

# Creating New Sources of Data and Embedded Systems to Understand Cities

Collaborators:

**Argonne:** Charlie Catlett, Pete Beckman, Rajesh Sankaran, Peter Lane.

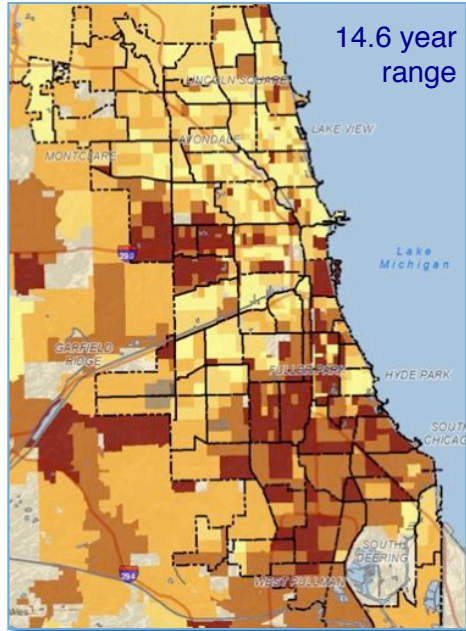
**UChicago:** Kate Kusiak Galvin, Sean Shakarami, Will Engler, Jesse Bracho, Bill Catino.

**City of Chicago:** Danielle DuMerer (CIO), Tom Schenk (CDO) Rebekah Scheinfeld (CDOT), Bob Ramos (CDOT-Electricians), and many others.

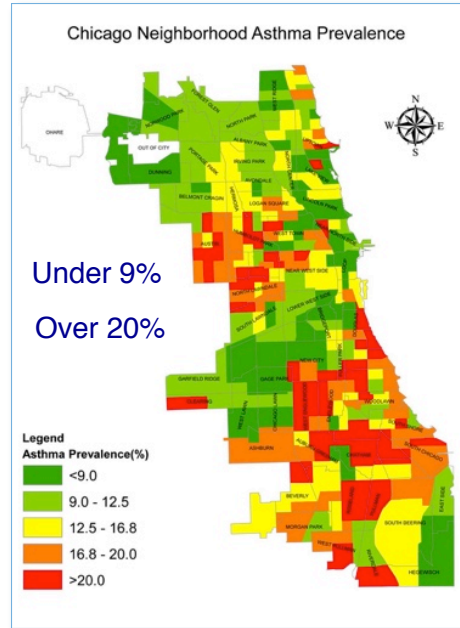
Partners include AT&T, Cisco, Intel, Microsoft, Motorola Solutions, Schneider Electric, Zebra, and scientists from over 30 universities. AoT is adapting the *Waggle* platform, developed at Argonne National Laboratory, for use in cities through a grant from the National Science Foundation to deploy 500 units in Chicago.



# Urban Challenges are Neighborhood-Specific



Life Expectancy



Asthma



Access to services

# Beyond Mapping

**City of Chicago Data Portal**

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**Array of Things Locations**  
Locations of Array of Things sensor nodes. For more information on the Array of Things project, see <https://arrayofthings.github.io>.

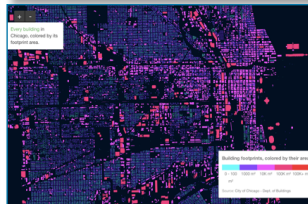
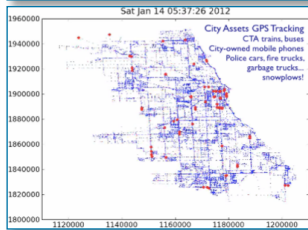
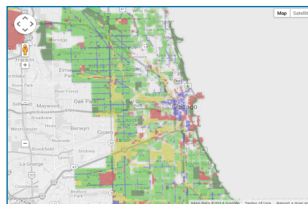
**Chicago Taxi Trips**  
Individual Chicago taxi trips from 2013 to the most recent month.

**2017 Chicago Budget**  
The Annual Appropriation Ordinance for 2017, as passed by the Chicago City Council. For the Positions and Salaries view of the budget, see <https://data.cityofchicago.org/g/vcdx-7p4u>.

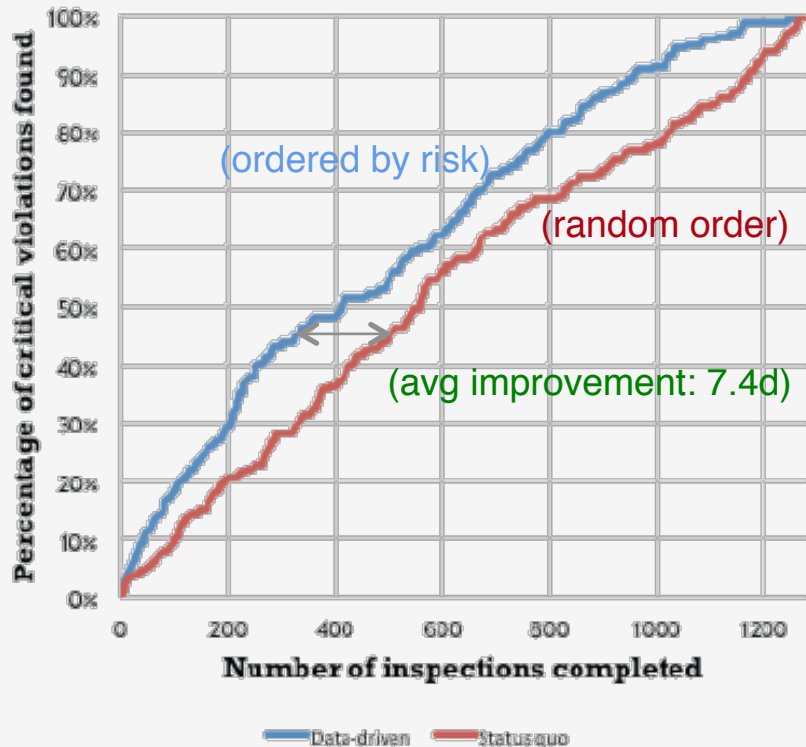
**Crimes - 2001 to present**  
This dataset reflects reported incidents of crime that occurred in the City of Chicago from 2001 to present, minus the most recent seven days.

Search & Browse Datasets and Views

Name	Popularity	Type
1. <b>Crimes - 2001 to present - Dashboard</b> Public Safety This dataset reflects reported incidents of crime (with the exception of murders where data exists)	570,881 views	
2. <b>Beach Weather Stations - Automated Sensors - 2016 - Humidity</b> Parks & Recreation beaches, parks, chicago park district, open spaces... The Chicago Park District maintains weather sensors at beaches along Chicago's Lake Michigan	516,000 views	
3. <b>Lobbyist Data - Historical - Lobbyist Registry - 2010</b> Ethics lobbyists, historical All lobbyist registration filings submitted to the Board of Ethics during the 2010 reporting period. /	368,787 views	
4. <b>Current Employee Names, Salaries, and Position Titles</b> Administration & Finance personnel This dataset is a listing of all current City of Chicago employees, complete with full names, depart	845,446 views	
5. <b>Performance Metrics - Streets &amp; Sanitation - Graffiti Removal</b> Administration & Finance performance metrics, service delivery, graffiti The Department of Streets & Sanitation's (DSS) Graffiti Blasters crews offer a vandalism removal	206,845 views	
6. <b>Small Business Improvement Fund (SBIF) Grant Agreements</b> Community & Economic Development sf, sbif, sustainability Small Business Improvement Fund (SBIF) program grants made since 2001. SBIF uses Tax Incr	193,740 views	
7. <b>Building Permits</b> Buildings permits Permits issued by the Department of Buildings in the City of Chicago from 2008 to the present. T	390,270 views	
8. <b>Crimes - 2001 to present</b> Public Safety crime, police This dataset reflects reported incidents of crime (with the exception of murders where data exists)	301,573 views	
9. <b>Affordable Rental Housing Developments</b> Community & Economic Development housing The affordable rental housing developments listed below are supported by the City of Chicago to	317,311 views	
10. <b>Crimes - Map</b> Public Safety crime, police This dataset reflects reported incidents of crime that have occurred in the City of Chicago over th	229,285 views	
11. <b>Business Licenses - Current Active</b> Community & Economic Development business licenses current This dataset contains all current and active business licenses issued by the Department of Busin	225,300 views	



# Impact



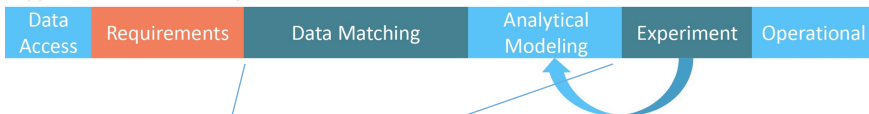
CHICAGO:  
**7.4 days**

## Comparing food inspection results

Argonne was provided the same data matched by Gene and challenge to outperform the city-driven model based on the earlier delivery of inspections. Argonne's automated model **outperformed** Chicago's model from 7.4 days earlier to 8.4 days earlier.

ARGONNE:  
**8.4 days**

Typical Research Project Timeline



"SDP" Timeline



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

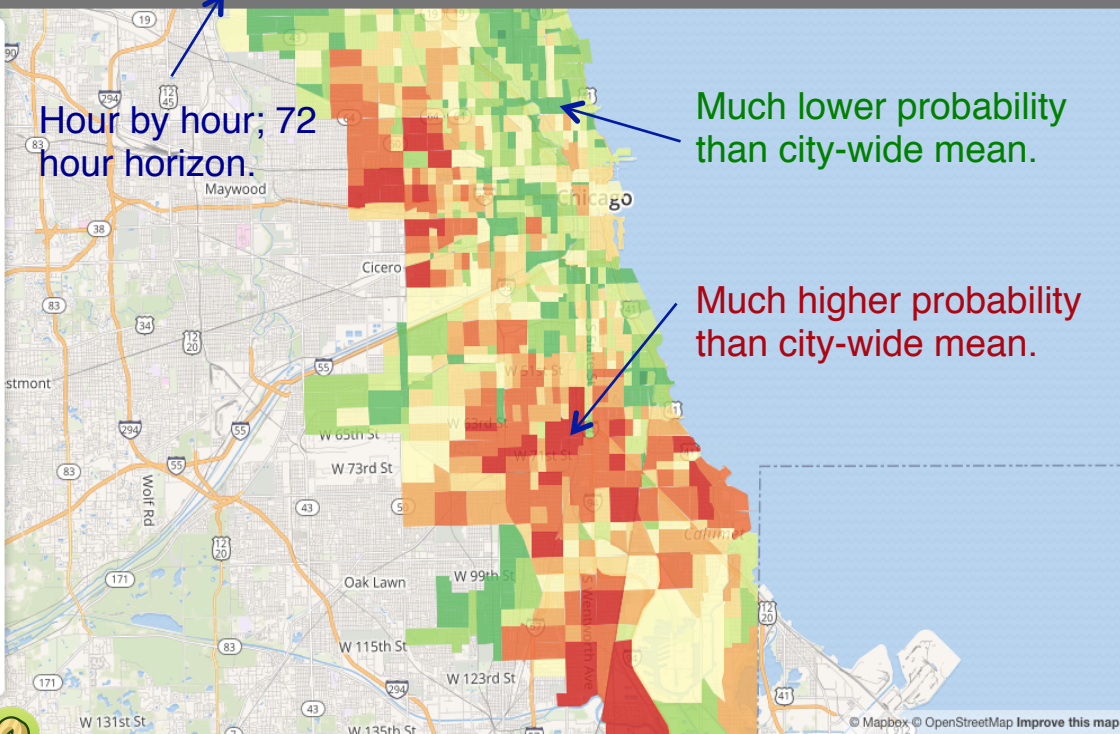
CHANCE OF CRIME



RECIPE



Hour by hour; 72 hour horizon.



Much lower probability than city-wide mean.

Much higher probability than city-wide mean.

$$y_i = \frac{(1 + \theta_1 B + \theta_2 B^2)(1 + \Theta_1 B^{52} + \Theta_2 B^{104} + \Theta_3 B^{156}) e_i}{(1 - \phi_1 B)(1 - B)(1 - B^{52})}$$

Data Sources  
(leading indicators)

**A NEW STANDARD FOR REAL-TIME POLICING**

A set of keys, a squad car, and a simple directive: go stop crime. The idea for Civicscape was born a decade ago when we – a group of police officers and technologists – started working together to develop a way to do that more effectively, more efficiently, and more safely.

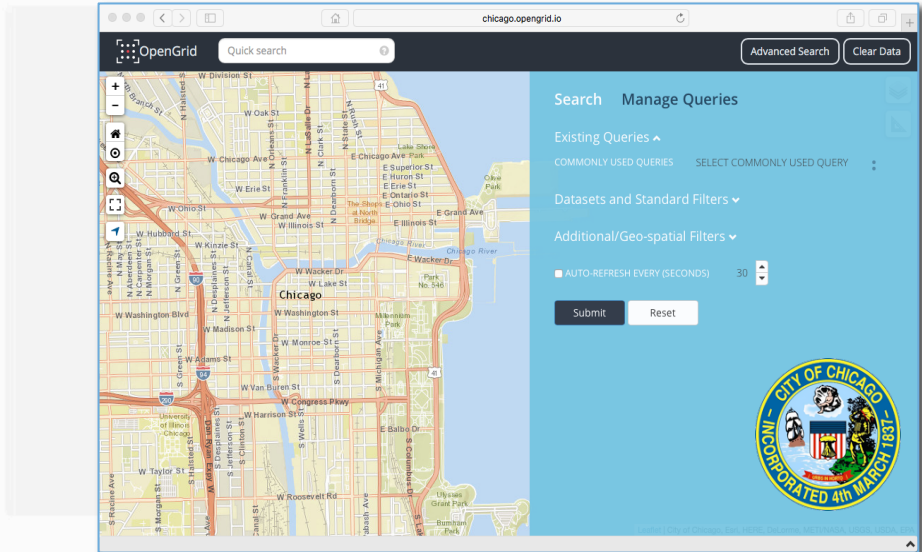
Civicscape / Civicscape

A new standard for real-time policing. <http://www.civicscape.com>

Branch	Commits	Branches	Releases	Contributors
master	99	2	0	6

File	Last Commit	Time Ago
data_loader_init	data_loader_init	2 days ago
Training_and_Testing	Update 20weather_upsert.sql	a month ago
docs	Add logs.svg	2 days ago
evaluation_notebooks	update to eval notebook	17 days ago
gitignore	Clean training, testing, and eval commit	3 months ago
LICENSE	Update LICENSE	6 months ago
README.md	Update README.md	6 months ago
README.md	Update README.md	5 days ago

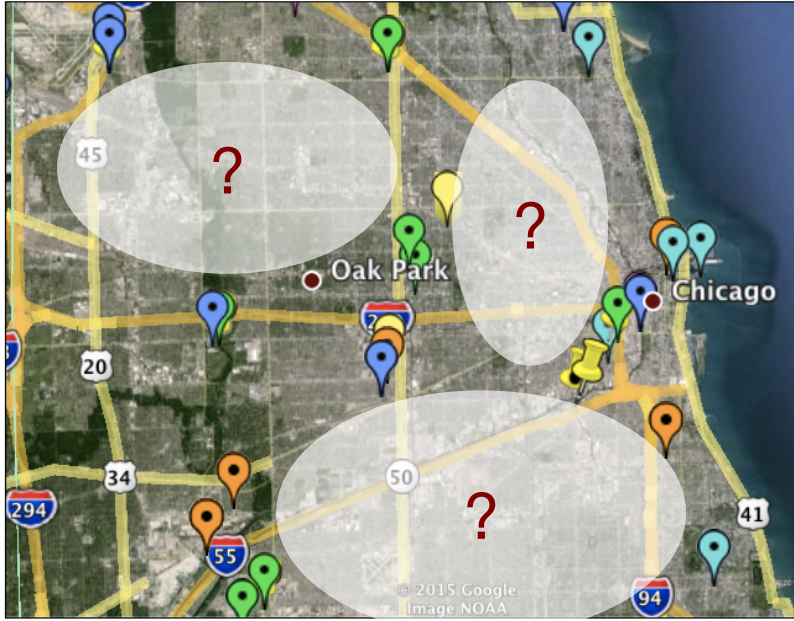
**CIVICSCAPE**  
Understanding the CrimeScape data and model



One database. One map.

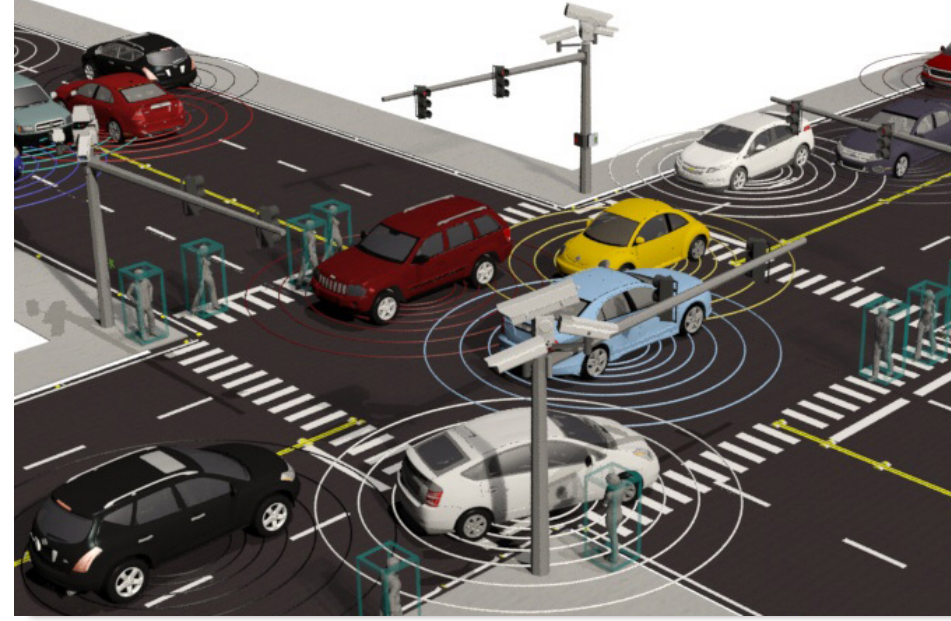
All data in Plenar.io exists on a single map and a single timeline, making it incredibly easy to access multiple datasets at once—especially those originally housed at different data portals.

**Here's an example:** A collection of data pulled from Southside Chicago during summer 2013.



Initial sensor selection from three years of science and policy workshops.

- Environment and Atmosphere
- Engineering and Transportation
- Information Sciences
- Social Sciences



Embedded computing enables development of new smart city applications.

- Image and sound processing in real time  
(intelligent sensing of vehicle or pedestrian flow, unusual conditions/events, etc.)
- Vehicle-to-infrastructure communications

# Example: Energy Applications Experimental Projects

## Data Analytics

- Use of sensor data to support load forecasting models for smart grid.
- Use of sensor data to support building energy management (e.g. solar loading factors)
- Measurement of light-pollution reduction from smart streetlights
- Detect severe weather phenomena and assist in the assessment of the potential impact on the grid and other infrastructure
- Investigate the use of weather data as part of a warning mechanism for the microgrid controller to initiate actions such as intentional islanding

## Machine Learning

- Flood detection for distribution system resiliency
- Use upward-facing camera and light (ambient, UV, IR) sensors to assist in the smoothing of the output of solar photovoltaic (PV) generators by supplying data to local energy storage technologies
- Monitor sound levels from traditional generation sources and wind turbines (as applicable)
- Use of air quality sensors to measure the emissions of local generation (such as gas fired Combined heat and Power (CHP))

*The AoT team is seeking international partnerships to evaluate the platform with respect to energy applications as well as other “smart-city” research and development.*



# AoT Uses Argonne's Waggle: An Open Platform for *Intelligent* Sensors

Exploiting Three areas of Disruptive Technology + "Deep Space Probe" design

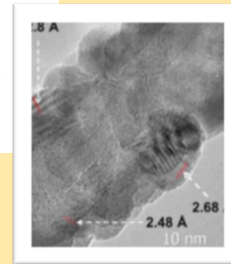
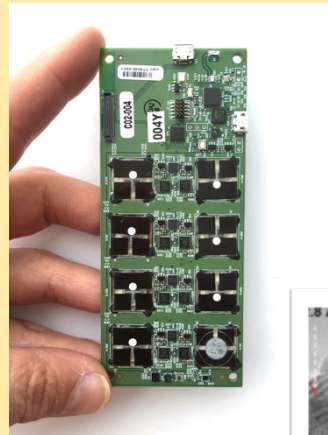
Machine Learning

Computer Vision



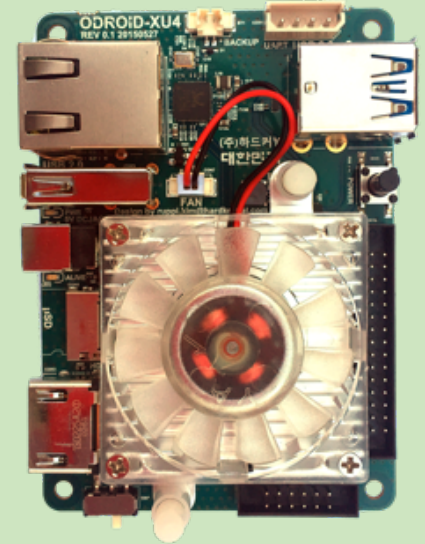
Novel Sensors

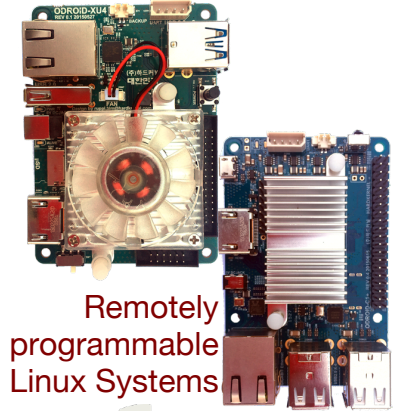
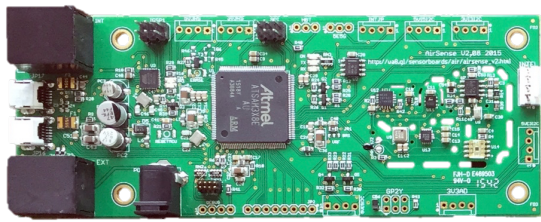
Nano / MEMS / Graphene



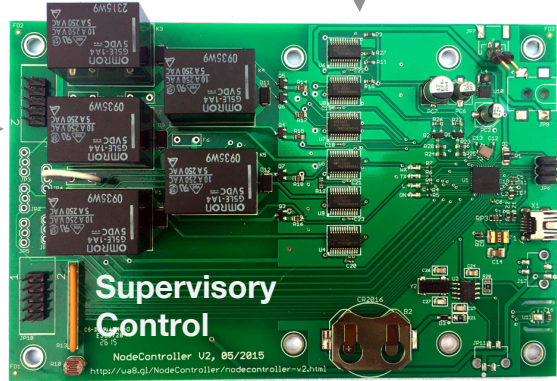
Low Power CPUs

GPU / Smartphones





Monitoring,  
Upgrade, &  
Recovery



Operating  
conditions

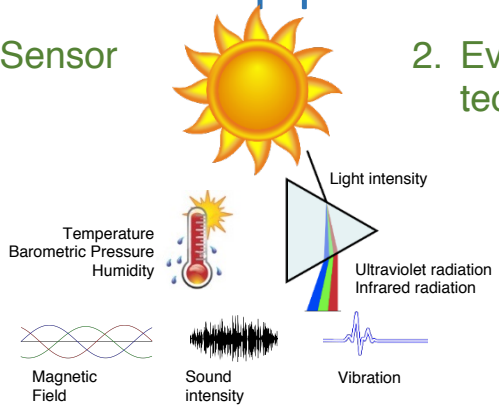


Sensor networks are simple.

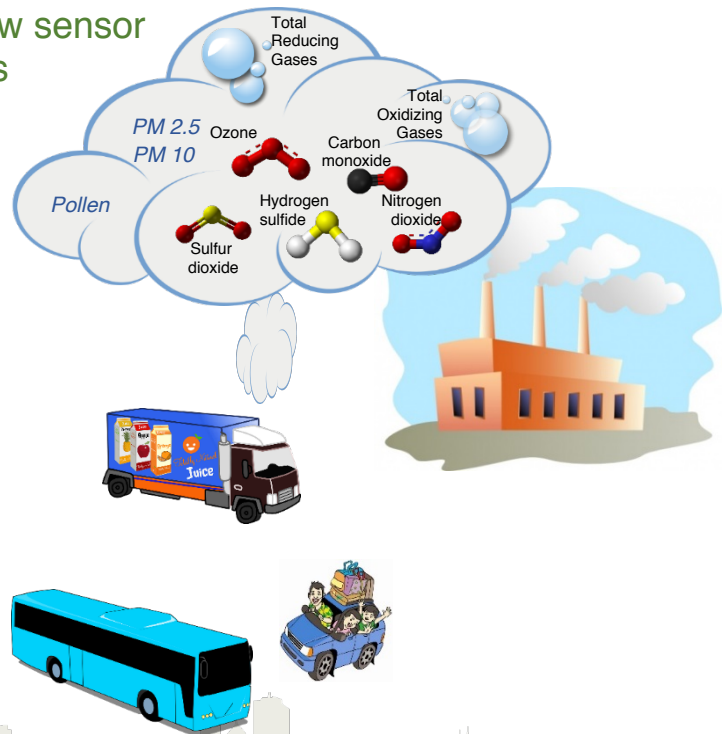
The AoT Waggle platform is unique in that it is an open, modular platform supporting development, evaluation, and demonstration of new sensor technologies and intelligent sensing via machine-learning sensor and image/sound analytics.

# AoT is a *Platform* supporting three functions.

## 1. Traditional Sensor Network

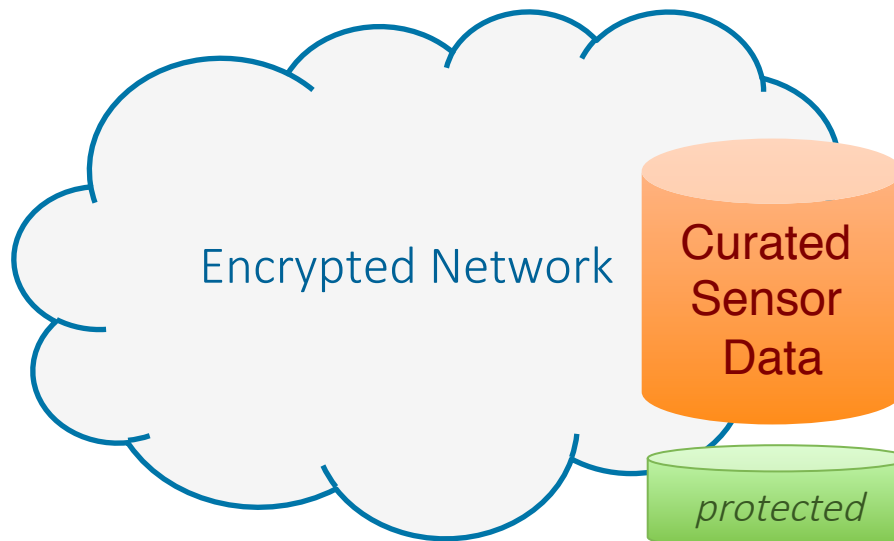


## 2. Evaluate new sensor technologies



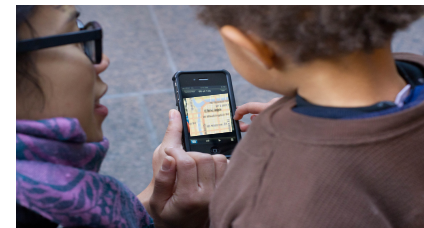
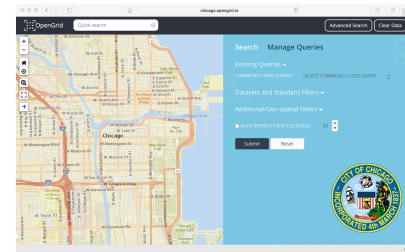
## 3. Develop and evaluate new computer perception capabilities.

# Open Data Updated every 30 Seconds



Protected Image and sound library for computer perception research and algorithm development and calibration..

## Open Portals

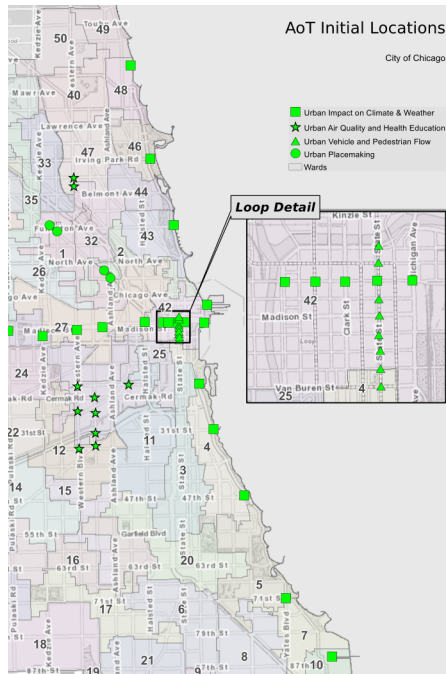


Streams and APIs for developers to create new applications, analyses, and portals.



# A Partnership with Chicago

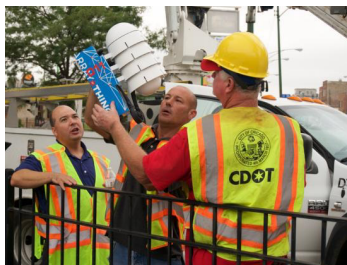
*Residents partner on location choices.*



**Residents**

**Scientists**

**Government**



**CONTROL PLATFORM**

- Processors
- Communications
- Fault detection/recovery



**SENSORS**

- Air quality
- Weather
- Events and activity



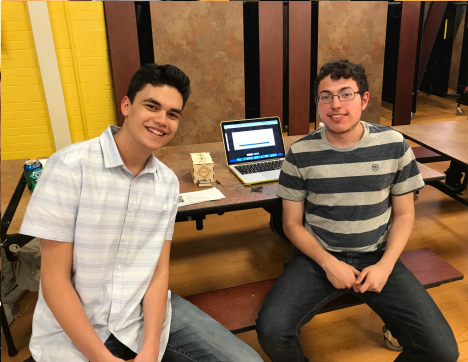
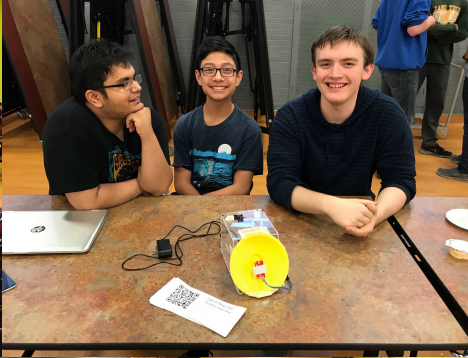
**Open Source**

**Aesthetics**

**Quick-Replace**



*City workers partner on design and installation.*



## Partnering with Chicago Youth




Over 300 Chicago High School students trained so far in a new curriculum to be packaged and replicated. (UChicago, Lane Tech H.S, and the School of the Art Institute of Chicago w/ funding from the Motorola Solutions Foundation.)

# Pilot Project Requests and Inquiries



[www.ArrayOfThings.org](http://www.ArrayOfThings.org)  
<http://Wa8.gl>

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-  Installations
-  City/University teams with defined projects for 2017
-  Under discussion

