
New Approaches to Improve Urban Measurements:
The Array of Things
Fredericia, Denmark
21-September 2018
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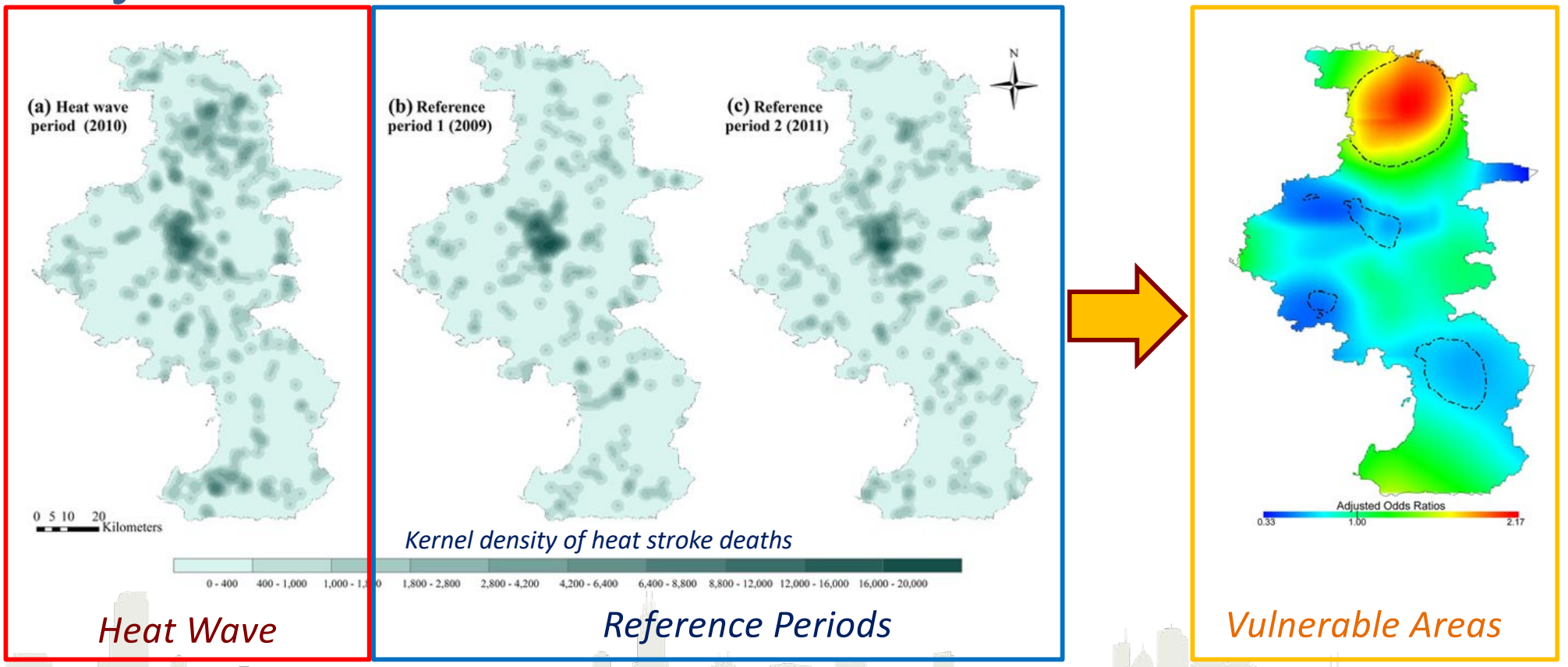
CITIES 5th General Consortium Meeting
FREDERICIA, 20-21 SEP 2018

Why Measure Cities? *Extreme Temperatures*

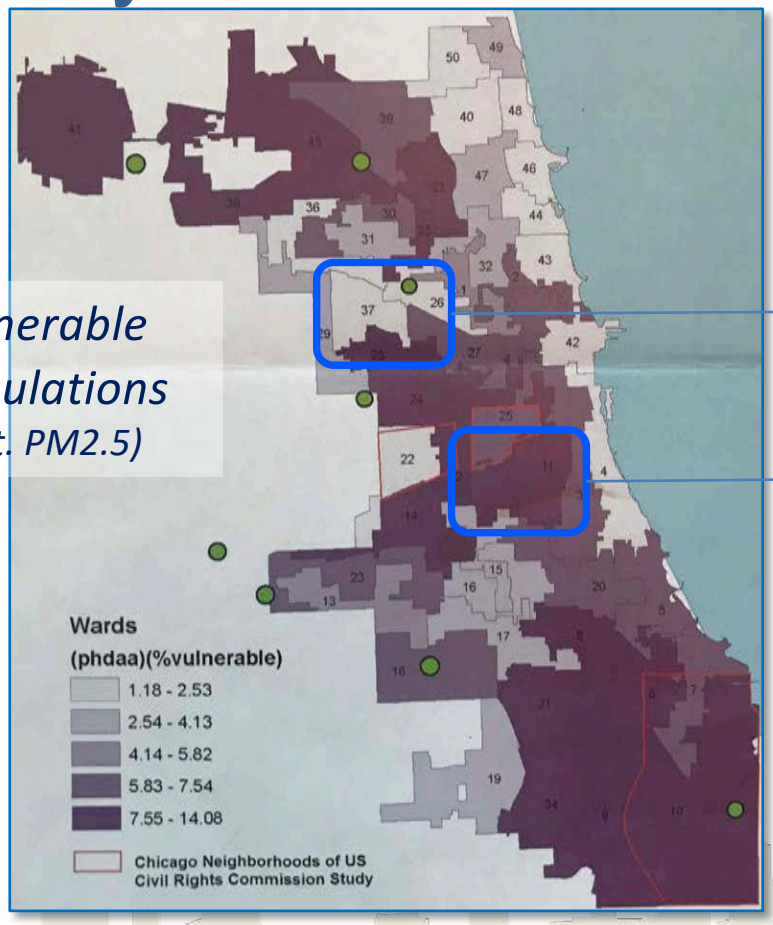


Spatial analysis of the effect of the 2010 heat wave on stroke mortality in Nanjing, China
Kai Chen, Lei Huang, Lian Zhou, Zongwei Ma, Jun Bi & Tiantian Li,
Nature, *Scientific Reports* volume 5, Article number: 10816 (2015)

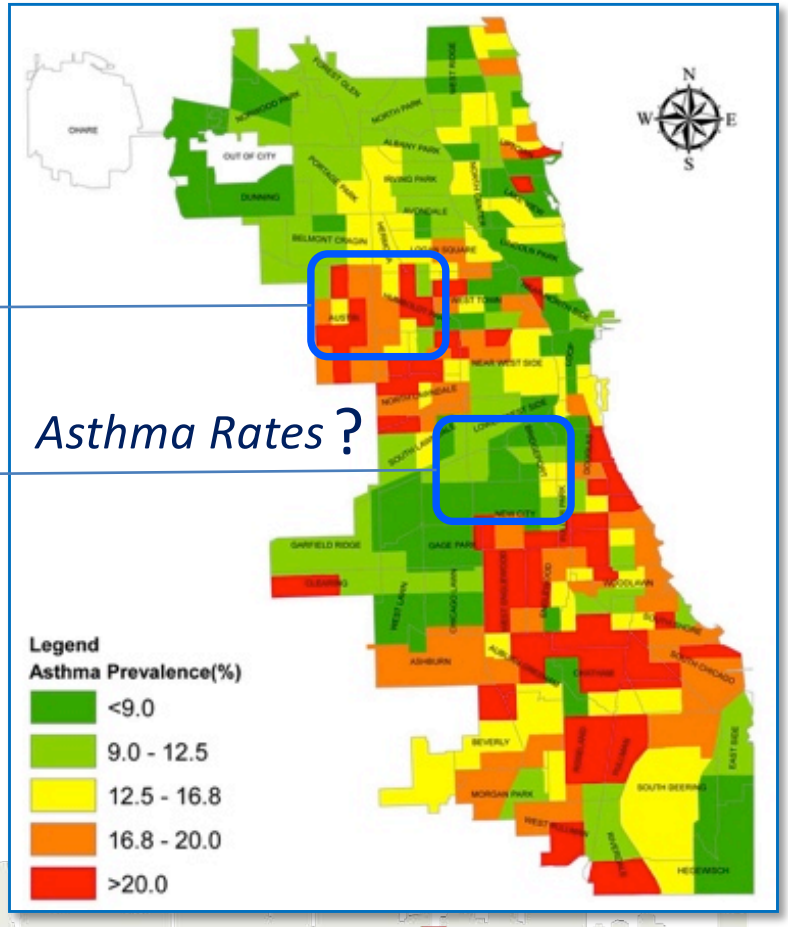
Contour lines show the areas with significantly increased or decreased adjusted odds ratio (p-value < 0.05).

Why Measure Cities? *Air Quality*

Vulnerable Populations
(w.r.t. PM2.5)



Asthma Rates ?



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Metalmunition.com

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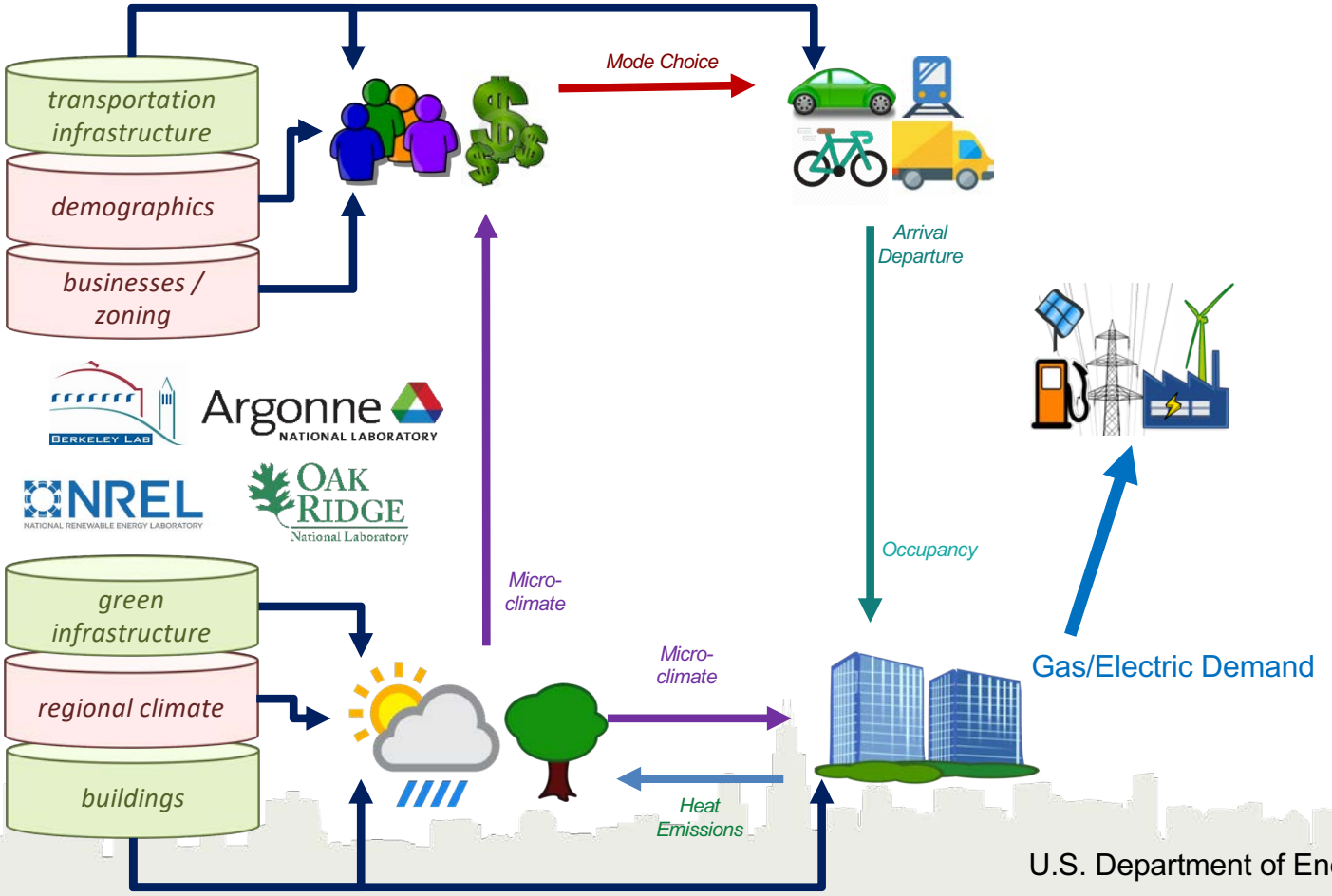
Multiscale Urban Systems: Energy Demand



New district/campus development with zero-net energy (ZNE) or zero-net carbon (ZNC) goal

For each of *n* candidate redevelopment plans:

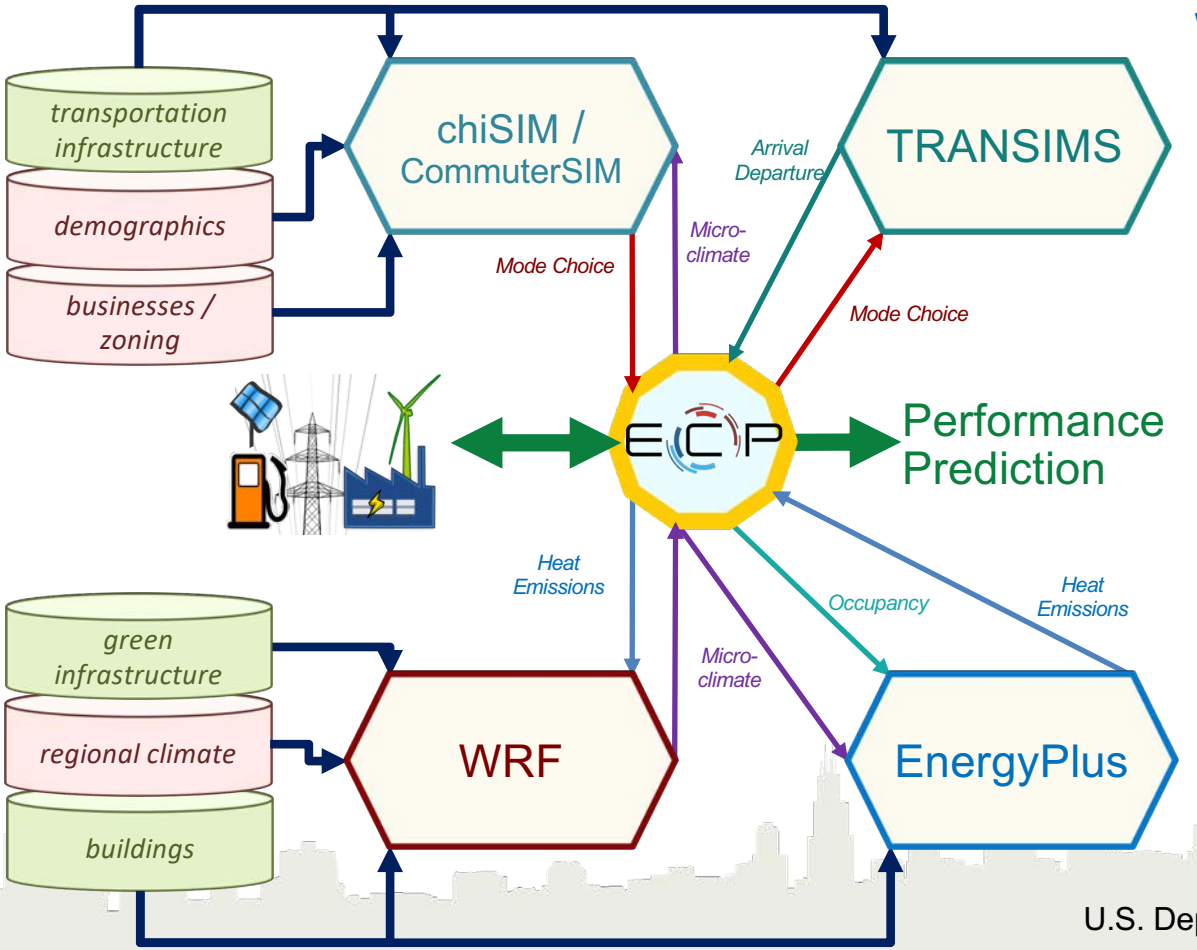
1. Predict energy demand over *m* years for *p* IPCC climate change scenarios
2. *Predict peak electricity demand under q scenarios of heat waves*
3. Optimize the balance of energy efficiency and on-site renewable energy generation towards the ZNE/ZNC goal, e.g. evaluating *r* energy infrastructure options
4. Evaluate impact of the *n* building mix/diversity and density on energy demand
5. Evaluate impact of urban morphology on energy demand
6. Feasibility study of *q* options for district energy systems considering loads diversity and density
7. Quantify interdependency between buildings and urban microclimate to guide UHI policy and mitigation
8. Evaluate impacts of EV and electrification on energy demand
9. *Risk assessment and mitigation of indoor environment under extreme weather events (e.g., heat waves, cold waves, wildfire-generated plumes)*
10. Evaluate energy resilience considering deployment of renewable energy, energy storage, EV, and advanced control strategies.
11. Evaluate changing future demographics and their transportation choices.
12. Evaluate transportation infrastructure changes such as adding dedicated transit corridors.

U.S. Department of Energy

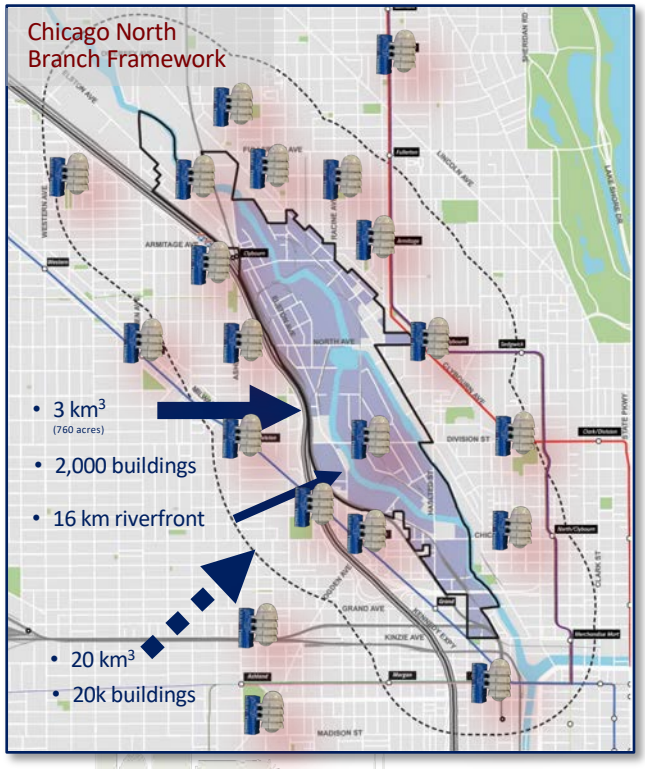
ECP EXASCALE COMPUTING PROJECT

Charlie Catlett (ANL), Tianzhen Hong (LBNL), Jibo Sanyal (ORNL), Ben Polly (NREL)

Evaluating Urban Design Options



How will different building, campus or district designs perform with respect to energy over 20 years, under different potential weather futures? What about water? Transportation?



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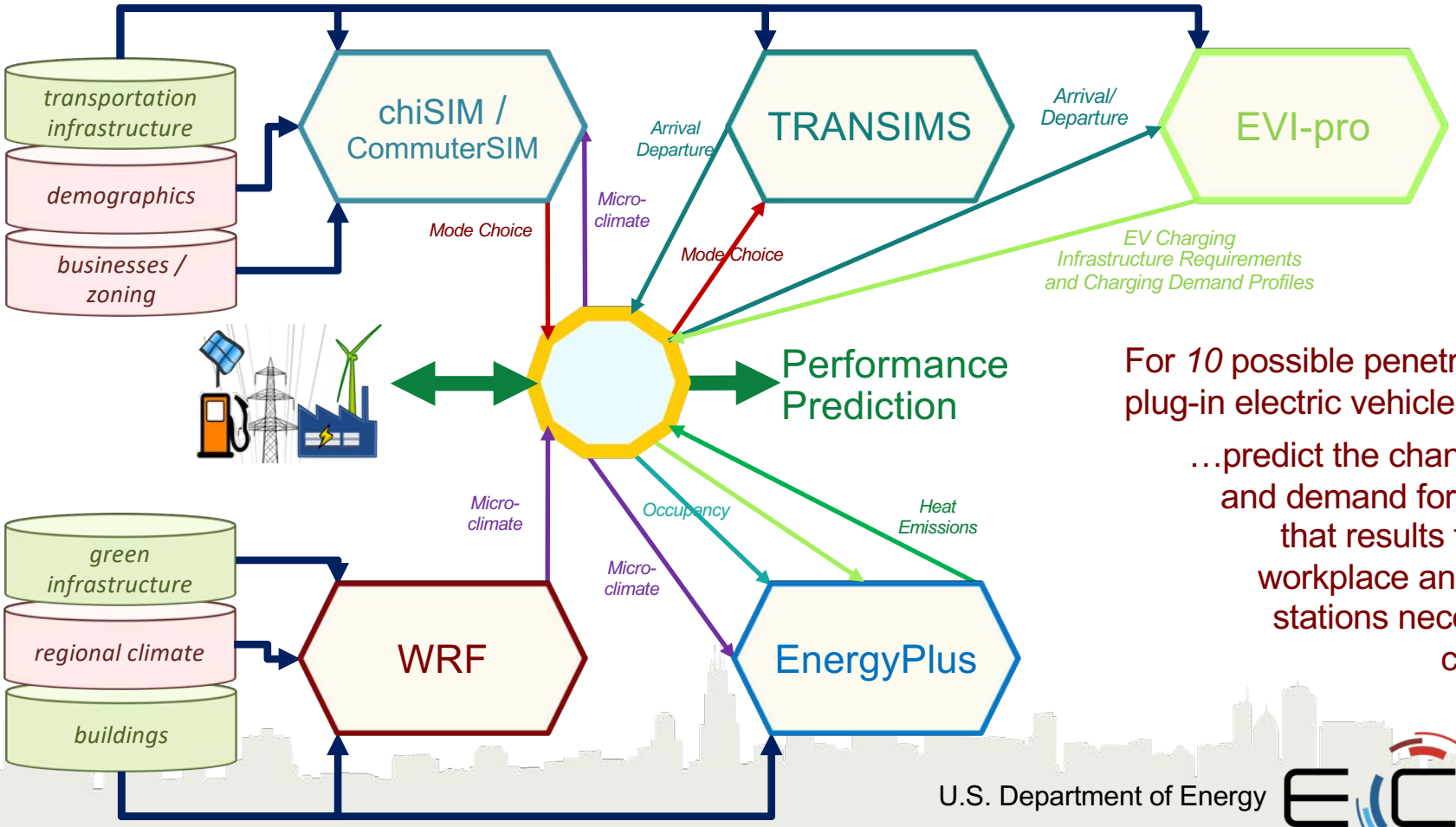
Impact of EV Adoption Levels

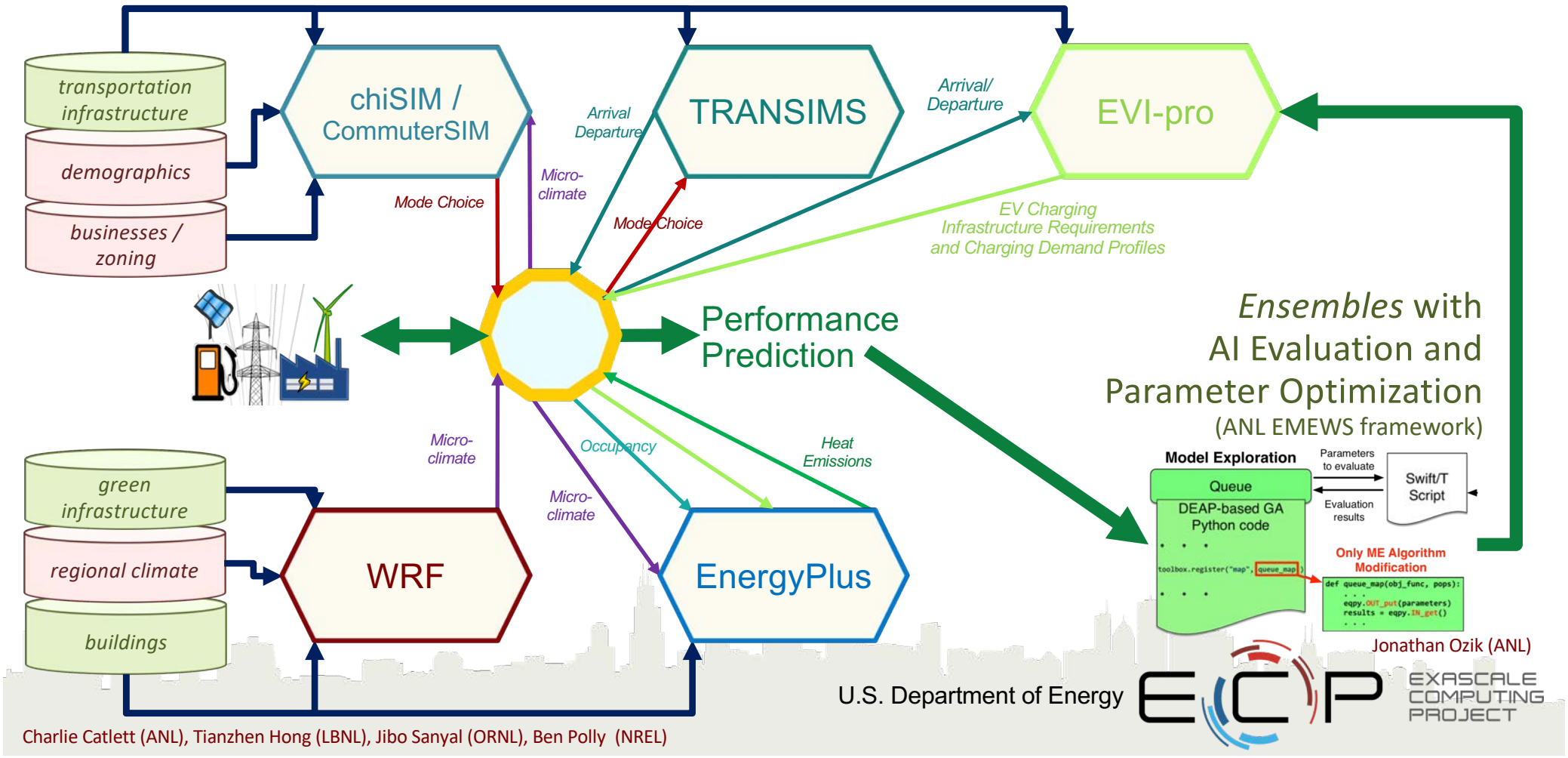


For *10* possible penetration levels of plug-in electric vehicles…

…predict the change in energy use and demand for 20,000 buildings that results from the required workplace and public charging stations necessary to support charging demand.

Charlie Catlett (ANL), Tianzhen Hong (LBNL), Jibo Sanyal (ORNL), Ben Polly (NREL)

Ensembles using Exascale Systems



Jonathan Ozik (ANL)

Charlie Catlett (ANL), Tianzhen Hong (LBNL), Jibo Sanyal (ORNL), Ben Polly (NREL)

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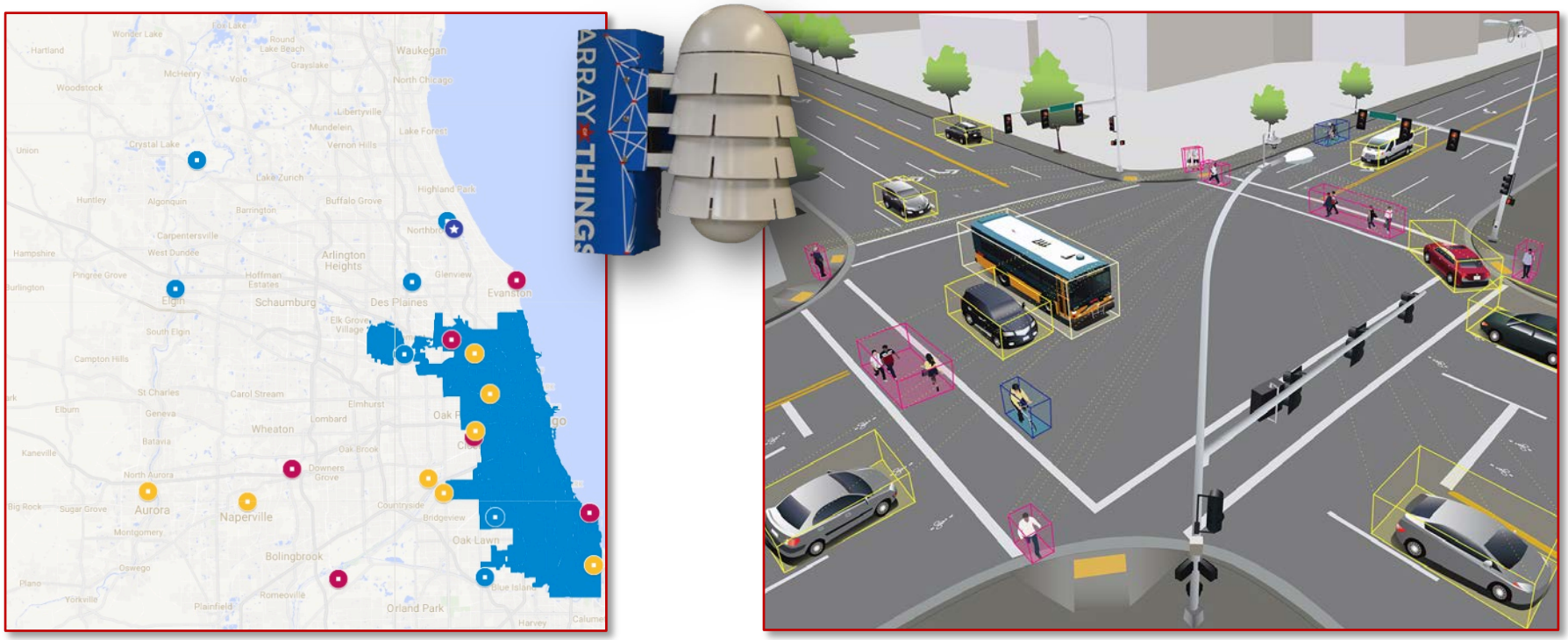
An Urban Instrument: Array of Things (AoT)



AoT is an NSF-funded Major Research Instrumentation project to create an urban cyberinfrastructure ”instrument” comprising hundreds of devices in partnership with the City of Chicago.

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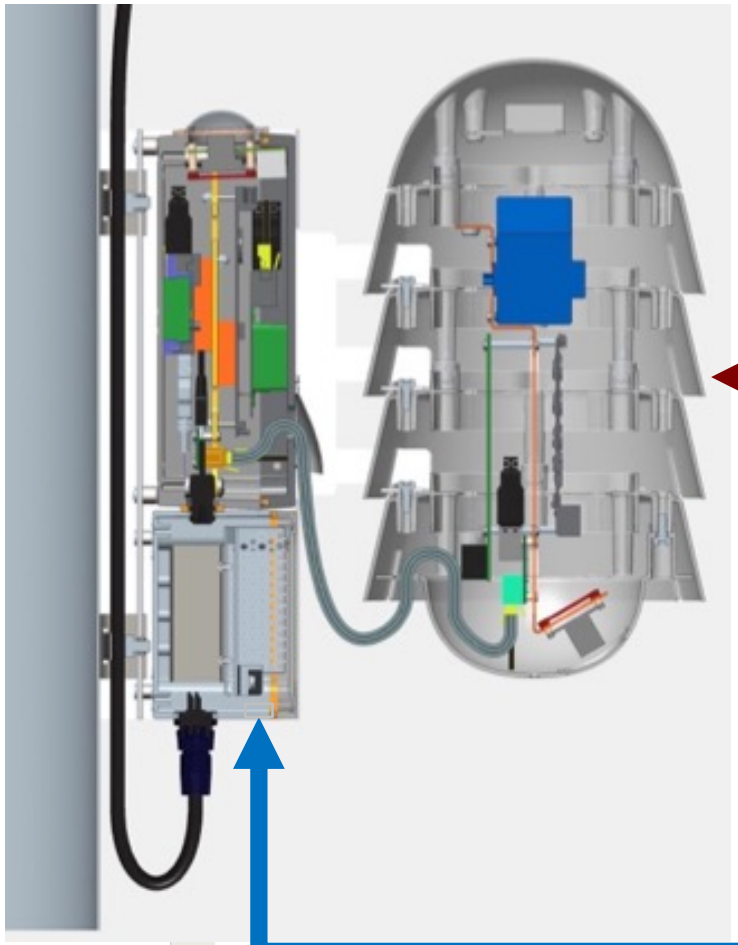


Environment

- Ambient, UV, IR light
- Visibility
- Magnetic Field
- Vibration
- Sound pressure
- Temperature
- Relative humidity
- Barometric pressure

Air Quality

- PM 1, 2.5, 10, 40
- Carbon monoxide
- Ozone
- Sulfur dioxide
- Nitrogen dioxide
- Hydrogen sulfide
- Total reducing gases
- Total oxidizing gases

Edge Computing

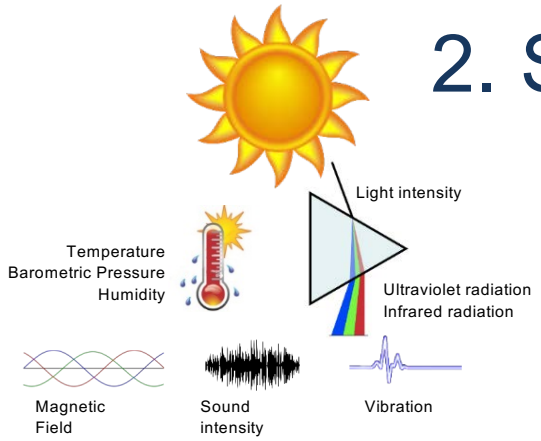
Computer Vision: Flooding, traffic flow, safety (bike helmet use, pedestrian patterns…), use patterns of public spaces, cloud cover

Computer Audio: Noise components, sound events

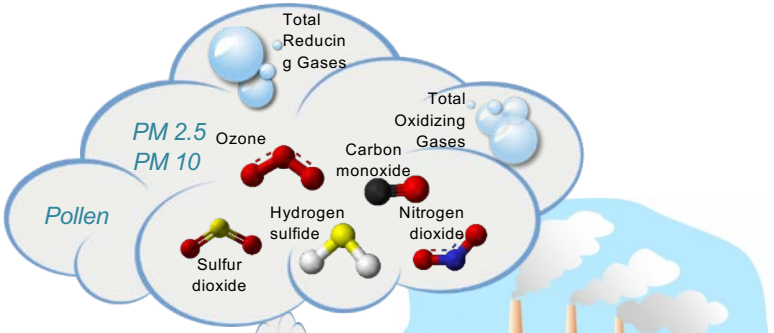
Pete Beckman, Rajesh Sankaran, Charlie Catlett (ANL)
Douglas Pancoast (SAIC), Dave Carhart (Astronics)
Bob Ramos, Michael Buchanan (Chicago Department of Transportation)

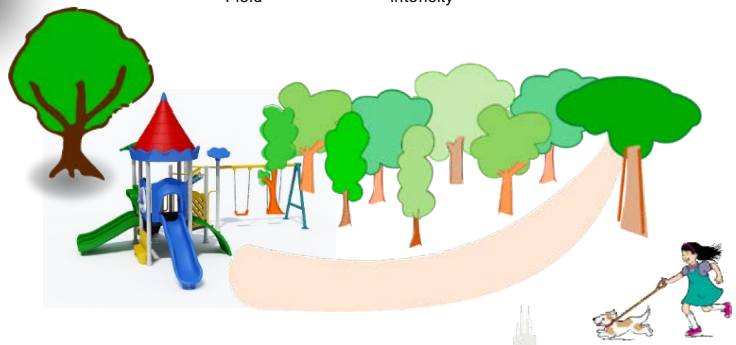
AoT: Cyberinfrastructure with Three Functions

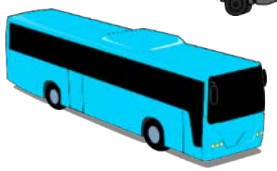
1. Sensors



2. Sensor Testbed







3. Artificial Intelligence Testbed

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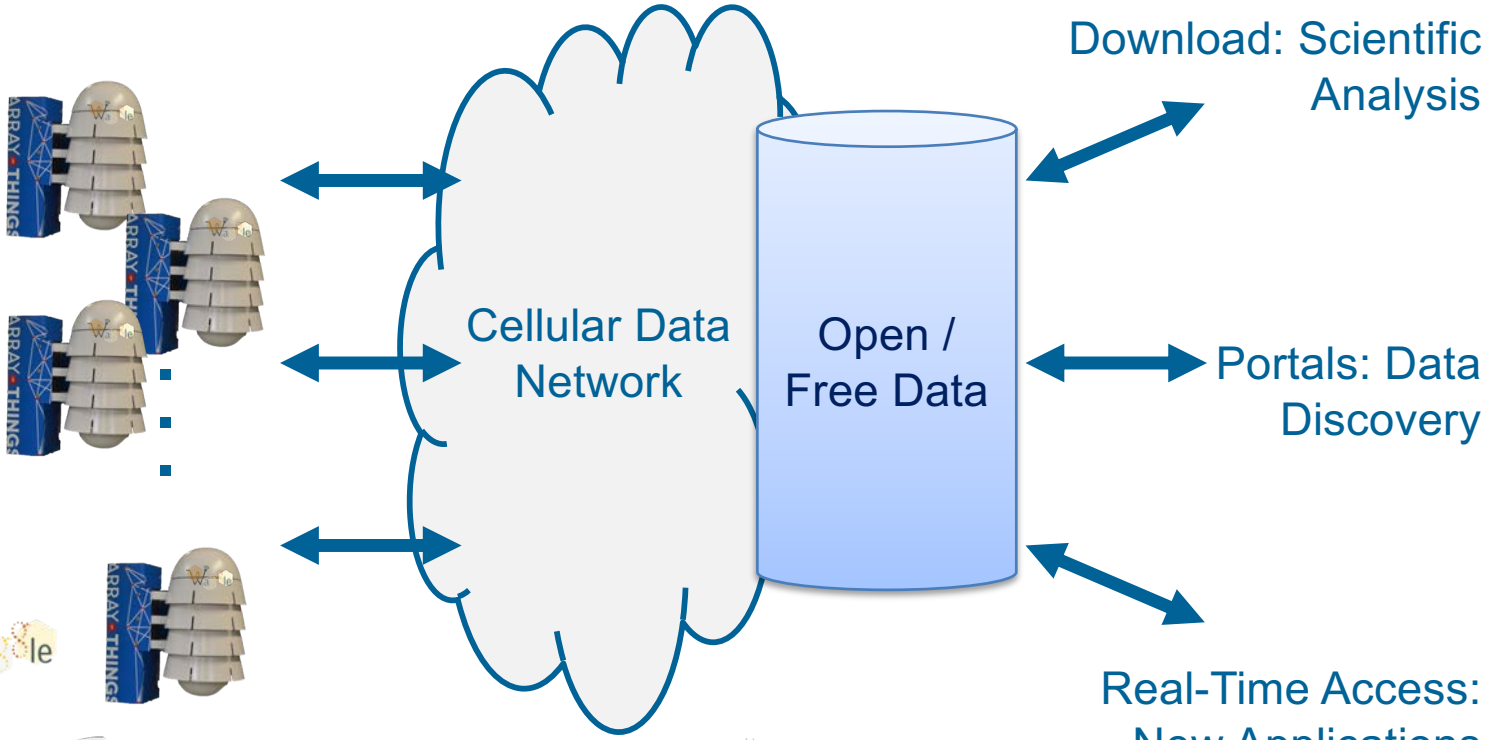
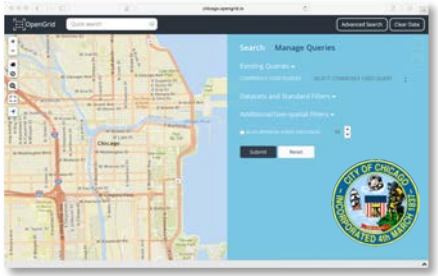
All data is *open* and *free*.





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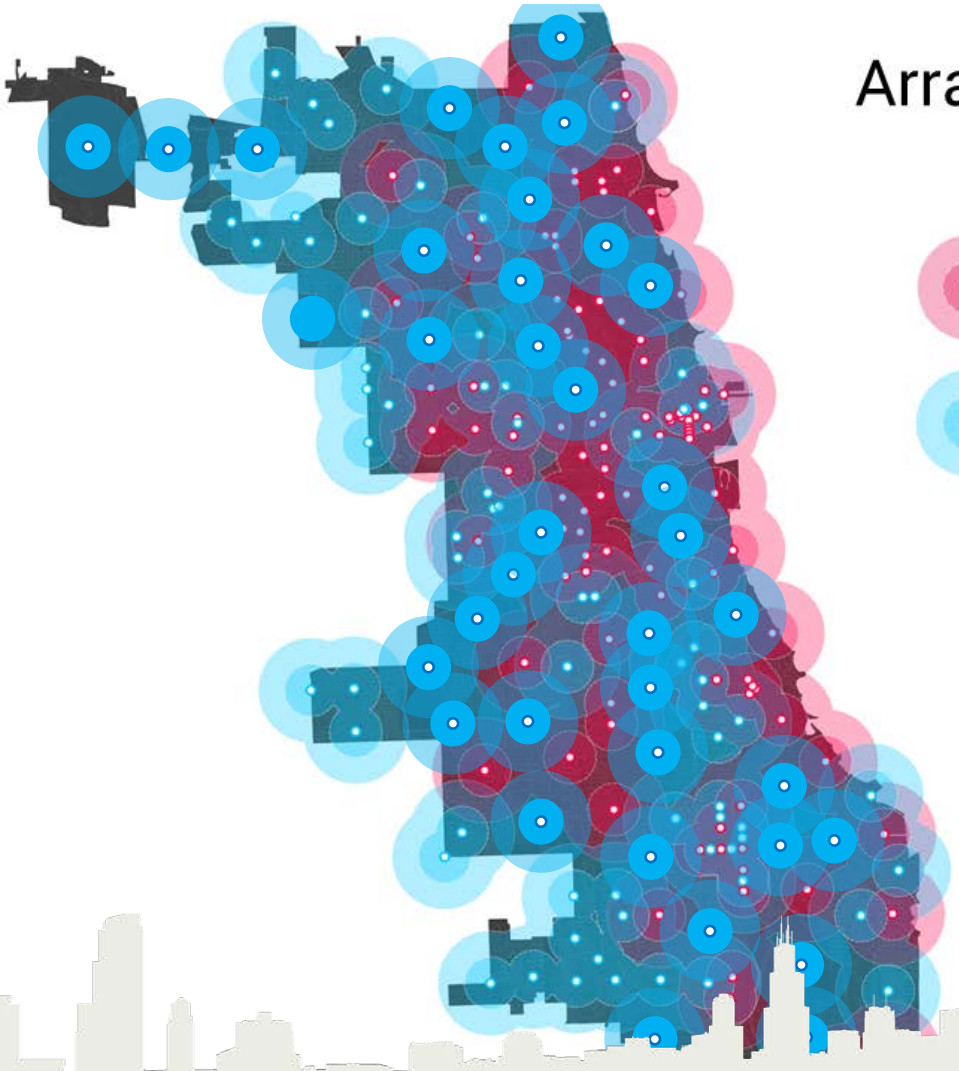

Array of Things Coverage

July 2018

May 2018 Nodes

Dec 2018 Nodes

For electrical utilities, near-real-time, high-precision view of:

- Cloud cover
- Solar loading

…to guide building HVAC, predict PV generation, etc.

Map: A. Laha (UChicago Spatial Data Science Center)

THE CENTER FOR SPATIAL DATA SCIENCE THE UNIVERSITY OF CHICAGO

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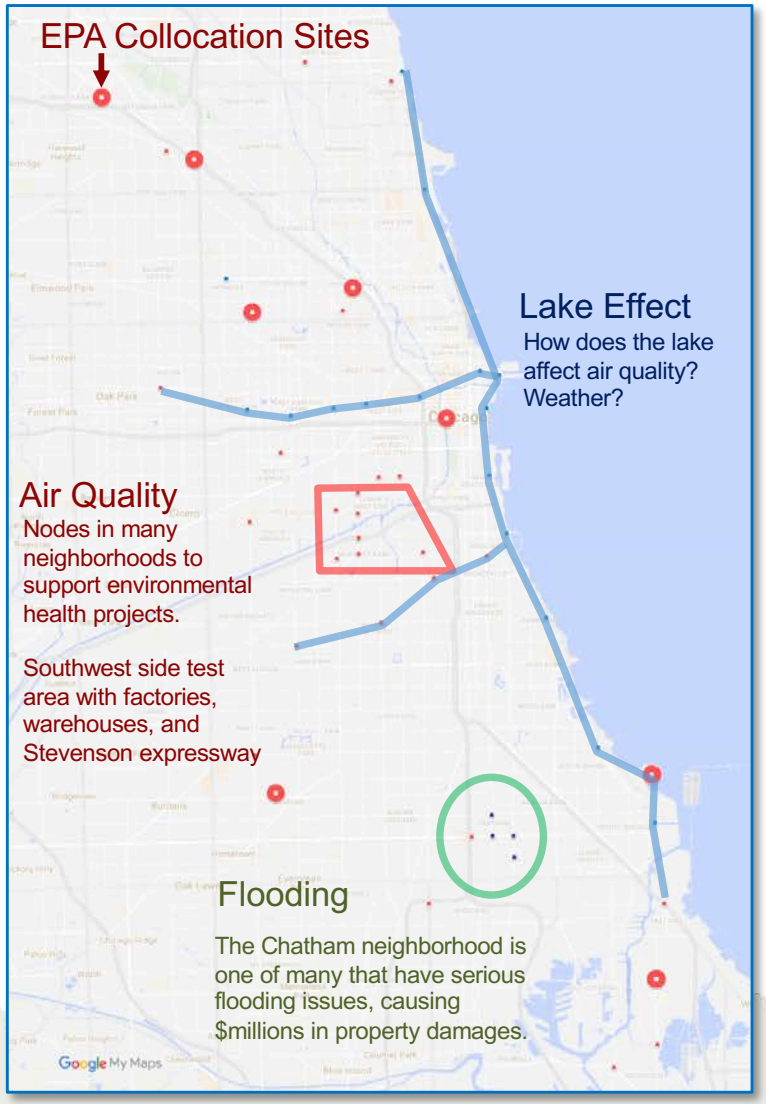
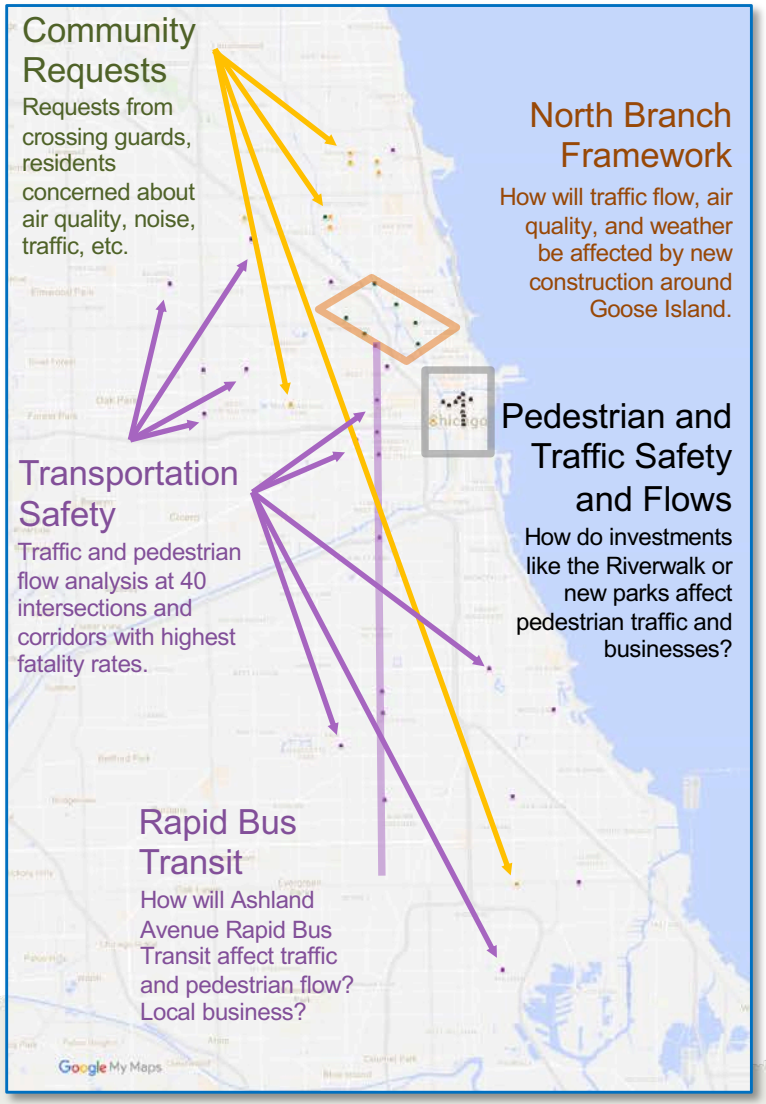
All nodes are identical, but placement is driven by specific science or policy questions.





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“School of Things”

- Eight week curriculum has trained over 400 HS students in three years.
- “School of Things” in multiple Chicago schools beginning Fall 2018.
- Seeking international partners in 2019.

STEM+C Education

Image: Horsch Gallery

Images: Jose Osorio, Chicago Tribune

Kate Kusiak Galvin, Douglas Pancoast, Jeff Solin, Dan Law, Satya Basu

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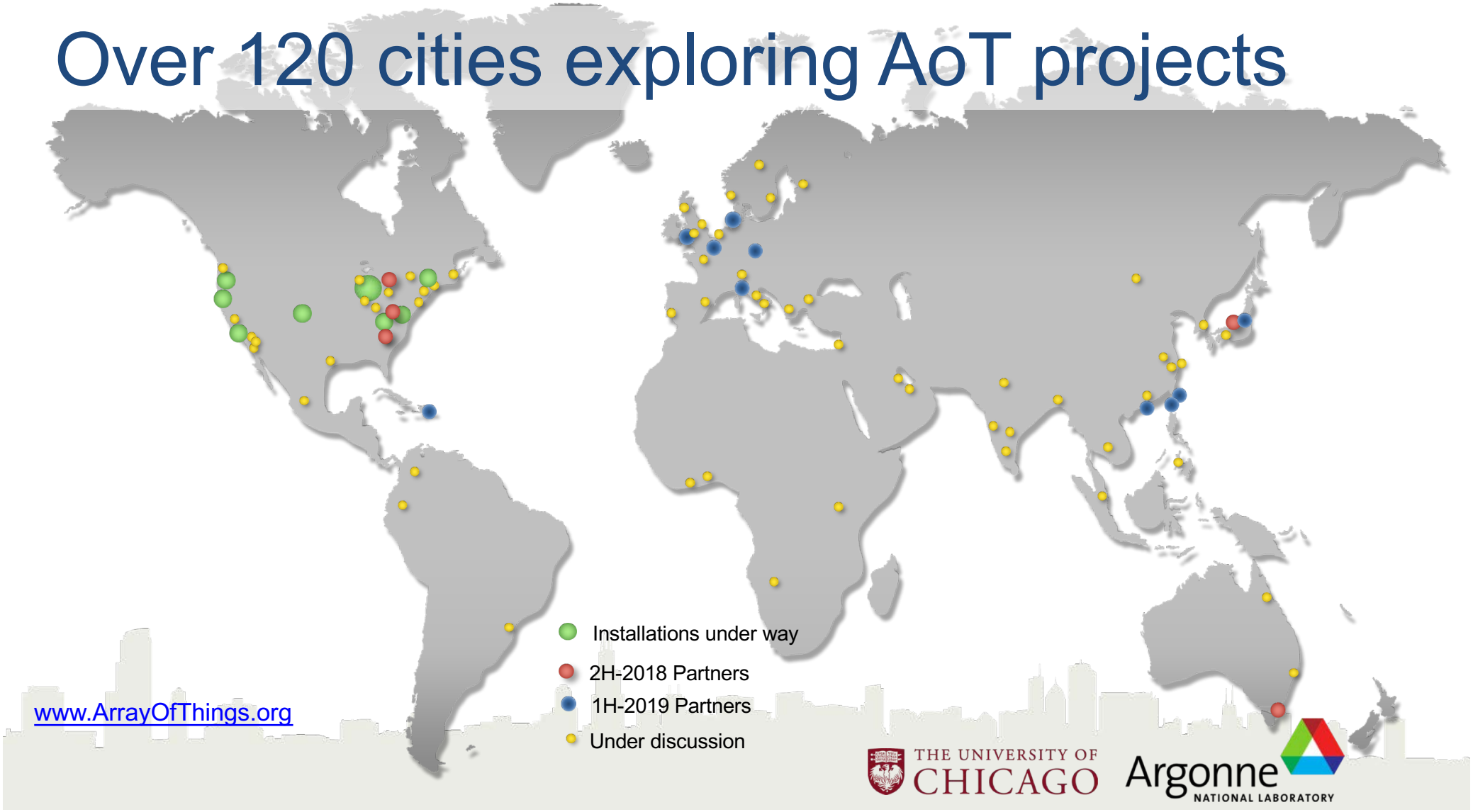
Over 120 cities exploring AoT projects



www.ArrayOfThings.org

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