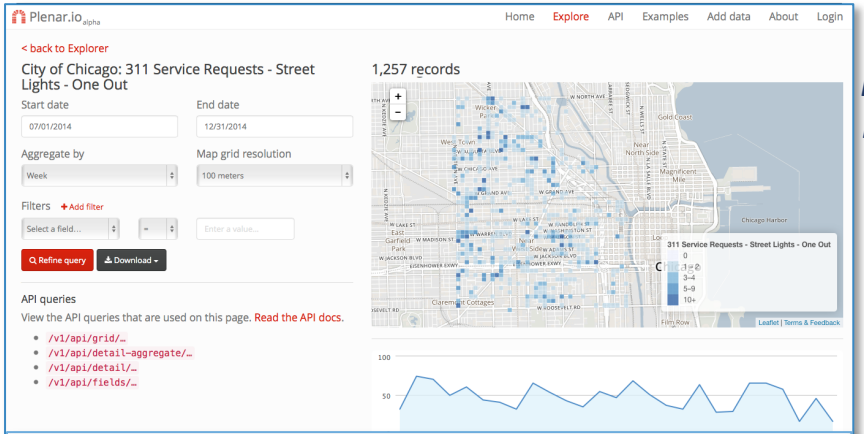
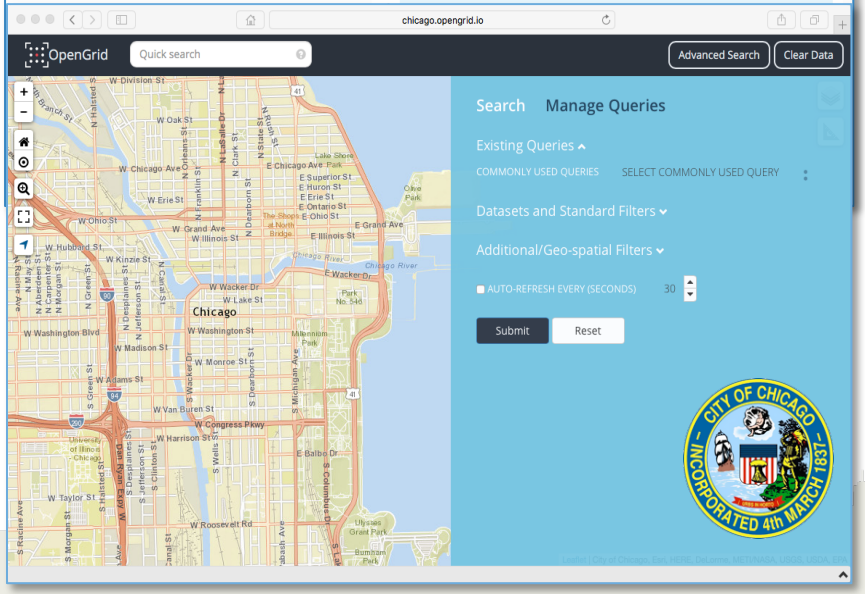
Selection rubric:

People (concern/interest of residents)

Science (collaborating science communities)

Policy (potential government intervention/investment)





The ultimate goal: providing open, free data about the performance, environment, and activities of the city to residents, policy makers, scientists, and industry.

Plenar.io

(for scientists, policymakers, businesses)

OpenGrid.io

(for residents, visitors)

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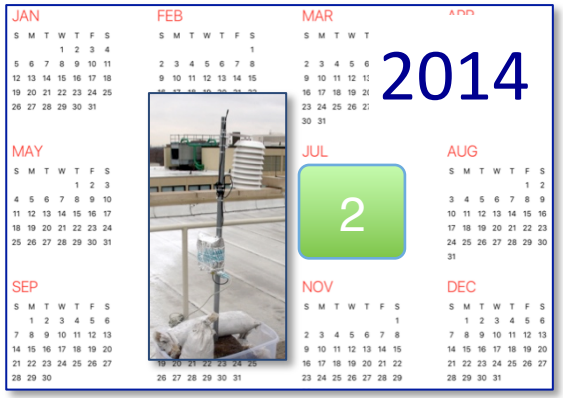
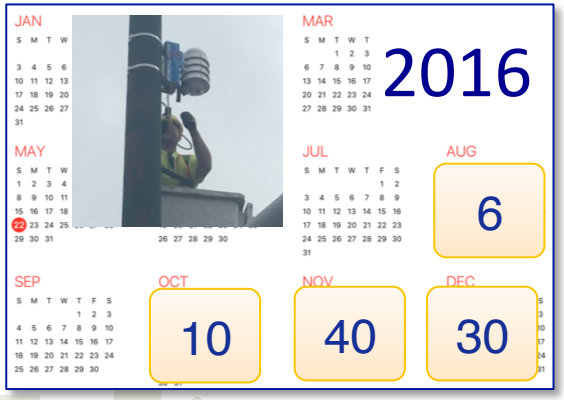
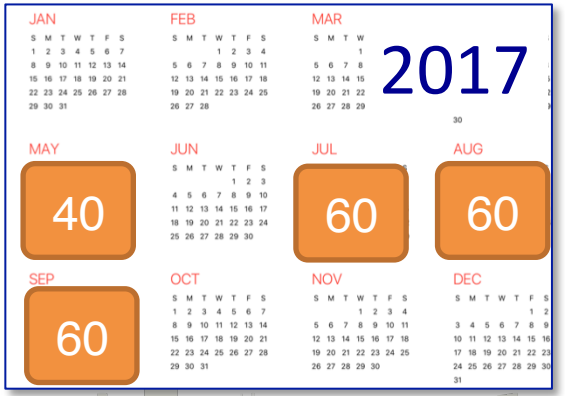
Argonne Server

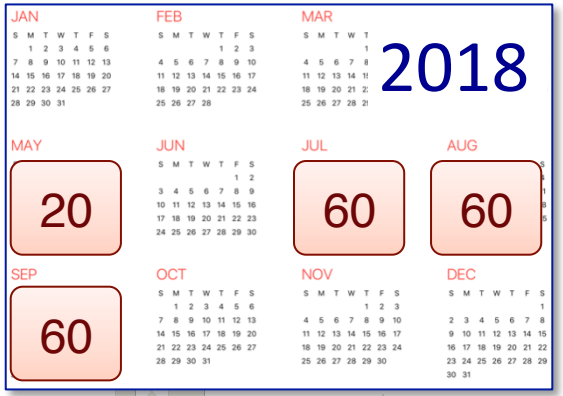
APIs

Third party apps & sites









Annual deployments with major design changes and additions/enhancements.

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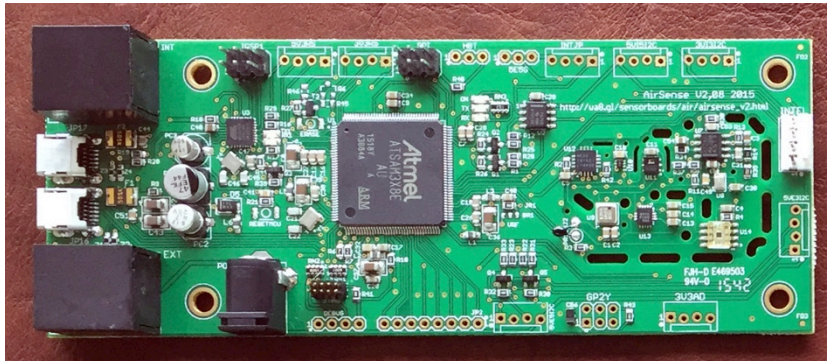

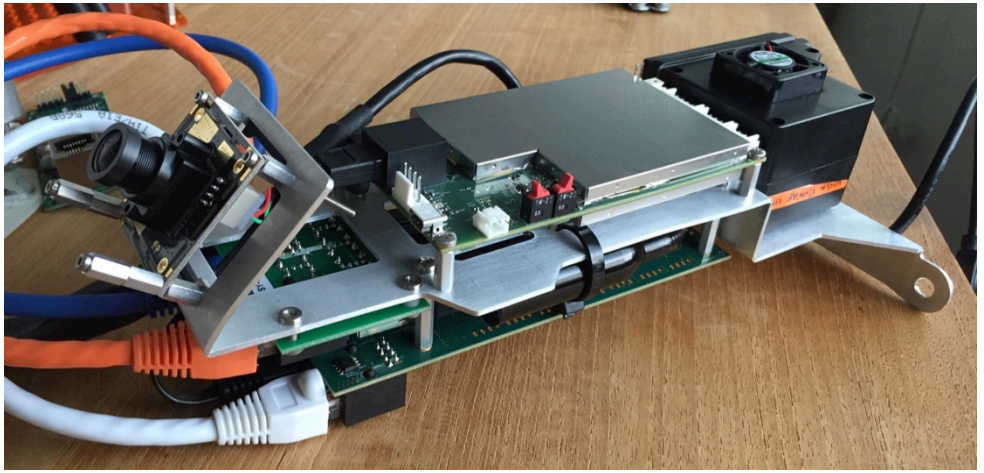

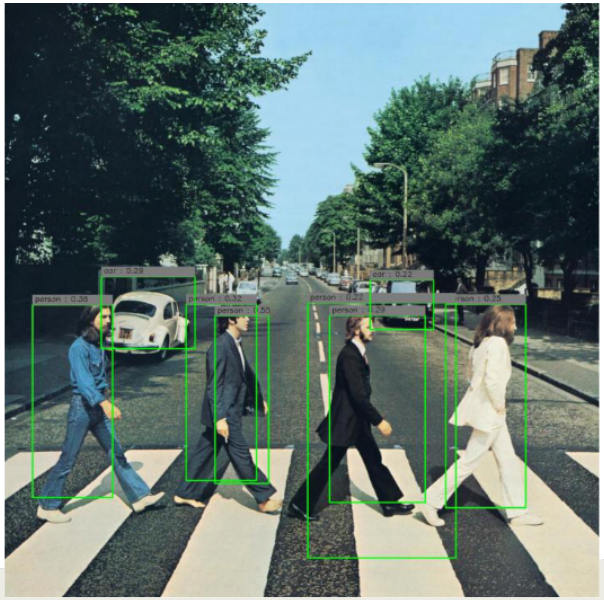

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- Disruptive Sensors – test at scale
- Computer vision and deep learning

https://waggle-sensor.slack.com/files/noaholsman/F243LQL66/output.jpg

Next: A Fitness Tracker for the Planet