



Some 120 participants from academia, government, industry, and community groups joined AoT leaders for the symposium.

In January 2012—exactly ten years ago—we began discussions with the City of Chicago regarding the possibility of installing scientific instruments as part of the City’s Smart Lighting project (300,000 streetlights). On January 20th, 2022 the *Mansueto Institute for Urban Innovation* (Univ of Chicago) and the *Discovery Partners Institute* (Univ of Illinois System) hosted a discussion with AoT leaders about lessons learned and looking ahead at what we are building upon the Array of Things.



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A New Way of Seeing

We're a hub for urban science, training the next generation of urban scholars.

At the Mansueto Institute for Urban Innovation, we study the fundamental processes that drive, shape and sustain cities. Our researchers come from the social, natural, and computational sciences, along with the humanities. Together, we pursue innovative, interdisciplinary scholarship, develop new educational programs, and provide leadership and evidence to support global, sustainable urban development.

The University of Chicago is proud to present the first-ever [Certificate in Urban Science and Sustainable Development](#), recognizing graduate student work addressing one of the most challenging and important issues of our time—Sustainable Urban Development. The Certificate, which is awarded in conjunction with existing UChicago graduate degree programs, establishes the scientific and intellectual underpinnings for a career in this emerging field.

[Learn more](#) about this new opportunity for Master's and PhD students who have completed the first year of their degree program and who are interested in the future of cities.

20181203_MansuetoLinks_3075-300x300.jpeg

 DISCOVERY PARTNERS INSTITUTE | UNIVERSITY OF ILLINOIS SYSTEM

Tech. Talent. Research.

Reviving up Illinois' tech community, preparing people for high-demand tech jobs, building R&D centers of excellence.

[OUR VISION](#)




[PLAY VIDEO](#)

Tech. Research. Talent.

DPI does three things: Tech Talent Development; Applied R&D; and Business Building.



Tech Talent Development
We are preparing promising and diverse individuals to step into lucrative and resilient tech jobs.

Applied R&D
DPI is a place where companies, researchers, and students can access smart people, advanced equipment, and funding to turn ideas into innovative products.

Business Building
DPI's tech talent development programs are going to help fix a massive racial and gender imbalance in Chicago's tech community.

Today's Speakers



Charlie Catlett
DPI



Valerie Taylor
ANL/UChicago



Luis Bettencourt
UChicago



Anne Dodge
UChicago

INSIGHTS: LESSONS LEARNED






Kathleen Cagney
UMichigan

Michael Papka
ANL/NIU

Pete Beckman
ANL/Northwestern

Brenna Berman
Fmr City of Chicago

INSPIRATION: WHAT'S NEXT





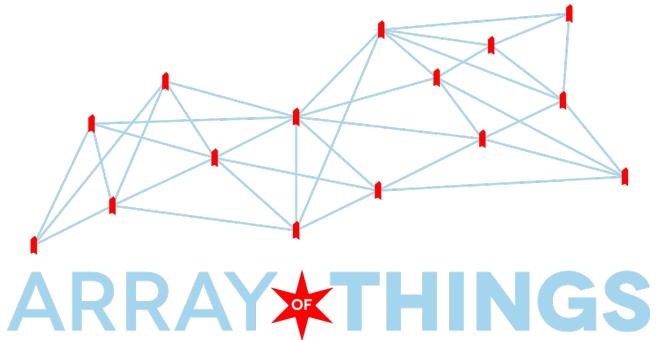


Douglas Pancoast
SAIC

Tiffany Werner
ELPC

Daniel Work
Vanderbilt

Marc G. Berman
UChicago



A Virtual Symposium
January 20, 2022

Welcome – Luis Bettencourt (UChicago)

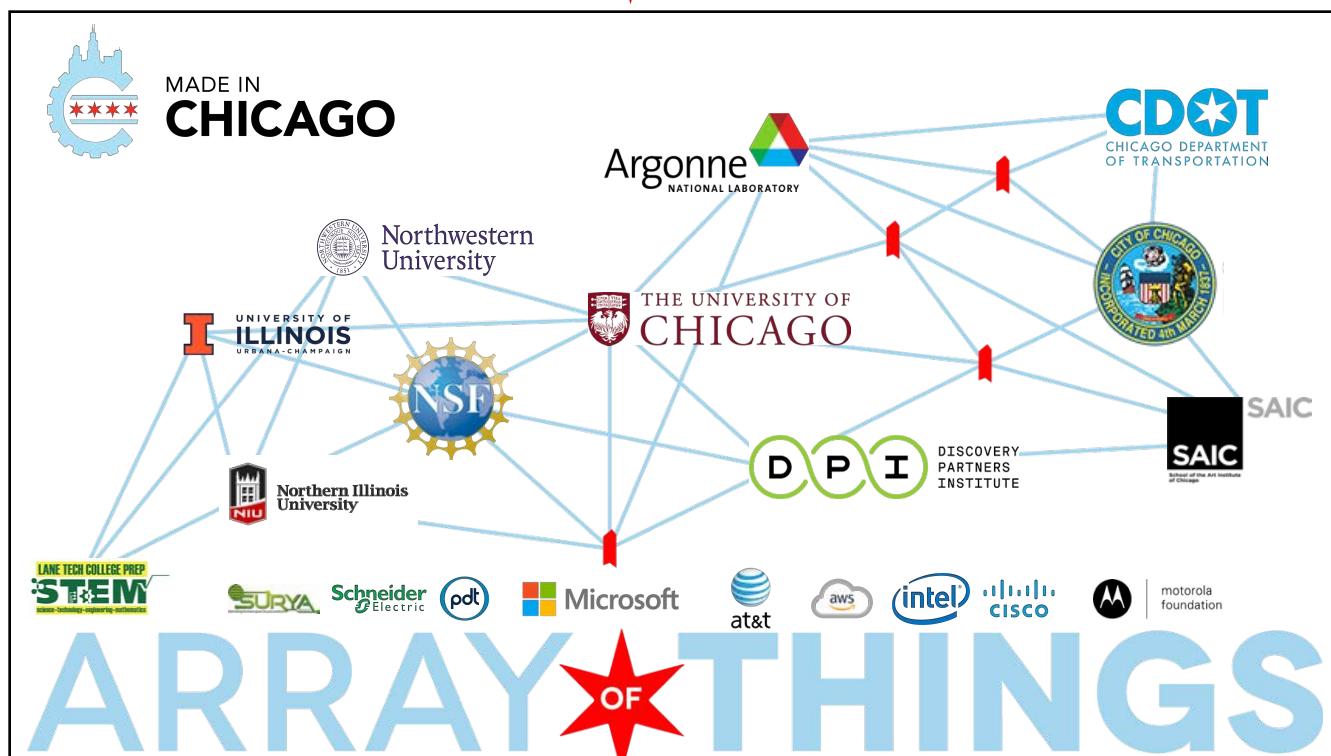
Origin, Six Lessons Learned, Impacts, and Vision – Charlie Catlett, DPI, AoT PI) 3

Insights: Lessons Learned and Outcomes – Valerie Taylor, Moderator (ANL/UChicago)

<i>AoT Architecture and SAGE - Pete Beckman (ANL/NU, AoT Architect)</i>	16
<i>Social Sciences - Kathleen Cagney (U Michigan, AoT Co-PI)</i>	19
<i>Policy and Community Engagement – Brenna Berman (Former Chicago CIO)</i>	21
<i>Translational Research and Education – Michael E. Papka (ANL/NIU, AoT Co-PI)</i>	23

Inspiration: Building on AoT Insights– Anne Dodge, Moderator (UChicago)

<i>Transportation Research – Daniel Work (Vanderbilt University, AoT Co-PI)</i>	26
<i>Social and Behavioral Sciences – Marc Berman (UChicago)</i>	28
<i>Environmental Justice and Community Partnerships – Tiffany Werner (Environmental Law and Policy Center)</i>	30
<i>Architecture, Design, and Urban Form – Douglas Pancoast (School of the Art Institute of Chicago, AoT Design Lead)</i>	32





The AoT community grew over a decade with contributors from academia, government, education, industry, and communities.

What motivated AoT?

Origins, Design, and Launch

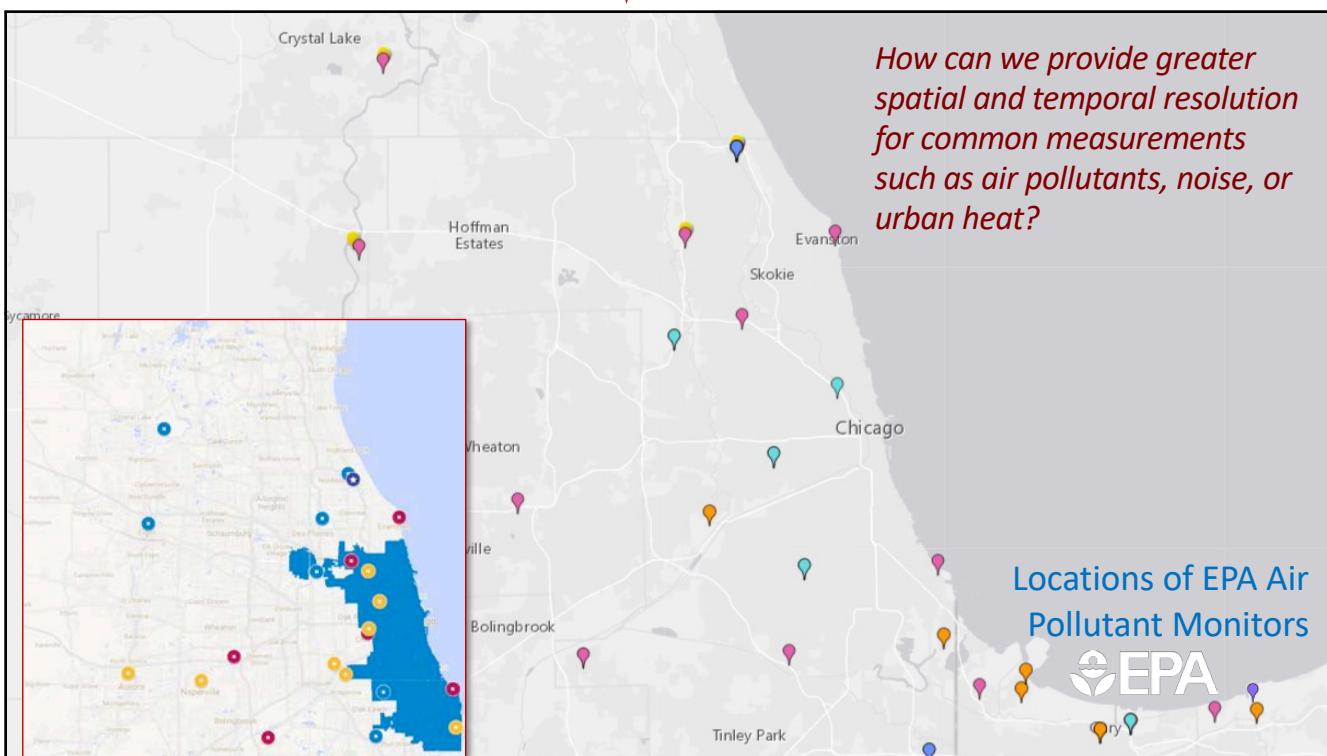
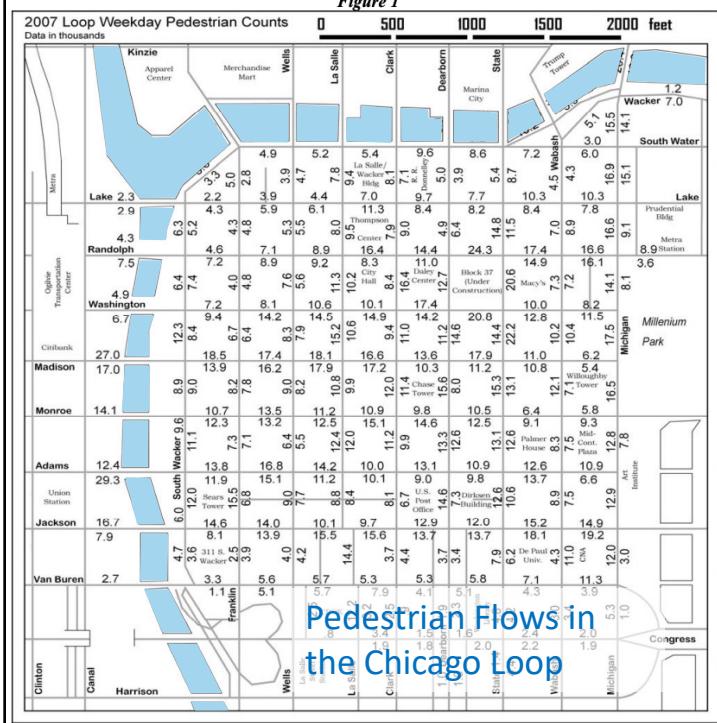


Figure 1

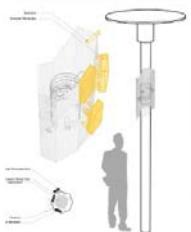


How can we use edge-AI to measure factors that traditionally require human observers, such as pedestrian flows, interactions among vehicles, or bicycle use?



Pedestrian Activity in Chicago's Downtown, prepared for Chicago Department of Transportation by TranSystems and TransInfo LLC, December 2008







Initiative 3

Implement policies and infrastructure to allow for urban technology experimentation. The City will implement policies and basic infrastructure that make Chicago friendly to technology experimentation, allowing Chicago to become a global leader in environmental sensing, spectrum research, and wireless connectivity, while enabling researchers to develop solutions to city problems.

#Jobs #Savings #Services #STEM

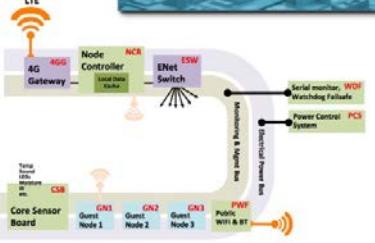
Urban sensing—collecting and using data from sensors in public urban spaces—is essential to the next generation of data science. By implementing access policies that respect individual privacy and installing basic infrastructure (including platforms with power/connectivity), Chicago will become a leader in this emerging field. In addition, Chicago looks to position itself at the forefront of advanced wireless research and development.

These policies and infrastructure will enable researchers to collect data at little cost to the City, will help attract technology companies and STEM talent, and could increase R&D money spent in Chicago.

Additionally, results from this experimentation can be used to help to solve city problems. Chicago expects to have these policies in place within the next six months, and basic infrastructure will be available to approved researchers shortly thereafter.

High-frequency phenomena require new sources of measured data.

URBAN CENTER FOR COMPUTATION AND DATA
ARCHITECTURE EPIC NODES/NETWORKS/INTERACTIVITY FALL 2013 SAIC



2013 Vision

How might the City of Chicago host a research instrument or infrastructure to support education and research?

AoT was a Science-Driven Instrument

Urban Landscape and Climate Change

Science Planning Workshop: An Urban Instrument for Measurement and Embedded Systems Research

September 2013

Science Planning Workshop: MRI Proposal for Urban Measurement and Embedded Systems Research

September 2014

Act Partner Kick-Off Meeting

Array of Things Partner Kick-Off Workshop September 2-4, 2015 Chicago, USA

1. AoT Partner Kickoff Workshop: Agenda
2. Breakout Report: Wednesday, September 2nd
2.1 Back-End Data Store
2.2 Data Flow
2.3 Federation and PDP
3. Breakout Report: Thursday, September 3rd
3.1 Data Flow
3.2 Water Quality and Urban Flooding
3.3 Urban Environment
3.4 Data Flow and Accountability/Demand Structure
3.5 Evaluation and Testing
3.6 PDP Self-Coordinating and RF Sensor Array
3.7 Configuration and Management
4. Participants

SAGE "AI@Edge" Science Workshop (April 2019 2017)

Workshop on Urban Scale Processes (May 2019)

Convening on Urban

Workshop on Urban Mobility in the Era of Smart and Connected Communities

Array of Things' User Workshop 29-30 August 2018 Venue: Argonne National Laboratory

SAGE "AI@Edge" Science Workshop (April 2019 2017)

REPORT

WORKSHOP ON URBAN SCALE PROCESSES AND THEIR REPRESENTATION IN HIGH SPATIAL RESOLUTION EARTH SYSTEM MODELS

MAY 20-24, 2018 ARGONNE NATIONAL LABORATORY LEMONT, IL, USA

UNIVERSITY OF ILLINOIS SYSTEM

ARRAY OF THINGS

Urban Landscape and Climate (August 2013)

Science Planning Workshop: An Urban Instrument for Measurement and Embedded Systems Research (January 2014)

Science Planning Workshop: MRI Proposal for Urban Measurement and Embedded Systems Research (October 2014)

Array of Things Partner Kickoff Workshop (September 2015)

Convening on Urban Data Science (April 2016)

Workshop on Urban Mobility in the Era of Smart and Connected Communities (February 2017)

Array of Things User Workshop (August 2018)



AoT Maximized Impact by driving the technology by urban research needs—not vice versa

Science input resulted in a design supporting traditional and experimental sensors, and *edge AI programmed measurements—requiring powerful computers in situ.*

← ***Environmental and Air Quality Sensors***

"Software-Defined Sensors"



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Northwestern University

Argonne NATIONAL LABORATORY

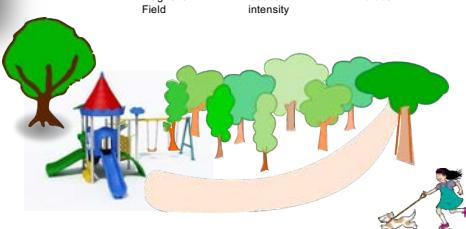
DPI



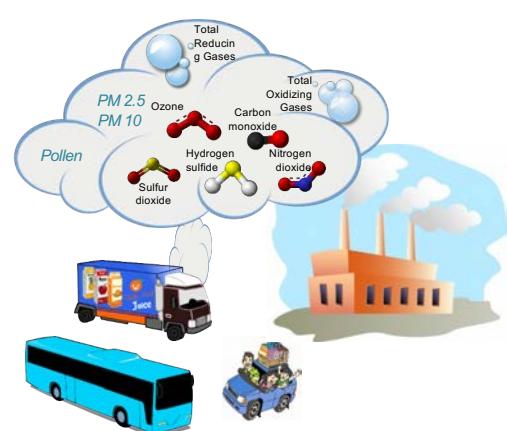
AoT: An Instrument with Three Functions



1. A Sensor Network



2. A platform to test new sensor technologies



3. A network of remotely programmable AI devices for R&D toward *perceptive infrastructure*



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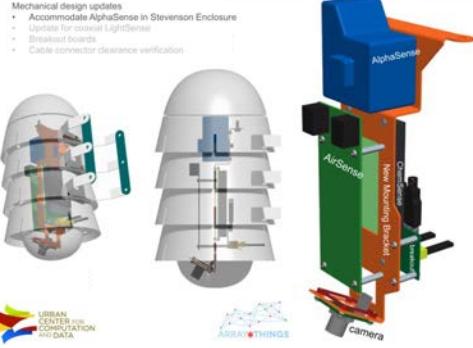


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Design Update

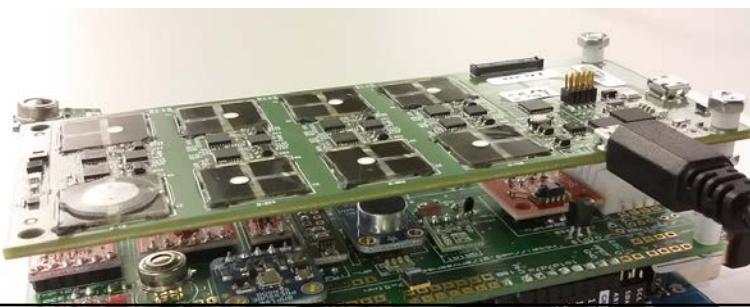
- Mechanical design updates
 - Accommodate AlphaSense in Stevenson Enclosure
 - Upgrades to Lightwave
 - Breakout boards
 - Cable connector clearance verification



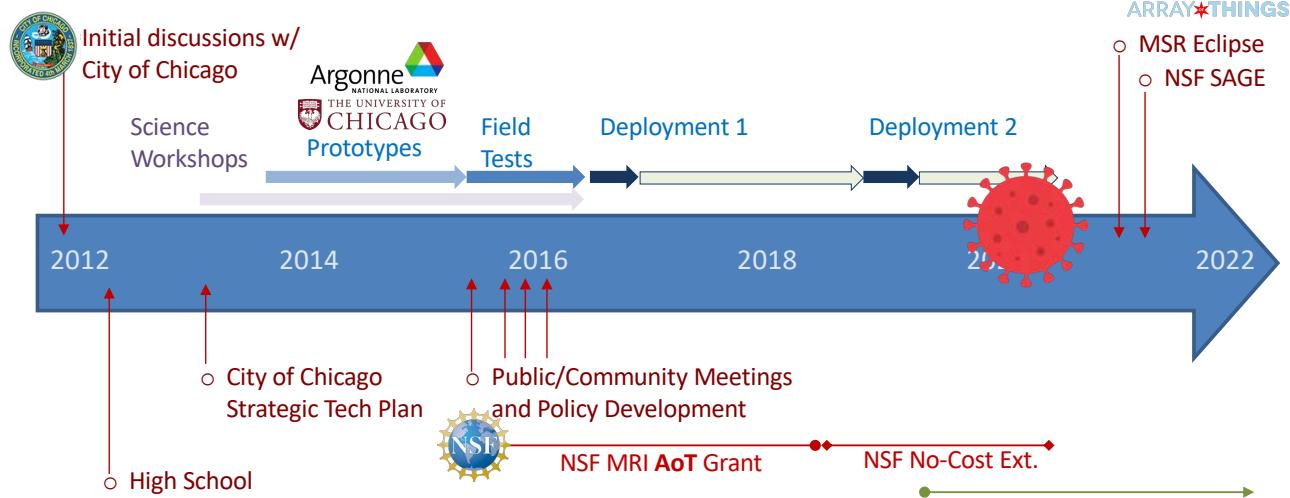
[pdf](#)



No open platforms existed to support these functions, so the team developed a new edge computing platform, *Waggle*.

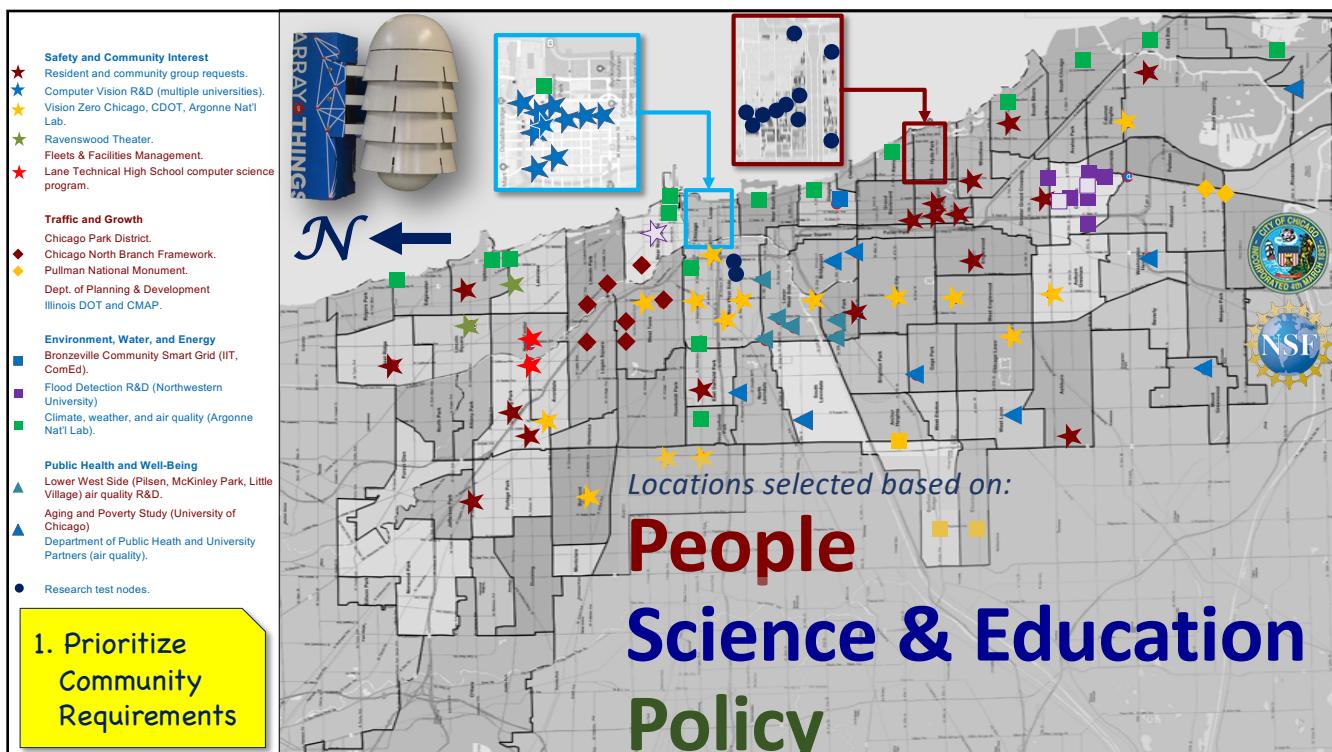
Timeline: The Array of Things





What have we learned?

Six key insights into translational research and the unique opportunities for *impactful* synergy among academics, city governments, and communities.



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Technology

Accountability
INDIANA UNIVERSITY
Center for Applied Cybersecurity Research

opengov FOUNDATION
THE CITY OF CHICAGO
CHICAGO MUSEUM OF SCIENCE AND INDUSTRY

Transparency

Privacy

2. Privacy built into the architecture

The Array of Things

AoT: Open Data

4,195,000,000 measurements

Map of Chicago showing sensor locations.

English, Zhao, Brown, Catlett & Cagney

Hu, Wang, Jiao, Sankaran, Catlett & Work

Potosnak, Sankaran, Papka, Kaberon, Kotamarthi & Catlett

Laha, Koschinsky, Kolak, Ladoy & Anselin

Time series plots for Temperature (T), O₃, and NO₂.

Diagram illustrating the data flow from Sensors to Edge Processor and Node Controller, then to Beehive (Cassandra Database) and Worker Bee (Plugins), finally reaching the Public Web Server and Plenario/AWS.



Community groups bring key perspectives and expertise.

~50-100 Edge-AI Nodes

**+
~100s of Low-Cost Sensors**

3. Engage Community Expertise

4. Make data legible

CDOT CHICAGO DEPARTMENT OF TRANSPORTATION

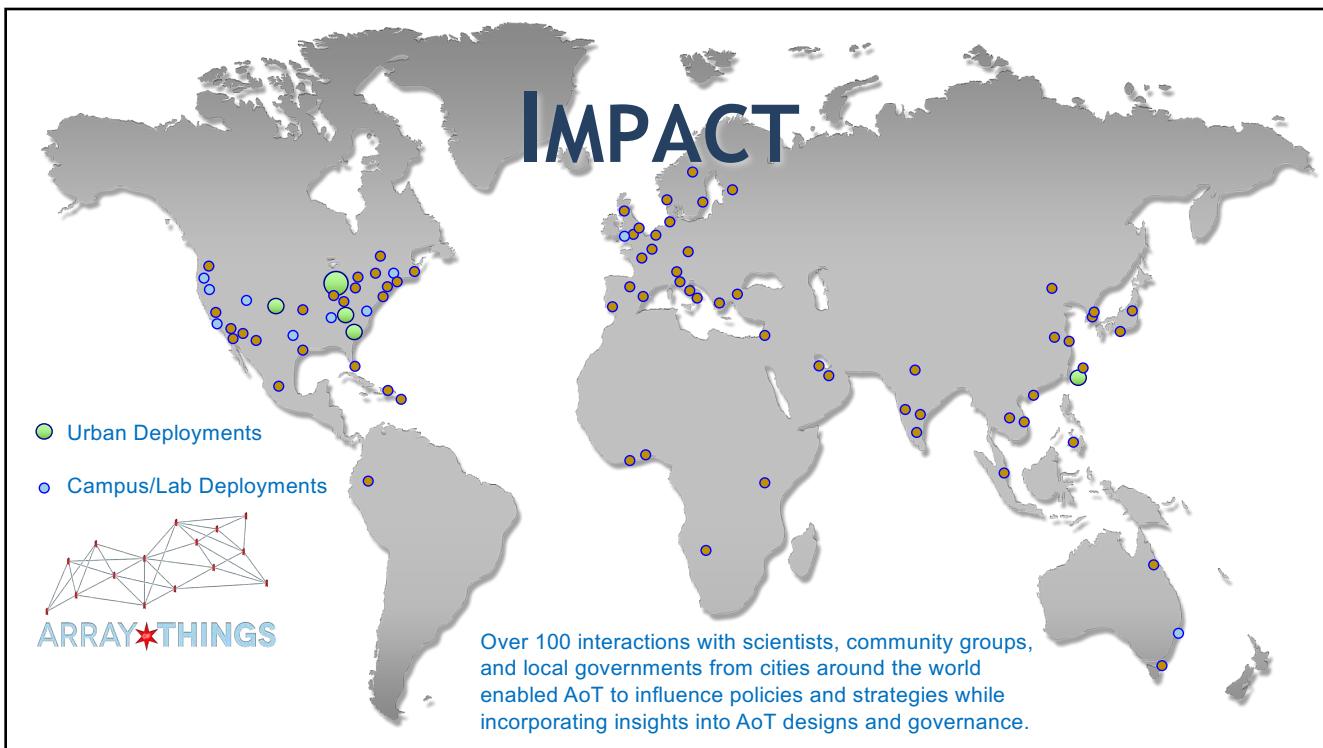
Microsoft

DPI ENVIRONMENTAL LAW & POLICY CENTER

JCDecaux

5. Engage Youth

"Lane of Things," funded by the Motorola Foundation with leaders at Lane Tech (Jeff Solin, Dan Law), the School of the Art Institute of Chicago (Douglas Pancoast, Satya Basu, and Robb Drinkwater), and UChicago (Kate Kusiak Galvin, Charlie Catlett)





AoT Science Exemplars

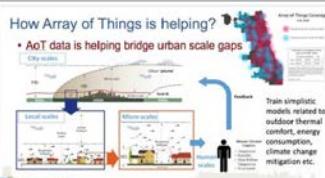


Figure 6: Urban Microclimate (Ashish Sharma, Notre Dame).

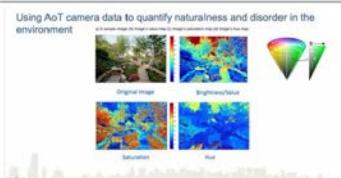


Figure 7: Behavioral Sciences (Marc Berman, UChicago).

AoT Computer Science Research Challenges

- From this morning:
 - CS scheduling
 - Resource management
 - Programming models
 - Data movement
 - Heterogeneous computing
- Improved ML/computer vision
 - Sampled vs Continuous data?
 - For each application, what do we need, what is enough?
 - Traffic engineering convention: 15 minute block vs all day but lower frequency?



Figure 8: Computer Science (Nicola Ferrier, ANL/UChicago).

Takeaways

- Mobility is changing in fundamental ways
- Programmable cameras (w/ privacy by design) are the most flexible instruments for tracking these changes
- AoT instrument/computer vision capabilities can evolve as quickly as mobility technologies
- AoT offers a chance to see things at city scales, i.e., understand generalizable results
- AoT offers chance to validate data-driven mobility experiments

Figure 10: Transportation Research (Daniel Work, Vanderbilt).

AoT and Urban Health and Well-Being Research



Figure 11: Urban Well Being (David Liebovitz, UChicago).

Innovation: AoT and Social Sciences

- Intersection of activity space approaches with AoT data opportunities
 - Nodes represent unique nature of these data
 - Nodes proximal to sampled neighborhoods
- New ways to examine inequality in exposure and resources
 - Public space and "stickiness"
 - Nature of street activity
 - Automated assessment of emotional states and environmental exposures
- Attention to variation in the micro-environment
 - Longitudinal assessment of neighborhood social and physical context

Figure 9: Social Sciences (Kathleen Cagney, UChicago).

Linking real-time monitoring with model development for prediction of urban flooding



Figure 12: Urban Hydrology (Aaron Packman, Northwestern).

microWaggle: Architecture

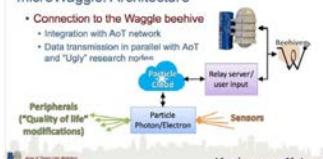


Figure 13: Sensor Network Architectures (Vivien Rivera, Northwestern/ANL).

Example Papers and Articles



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Where are we going now?

“AoT 2.0”



- Increased AI@Edge capabilities and decreased barriers to entry.
- Dozens to hundreds of devices in selected locations-of-interest.

- Increased density and decreased cost for key urban measurements.
- Hundreds to thousands of devices for comprehensive coverage.



Sage

A Software-Defined Sensor Network
Cyberinfrastructure for Edge Computing
www.sagecontinuum.org



SAGE: National Cyberinfrastructure for Distributed Sensing: Moving Artificial Intelligence to the Edge

Pete Beckman, Eugene Kelly, Charlie Catlett, Ilkay Altintas, Scott Collis, Nicola Ferrier, Raj Sankaran, Jim Olds, Valerie Taylor, Dan Reed, Frank Vernon, Joe Swantek, Mike Papka, Bill Miller, Aaron Packman, Irene Qualters, and many more...



Northwestern
University



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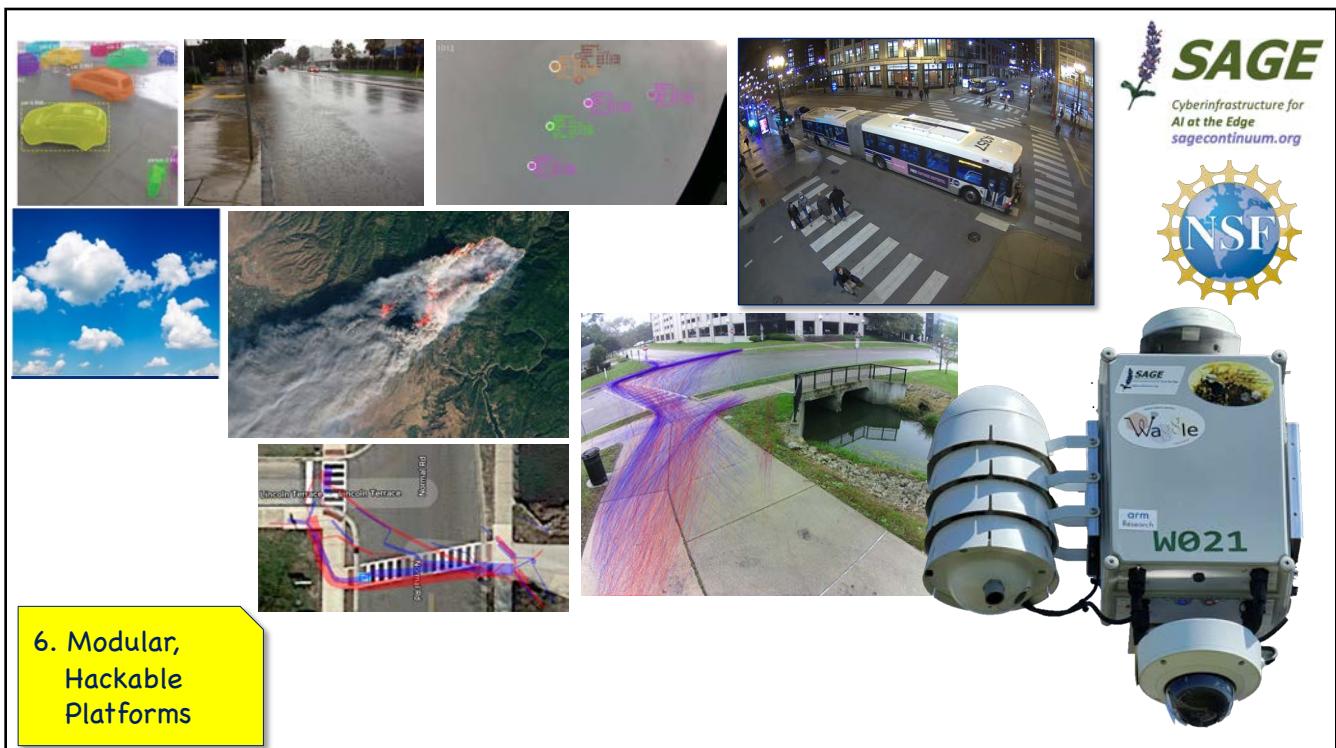
Northern Illinois
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Insights: Lessons Learned

Valerie Taylor (ANL/UChicago) (Moderator)

Pete Beckman (ANL/Northwestern)*

Kathleen Cagney (UMichigan)*

Brenna Berman (Former CIO, City of Chicago)

Michael Papka (ANL/NIU)*

*Array of Things NSF grant Co-Principal Investigator



Pete Beckman

Distinguished Fellow at Argonne National Laboratory and the Co-Director of the Northwestern University / Argonne Institute for Science and Engineering. As Co-Principal Investigator of AoT, Pete was the architect of the Waggle platform, first deployed in AoT and today forming the basis for the SAGE project.

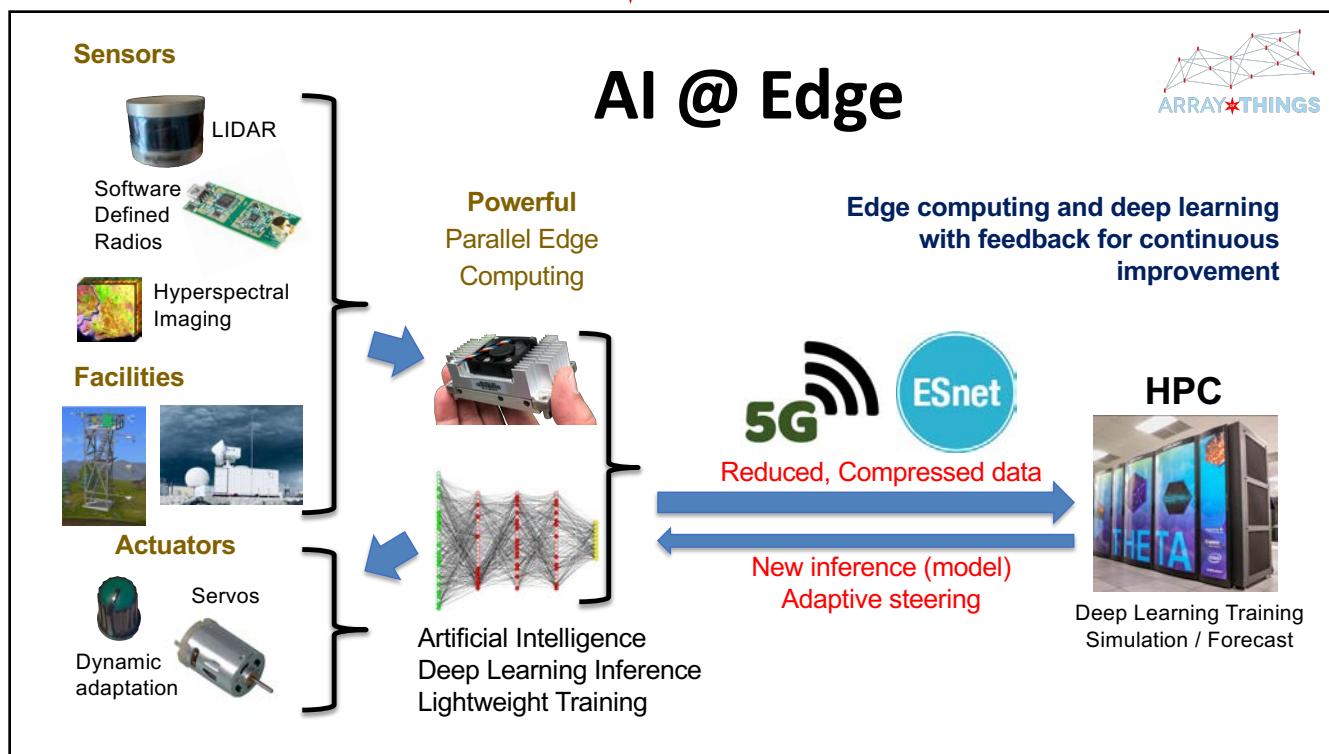


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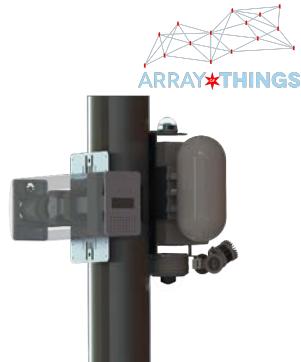
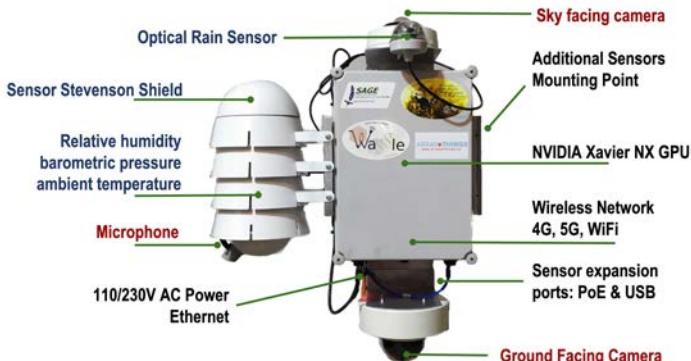
Why Live on the Edge?

- **More data than bandwidth**
 - Spallation neutron source, light source, SW defined radios, HD Cameras, LIDAR, radar, hyperspectral imaging, grid micro-synchrophasors, etc.
- **Latency is important**
 - Quick local decision & actuation; adaptive sensing & control systems
- **Privacy/Security requires short-lived data: process and discard**
 - Compromised devices have no sensitive data to be revealed
- **Resilience requires distributed processing, analysis, and control**
 - Predictable service degradation, autonomy requires local (resilient) decision
- **Quiet observation and energy efficiency**
 - Vigilant sensors, transmit only essential observations, not big data streams





Newest Waggle Platform: Combines sensors with AI@Edge Computing to build responsive, autonomous scientific instruments



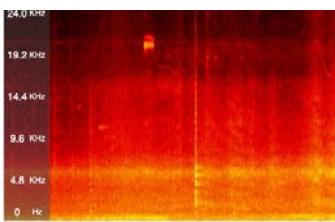
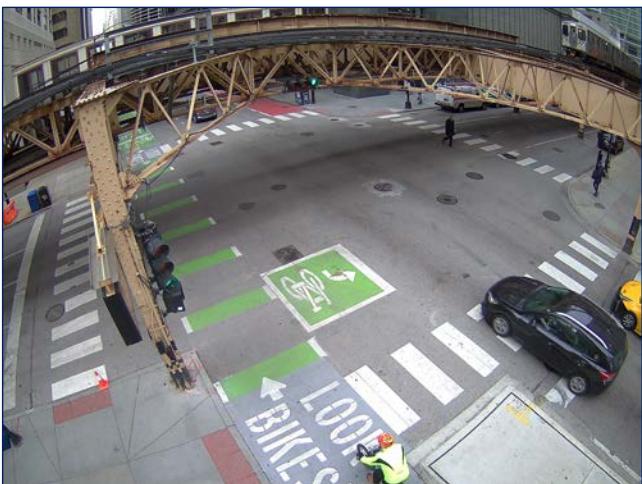
Waggle node passing freezing water/ice test chamber

Waggle node configuration for LBNL PANDA Project

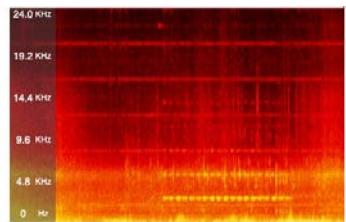


ALERTWildfire system in Oregon and Colorado, where Waggle nodes will use AI to process image data in real time for fire and smoke detection

Building atop standard community software:



Making data available
for students to learn AI.



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Sage (beta) App Catalog Docs Sign In

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Featured Apps

wildfire-smoke-detection Wildfire Smoke Detection seonghapark · 2 tags · Updated 15 days ago	object-counter Object Counter seonghapark · 4 tags · Updated 15 days ago	traffic-state Traffic State Estimator seonghapark · 4 tags · Updated 27 days ago
surface-water-detection Surface Water Detection seonghapark · 6 tags · Updated 28 days ago	motion-analysis Motion Analysis seonghapark · 5 tags · Updated 28 days ago	sound-event-detection Sound event detection (SED) plugin, using YAMNet audio classificati... dariodematties · 1 tag · Updated 34 days ago
avian-diversity-monitoring Records environmental sounds, identifies birds by such sounds and f... dariodematties · 1 tag · Updated 34 days ago	weather-classification An app for identifying cloud or rain coverage from the ARM Doppler ... rjackson · 1 tag · Updated 40 days ago	cloud-cover U-Net Cloud Coverage Estimator seonghapark · 1 tag · Updated 42 days ago
solar-irradiance Solar Irradiance Estimator Using U-Net seonghapark · 1 tag · Updated 42 days ago	motion-detection A general-purpose motion detection system that locates and tracks m... seonghapark · 1 tag · Updated 42 days ago	cloud-motion Cloud Motion Estimator for the Sky Camera bhupendraraaut · 1 tag · Updated 42 days ago

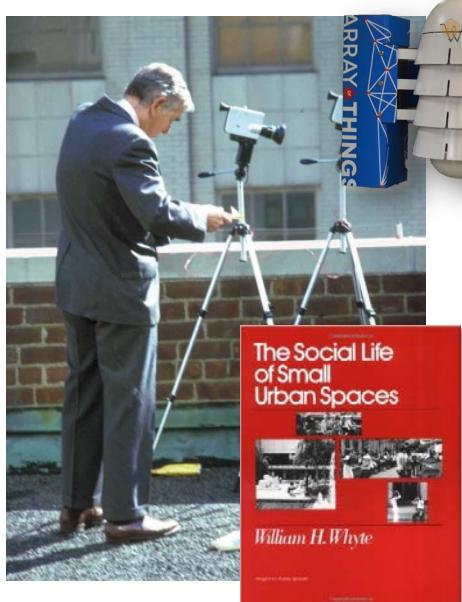


Kathleen Cagney

Director of the University of Michigan Institute for Social Research. Kate was the director of UChicago's Population Research Center and Associate Dean of Social Sciences during the conceptualization of AoT and as an AoT Co-Principal Investigator she led AoT's social and behavioral sciences team.



Using Edge-AI to “observe”

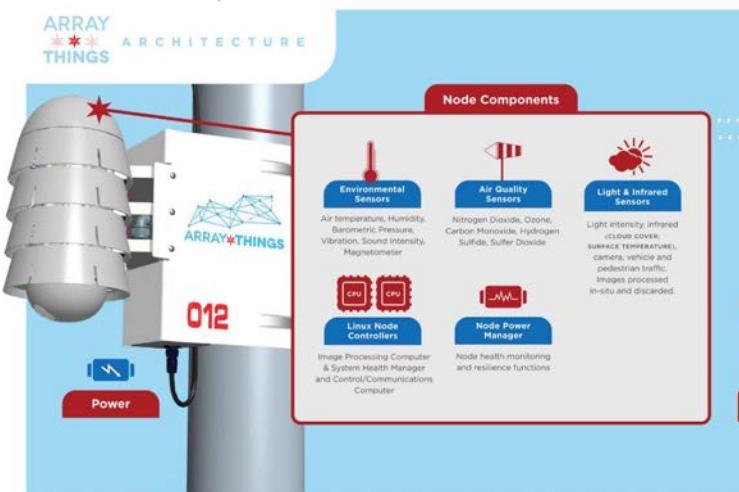


Chicago Health and Activity Space in Real Time (CHART)

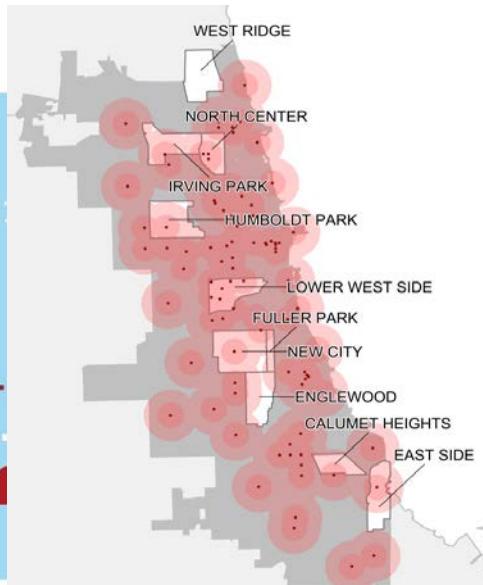


AoT & Chicago Health and Activity Space in Real Time (CHART)

450 respondents age 65+ in 10 neighborhood over three waves (Summer, Winter 2018 and Summer 2019)

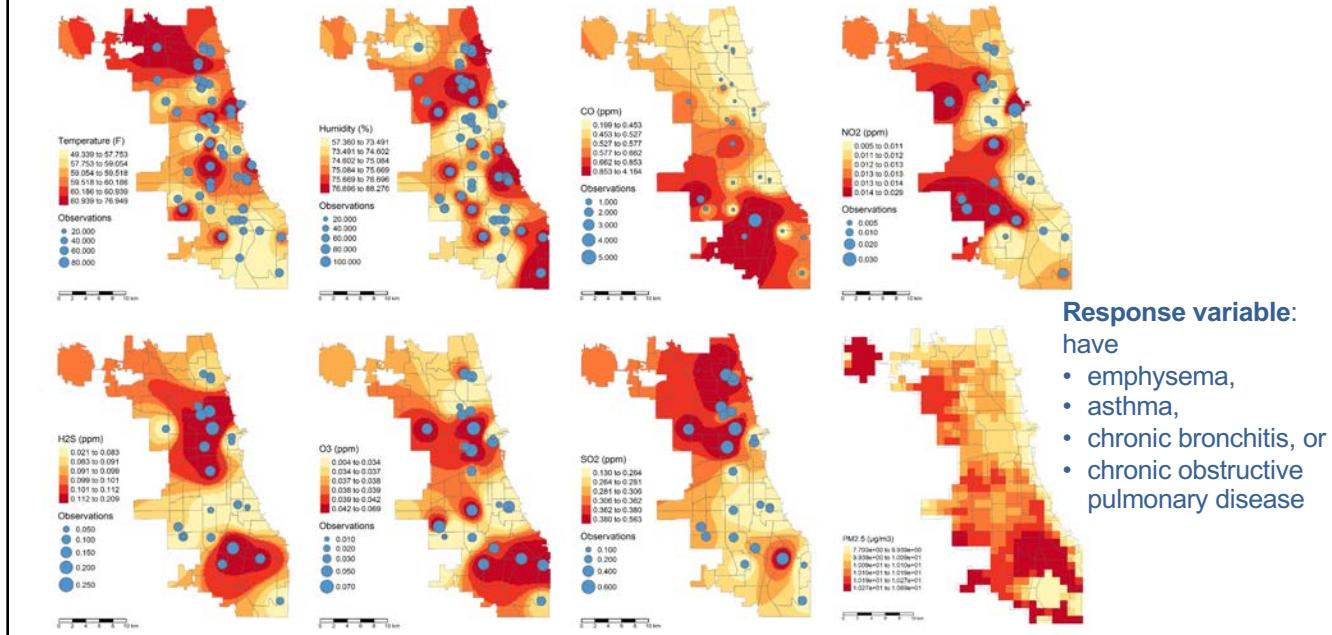


NORC & UChicago; English, Zhao, Brown, Catlett & Cagney (2019)





Results: Prediction maps annual average



Brenna Berman

Brenna was Chicago's Chief Information Officer during the formative stages of the AoT project and through its deployment. She subsequently led CityTech Collaborative, providing 'smart city' innovations and strategies for cities across the nation.



Broad stakeholder engagement builds the extended team for long-term support and success.

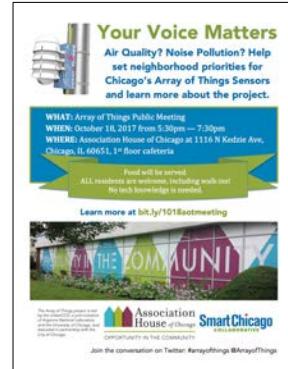
The Who

- Chicago Residents
- Policy Organizations
- City Departments
- Political Leadership
- Project Partners



The How

- In-person
- In writing
- Online with forms
- Consolidated comments in one place – Madison.io
- Predictable cadence



The governance & privacy policies of public science projects must balance the input of many parties.

Array of Things Governance & Privacy Policies

The Array of Things project and its researchers value **privacy, transparency, accountability, and openness**. We have worked with **the city, the public, and legal experts** to create governance and privacy policies that reflect these principles.

AoT privacy and governance policies were developed initially in the second half of 2015 and reviewed through a workshop including legal, academic, ethics, and privacy experts from the City of Chicago, the University of Chicago, Indiana University's Trusted CI (NSF Cybersecurity Center of Excellence) in early 2016. Throughout the first half of 2016 a series of **public meetings** were held to engage Chicago residents and community groups, and after this six-month period of public comment the policies were finalized and adopted. Since that time the project has regularly reviewed the policies and found them to be effective, thus they have remained unchanged. You can download the governance and privacy policies [here](#).

We thank the public for their valuable input during the feedback period in the spring and summer of 2016. We have **published responses** to all questions received online and during public engagement meetings. You can also view a final [Engagement Report](#) from Smart Chicago, summarizing the public feedback period and lessons learned from these outreach efforts.



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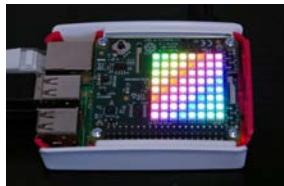
Michael E. Papka

Mike is a Presidential Research, Scholarship, and Artistry Professor in the Department of Computer Science at Northern Illinois University. He is also a Senior Scientist and member of the senior leadership at Argonne National Laboratory, where he directs the Argonne Leadership Computing Facility. As an AoT Co-Principal Investigator, Mike developed innovative education programs that immersed students and early career faculty members in AoT.

TRANSLATIONAL RESEARCH: AOT AND EDUCATION

Undergraduate Research (Citizen Science)

- Activities based on AoT
 - Hardware exploration
 - Raspberry Pi (with sense hat)
 - Particle IoT (electron)
 - NVIDIA Jetson Nano
 - Software
 - Data management
 - Running and maintaining services
 - Software development (teams)
 - Python and jupyter notebooks



```
In [209]: TSY001 = temperature(temperature['sensor'] == 'tay001')
TSY001.index = TSY001['Timestamp'].values
TSY001['Timestamp'] = pd.to_datetime(TSY001['Timestamp'])
# Set the graphing style we will use (https://matplotlib.org/users/style\_sheets.html)
plt.style.use('seaborn-whitegrid')

# Plot the data as a line chart
fig, ax = plt.subplots()

# One node was reporting ZONE
ax.set_xlim(0, 50)
# Set title and labels
ax.set_title('Temperature for ALL (-1) Nodes for Sensor TSY001', fontsize = 15, fontweight = 'bold')
ax.set_ylabel('Temperature (C)', fontweight = 'bold')
# Plot individual nodes as a line - marker - marker ensures the nodes are on top and
# the markers are at the TSY001 index
tj_value,hf = TSY001.groupby('node').tail(1)
tj_value.hf['Week of Data'] = 15, linewidth=1
ax.set_xlabel('Week of Data', fontsize = 15, labelweight='bold')
ax.set_ylabel('Temperature (C)', fontsize = 15, labelweight='bold')

Out[209]: Text(0.5, 0.05, 'Temperature for ALL (-1) Nodes for Sensor TSY001')
```

James Bonasera, Thomas Franczak, May Myo Khine, Ryan Lewis, Matthew Swed, Ryan Sy, Kevin White, Alex Wills 2017 - 2019



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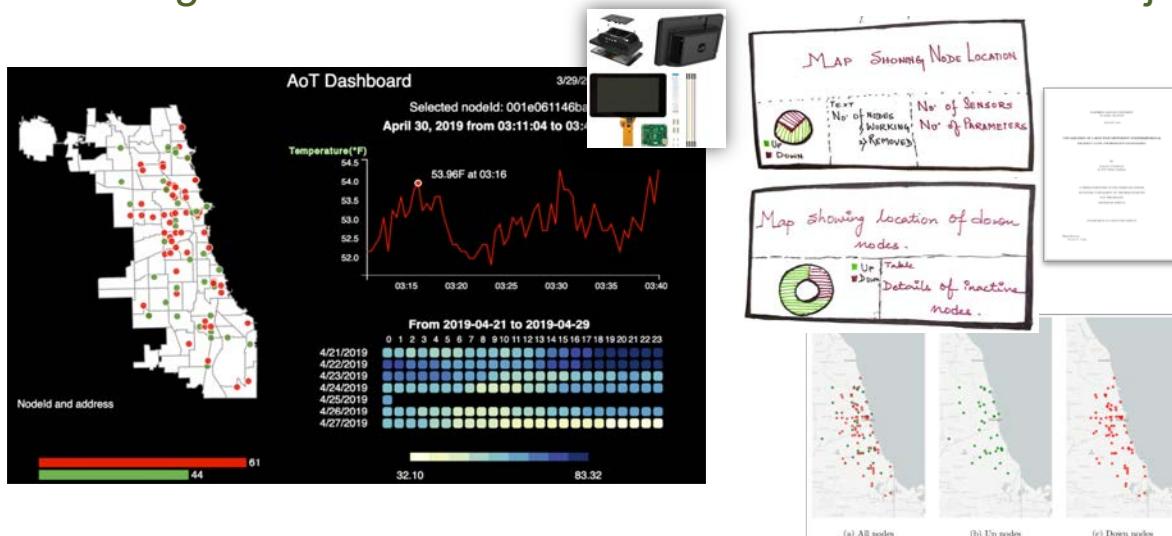


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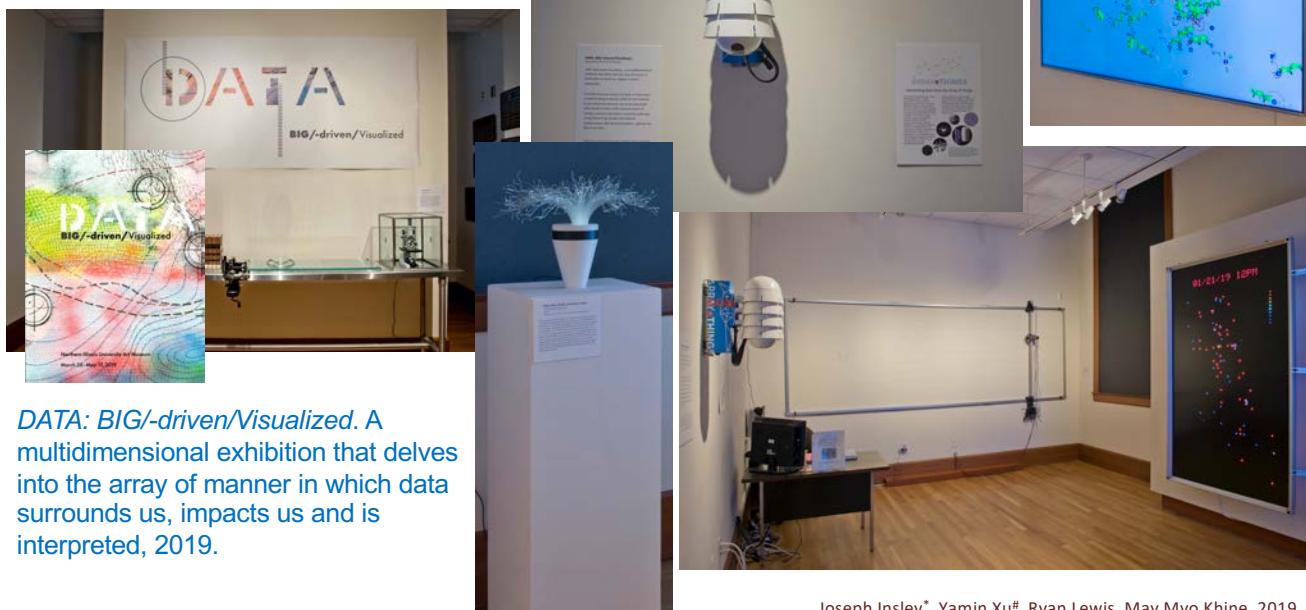
Scholarly Activity

- Undergraduate Honors Thesis
- Masters Thesis Project



May Myo Khine, Ankita (Ricky) Upadhyay#, 2019

Science as Art





Big Data Camp (2018 - 2021)

- Free, 5-day summer camp
- Participants get to learn first-hand what it's like to be a data scientist
- Students learn to visualize data and realize unexpected and amazing relationships within the data

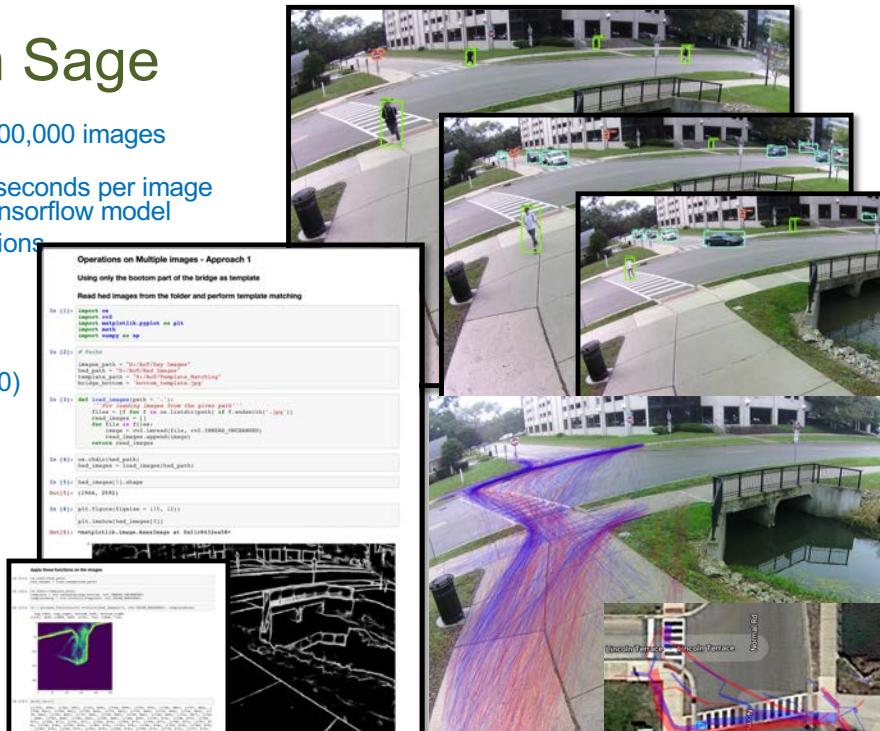


John Domyancich, 2018 - 2021

Continuing with Sage

- In the process of labeling ~2,500,000 images
~two weeks of NIU AoT video data
- Test labeling of > 17,000 @ 2 seconds per image using 2 GPUs and standard tensorflow model
- Crafting classroom level questions
 - Fraction that uses crosswalk
 - Speed of cars
 - Do cars stop for people
 - Traffic and pedestrian flows
- Foundation for MS thesis (2020)
 - Project
 - Collect images
 - Process for water height
 - Extract data
 - Plot to long running service
 - Status
 - Tools for loading images
 - Determining day/night
 - Prototype water extraction

Pratool Bharti*, Dave Koop*, Emily Brown,
Enkhamgalan Tamillow, Wesley Kwiecinski, Justin
Derus, Priyajani Chandra[#]



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Inspiration: Building on AoT Insights

Anne Dodge (UChicago)(Moderator)

Daniel Work (Vanderbilt)*

Marc Berman (UChicago)

Tiffany Werner (ELPC)

Douglas Pancoast (School of the Art Inst. of Chicago)

*Array of Things NSF grant Co-Principal Investigator



Daniel Work

Chancellor Faculty Fellow and associate professor in civil and environmental engineering, computer science, and the Institute for Software Integrated Systems at Vanderbilt University. While at the University of Illinois, Dan was a co-Principal Investigator for the AoT project, leading the AoT transportation, infrastructure, and energy team..

[Research Sponsors: NSF, USDOE, US DOT, Tennessee DOT, views are my own]



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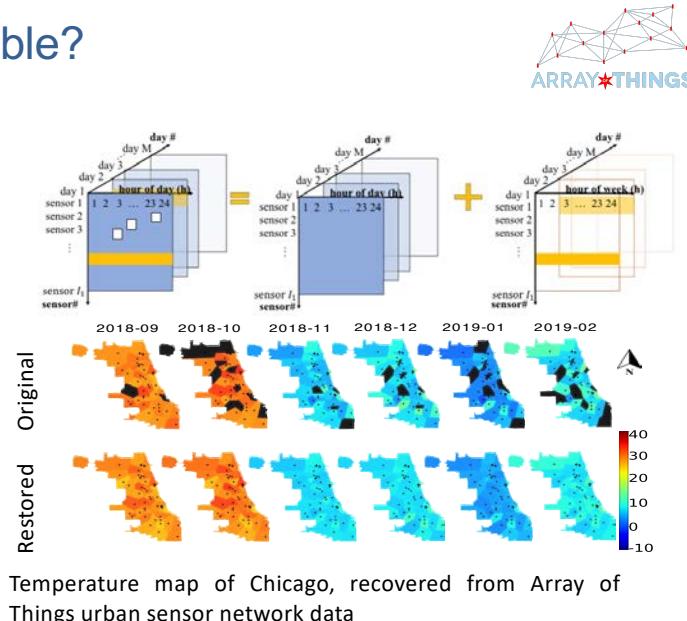


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What did Array of Things enable?

- New techniques for data cleaning for streaming sensor networks
- Developed for Array of Things, generalized to urban traffic networks



Temperature map of Chicago, recovered from Array of Things urban sensor network data

Y. Hu, Y. Wang, C. Jiao, R. Sankaran, C. Catlett, and D. Work, "Automatic data cleaning via tensor factorization for large urban environmental sensor networks," in *Proceedings of the Workshop on Tackling Climate Change with Machine Learning at the Thirty-third Annual Conference on Neural Information Processing Systems (NeurIPS)*, 2019





Deployment at full-scale: I-24 MOTION



A scientific instrument to understand and enable

- connected and automated vehicles
- Advanced traffic management technologies
- reliability, safety, & mobility

Differentiators:

- 300 4K resolution video cameras on 4 miles of I-24
- 260,000,000 vehicle-miles of trajectory data per year
- Unlocks next generation traffic science & cyber physical systems



Prototype system construction



Prototype system is now operational; Phase 1 construction in 2022



Marc Berman

Marc is an Associate Professor in the UChicago Department of Psychology and is involved in the Cognition, Social and Integrative Neuroscience programs. Marc and his team are seeking to understand the relationship between individual psychological and neural processing factors with environmental factors. Working with the AoT team, Marc leads an NSF Smart and Connected Communities project that will test new edge AI capabilities introduced with the NSF SAGE project, while benefiting from new data from low-cost air pollution sensors in Chicago.



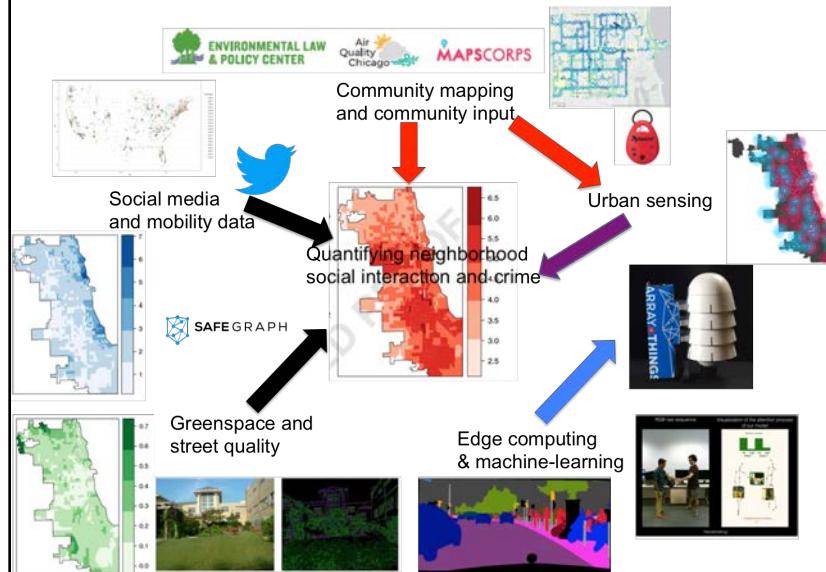
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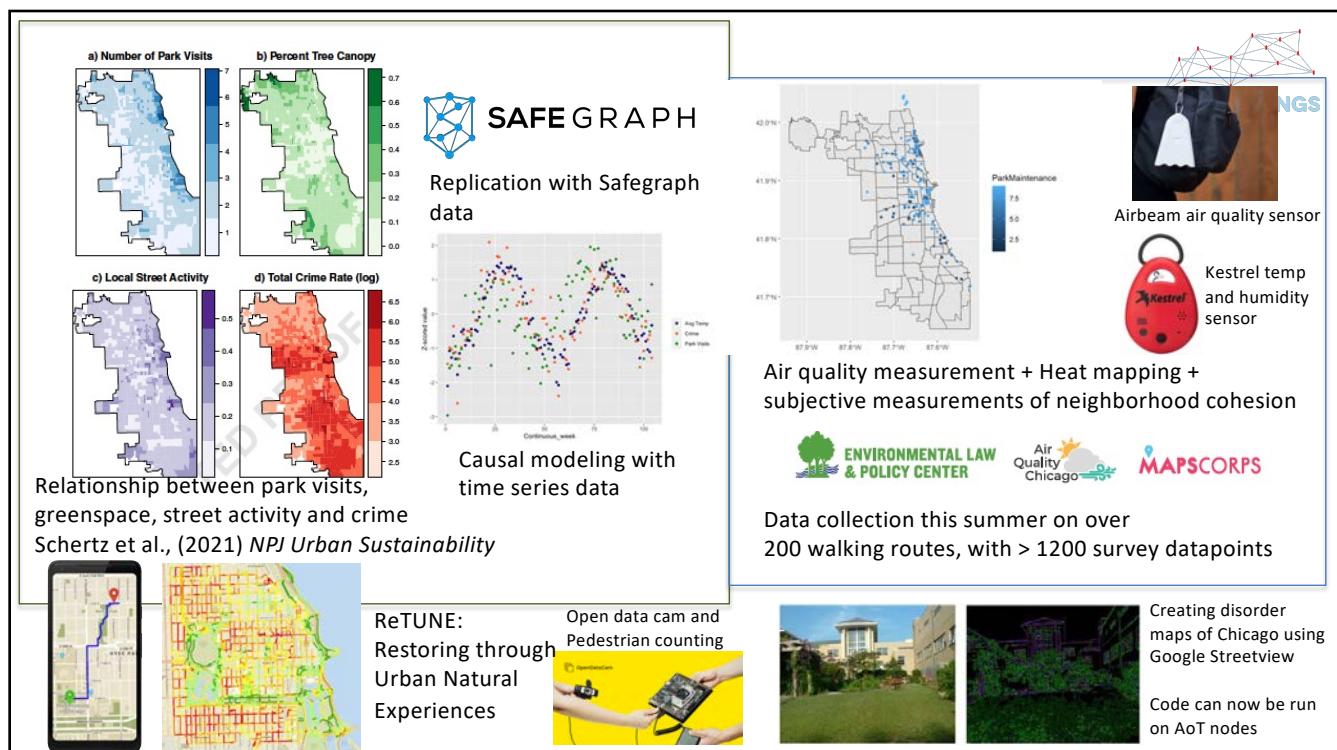
Quantifying Neighborhood Social Interaction and Crime



Project Vision

We seek to quantify the nature of social interactions in different neighborhoods based on community input, social media data, mobility data, greenspace, street quality and urban sensing data.

We plan to uncover the psychological, sociological and physical environmental factors that explain variance in social interactions. This will lead to proposed interventions to improve well-being and neighborhood social cohesion.



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Tiffany Werner

Tiffany Werner is a community science organizer at ELPC, working on diesel pollution reduction and air quality monitoring. She was one of the key leaders working with Microsoft Research, JCDecaux, and the AoT team to engage Chicago community groups in the exploratory air quality sensor project with prototype sensors on Chicago bus shelters.



Air Quality Chicago



- Educating communities about what is in the air they breathe and ways to protect their health.
- Providing communities with hand-held air quality monitors to collect and understand air data, in hopes that the hands-on experience will empower them to become clean air advocates.
- Partnering and collecting data with communities that may be disproportionately affected by particle pollution
- Informing the city on how to enforce and create clean air policies that will protect public health.



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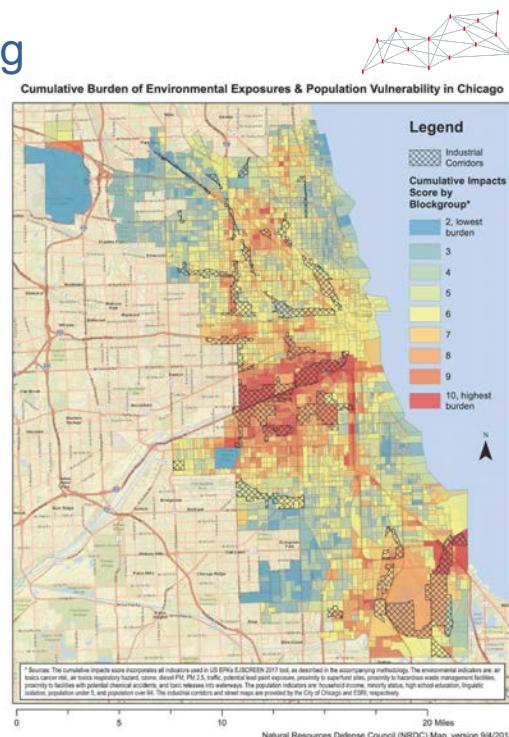


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The need for more localized monitoring

- The current network of EPA sensor are not located in areas that are the most vulnerable. This leads to a system that washes out, or entirely misses local air pollution spikes.
- Localized monitoring networks (on a neighborhood or community scale) that yield quality data provides a better picture of what is happening in our most vulnerable neighborhoods.
 - E.g., Shared Air Shared Action, community led mobile monitoring with Airbeams, and Purple Air stationary monitor placement.
- City-wide networks that provide 24hr data can provide insight on what neighborhoods / communities are more vulnerable than others and when and where air pollution spikes are happening.
 - E.g., AoT and Project Eclipse



Data Legibility and Visibility Empower Participation.

What is the air quality here?
¿Cuál es la calidad del aire aquí?

We're measuring air quality data hourly at this bus stop. Our mission is to ensure that the places you care about are included in pollution monitoring networks. Microsoft does not collect any personal information.

Estamos midiendo los datos de calidad del aire por hora en esta parada de autobús. Nuestra misión es garantizar que los lugares de su interés se incluyan en las redes de monitoreo de contaminación. Microsoft no recopila información personal.

scan or go to:
escanee o vaya a:
www.urbar.microsfot.com/air/go

Why is there a leaf on my bus stop?
Do you know what is in the air around you? The air you breathe greatly impacts your health over time. Understanding how clean or dirty the air is where we live, where we play, or where we wait for the bus informs how and where to work.

How clean is your air?
Good Ok Poor

Microsoft does not collect or maintain personal or private information.



Making data visible and legible to residents, and including them in design, makes Urban Planning more effective and participatory rather than merely responsive (though responsive would be good!)



Douglas Pancoast

Douglas Pancoast is Associate Professor and Chair of Architecture, Interior Architecture and MFA(Arch) / MFA(DET) at the School of the Art Institute of Chicago. As part of the team that conceived of AoT as an urban-scale instrument, Douglas led the design of the physical form of the nodes. He also led the School of the Art Institute's collaboration with Lane Technical High School and the "Lane of Things" program.

PROJECT GOALS
DESIGN A DEPLOYABLE PLATFORM FOR URBAN SENSING IN THE FORM OF LIGHT EMITTING SENSOR ENCLOSURES TO BE ATTACHED TO EXISTING STREETLIGHTING ELEMENTS ON CAMPUS. PROVIDES OPPORTUNITY FOR INFLUENCING THE ENVIRONMENT AT PEDESTRIAN LEVEL.

THE PROJECT SHOULD DEVELOP A FORM THAT ATTACHES TO STREETLIGHTING ELEMENTS ON CAMPUS. PROVIDES OPPORTUNITY FOR INFLUENCING THE ENVIRONMENT AT PEDESTRIAN LEVEL.

PROJECT SHOULD SERVE AS A PROTOTYPE FOR A DEVELOPED SYSTEM OF URBAN SENSING NODE/INTERACTION PLATFROMS TO BE DEPLOYED ACROSS CAMPUS. EACH NODE CAN TRANSMIT INFORMATION THROUGH COLOR AND INTENSITY. EACH NODE CAN TRANSMIT INFORMATION OF ENVIRONMENTAL CONDITIONS, SAFETY, AND COMMUNITY BULLETINS.

PROJECT TIMELINE

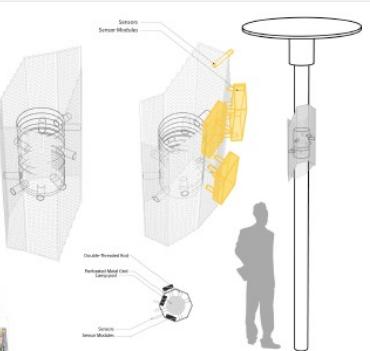
- CLIENT MEETING 10/15 - UNIVERSITY OF CHICAGO
 - IDENTIFY CONDITIONS AND OPPORTUNITIES
 - IDENTIFY HOW TO MAKE THIS INVISIBLE
 - BIG IDEA
 - DO LIST
 - DESIGN LIGHTURE
 - CLARIFY SCOPE
 - LEARN FROM PRESENTATION
 - TEAM PROGRAMS
- CRITIQUE 10/29/13 - SAIC CLASSROOM
 - CONSIDER OBJECT AND HOUSING ENCLOSURE
 - CONSIDER LIGHTING
 - CONSIDER MASS PRODUCTION
- CRITIQUE 11/13
 - DESIGN CONCEPTUAL SKETCHES OF FORM
 - MEETING 11/19
 - EVALUATE CONCEPT SKETCHES AND NARROW
 - MEETING 12/3
 - DEVELOP PROTOTYPES FOR FINAL PRESENTATION
 - MEETING 12/13
 - FINAL SELECTION OF CONCEPTUAL PROTOTYPES AND PREPARE PRESENTATION MATERIAL/PHYSICAL MOCKUPS AND RANKING PROTOTYPES

TEAM STRUCTURE

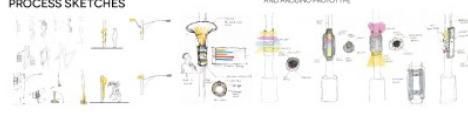
- GROUP LEADER: SATYA BASU
- GROUP SECRETARY: CECILIAN JACKSON
- INTERDISCIPLINARY TEAMING: CHANDRA ALGHAMID, JEROME KIM, FATHIMA TANIR

- RESEARCH: KOOROSH BEKHCHAMADI, DEBORAH JACKSON, JEREMY KELLY, KAREN MUSHKOVIC

- ADDITIONAL: COREY HUANG, SATYA BASU



PROCESS SKETCHES



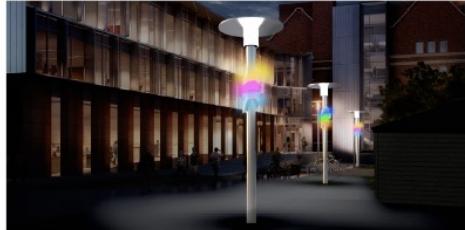
EARLY PROTOTYPE



SCREEN PATTERN PROTOTYPES



RENDERED CONCEPT



 **URBAN SENSING NODE**
UNIVERSITY OF CHICAGO

ARCH/INARCH 6112
NODES/NETWORKS/INTERACTIVITY
FALL 2013 



2013 Vision





Acknowledgements



- Array of Things was funded through a Major Research Instrumentation (MRI) grant (1532133, 2015) from the U.S. National Science Foundation (supported by Computer and Information Sciences and Engineering, Crosscutting Programs, and Engineering).
- Array of Things cost-sharing partners included the City of Chicago, the University of Chicago, AT&T, Cisco, Intel, Microsoft, Motorola Solutions, and Schneider Electric.
- Array of Things technology partners included Amazon Web Services, Crown Castle Communications, Exelon, JCDecaux, Sidewalk Labs, PDT/Astrotech, and Surya Electronics.
- The Waggle platform used for AoT was developed with funding from Argonne National Laboratory (Laboratory Directed Research and Development, LDRD), with extensions and customizations funded by the University of Chicago and through the NSF MRI grant.
- The SAGE project is funded through a Mid-Scale Research Infrastructure (MSRI) grant (1935984, 2019) from the U.S. National Science Foundation.
- Beyond cost sharing, the AoT project would not be possible without the extensive support from, and partnership with, the City of Chicago Department of Innovation and Technology, Department of Transportation, and Mayor's Office.