URBAN CENTER FOR COMPUTATION AND DATA

Argonne NATIONAL LABORATORY

THE UNIVERSITY OF CHICAGO

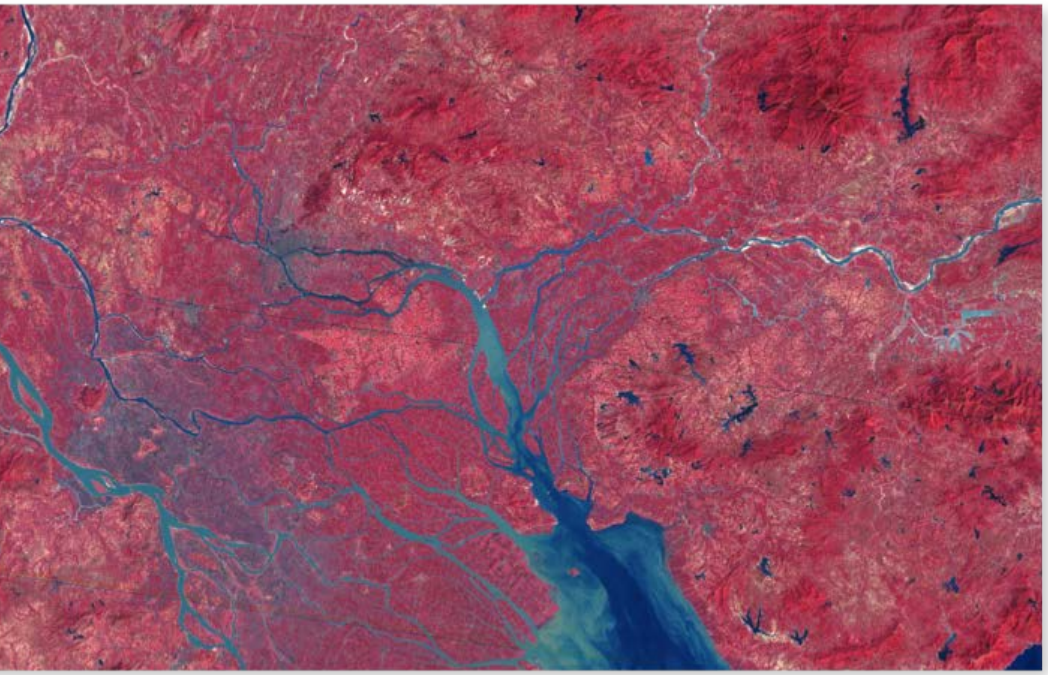
Computation Institute

"Urban Science"

Charlie Catlett
Senior Computer Scientist, Argonne National Laboratory
Director, Urban Center for Computation and Data
Senior Fellow, Computation Institute of the University of Chicago and Argonne National Laboratory

July 2014
HPC2014
Cetraro, Calabria, Italy

Rapid Urbanization



In 2025:

70%

of Chinese people will live in cities with 1M or more people.

And by 2030...

221

Chinese cities will have 1M or more people.

China will *add*

400

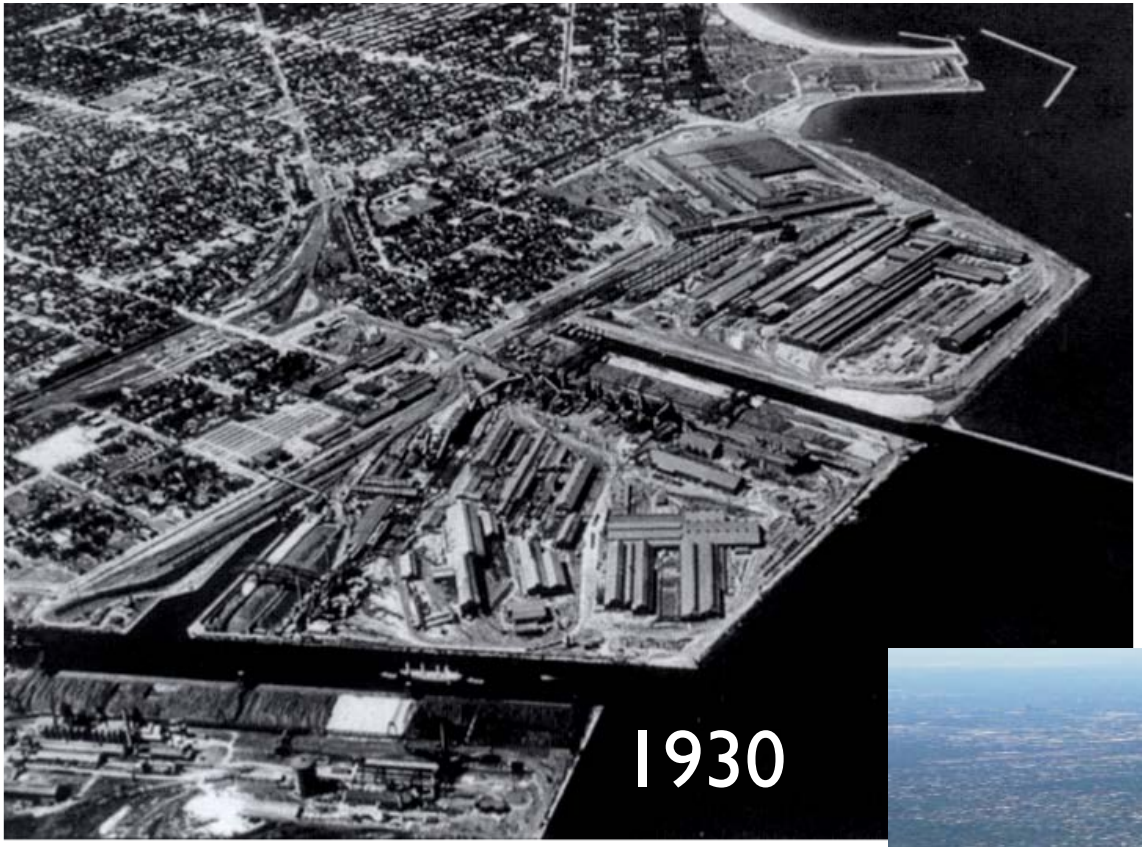
million city dwellers

....requiring the construction of one New York City every year for several decades

LANDSAT Images - NASA, Karen Seto (Yale)

Source: Foreign Policy Magazine, Sep/Oct 2010, "Megacities," Richard Dobbs (McKinsey Global Institute)

URBAN CENTER FOR COMPUTATION AND DATA	Environment	Infrastructure	People
Years--Decades	Science-based design and planning. Coupled Multi-Scale Models		
Days--Months	Evidence-based measurement and predictive analytics. Discipline-informed Data Analytics and Applied Mathematics		
Minutes--Hours	Decision-support and new interactions with infrastructure. Data to Validate and Calibrate Models		



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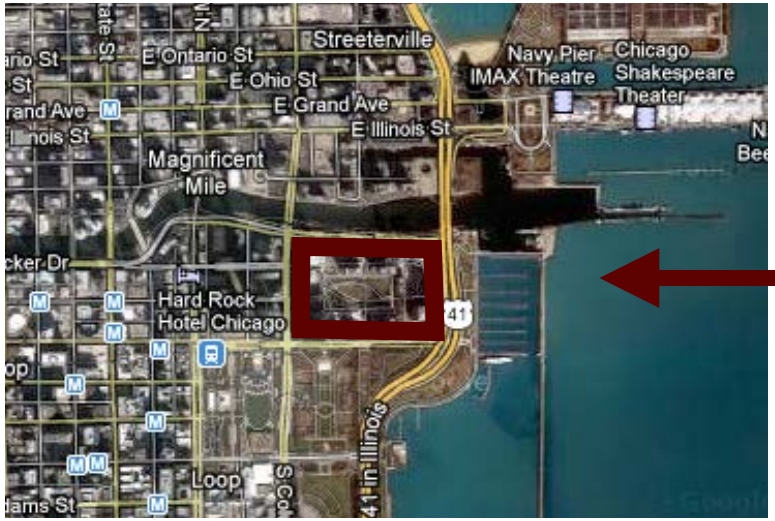
Today's urban growth is driving *city-scale* development projects.

Experience Demand



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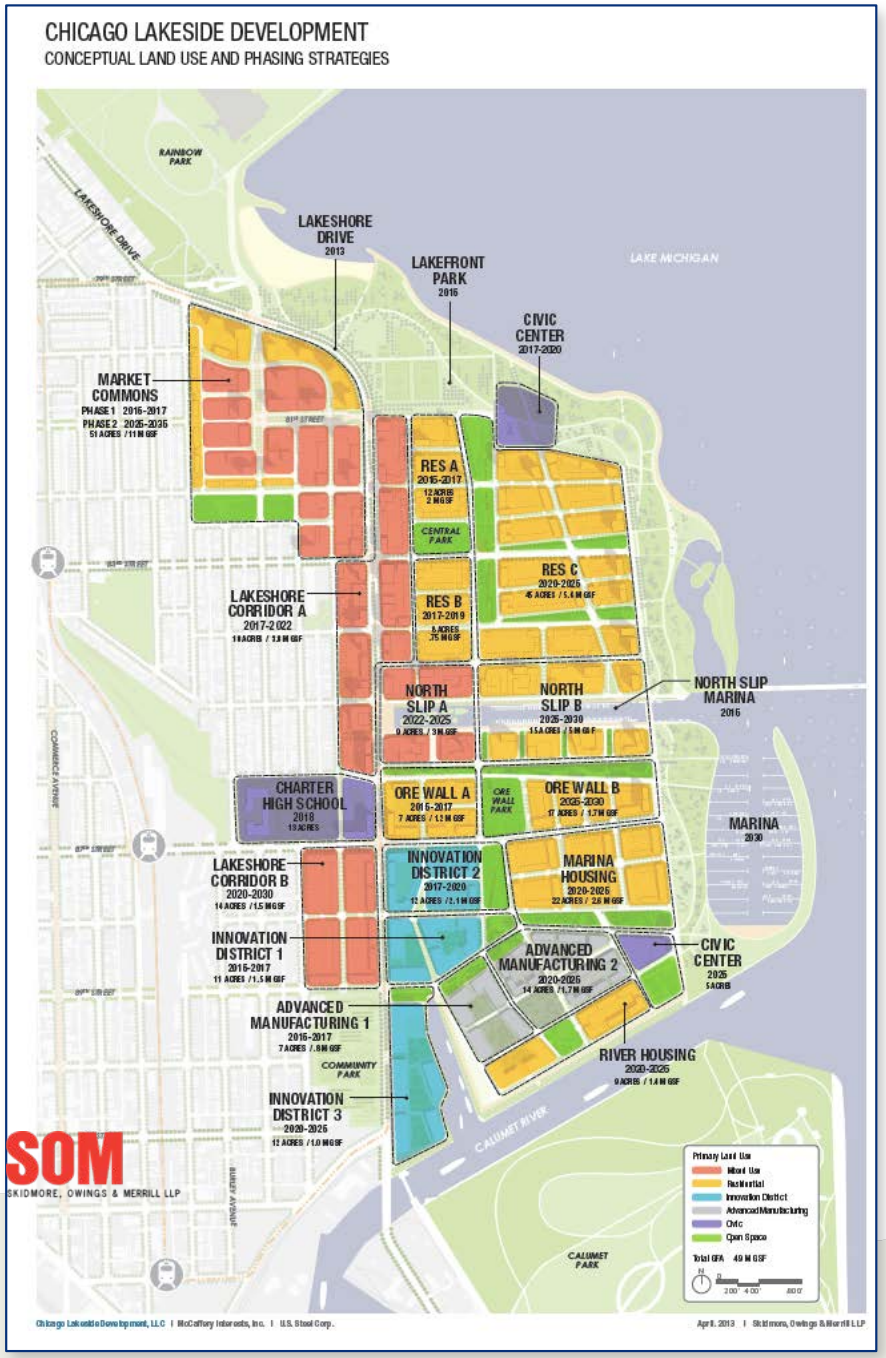
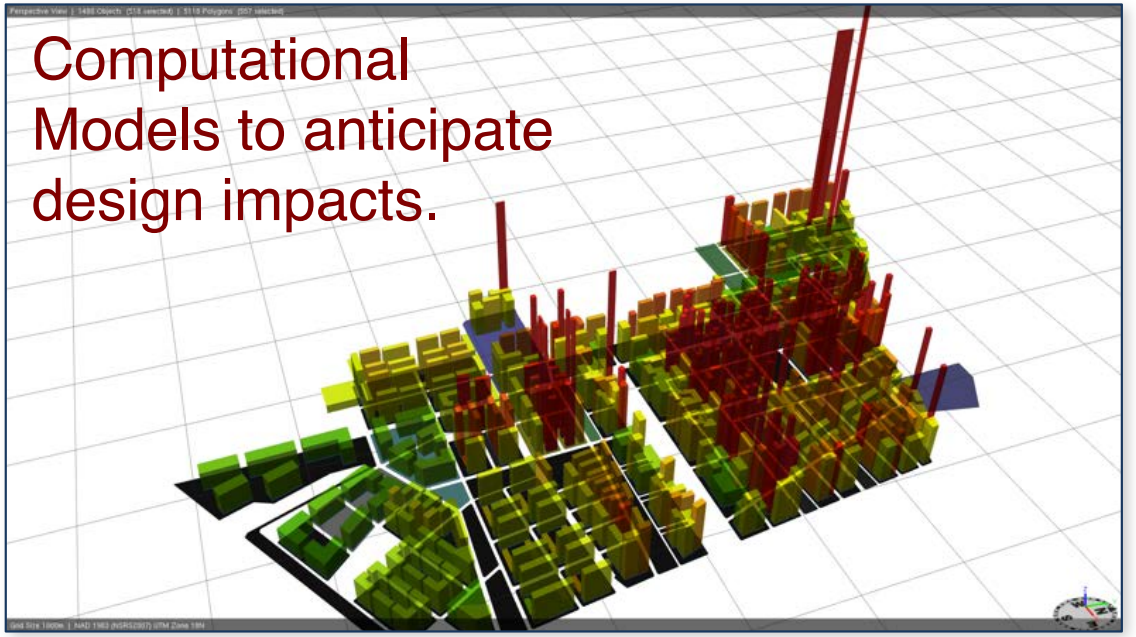
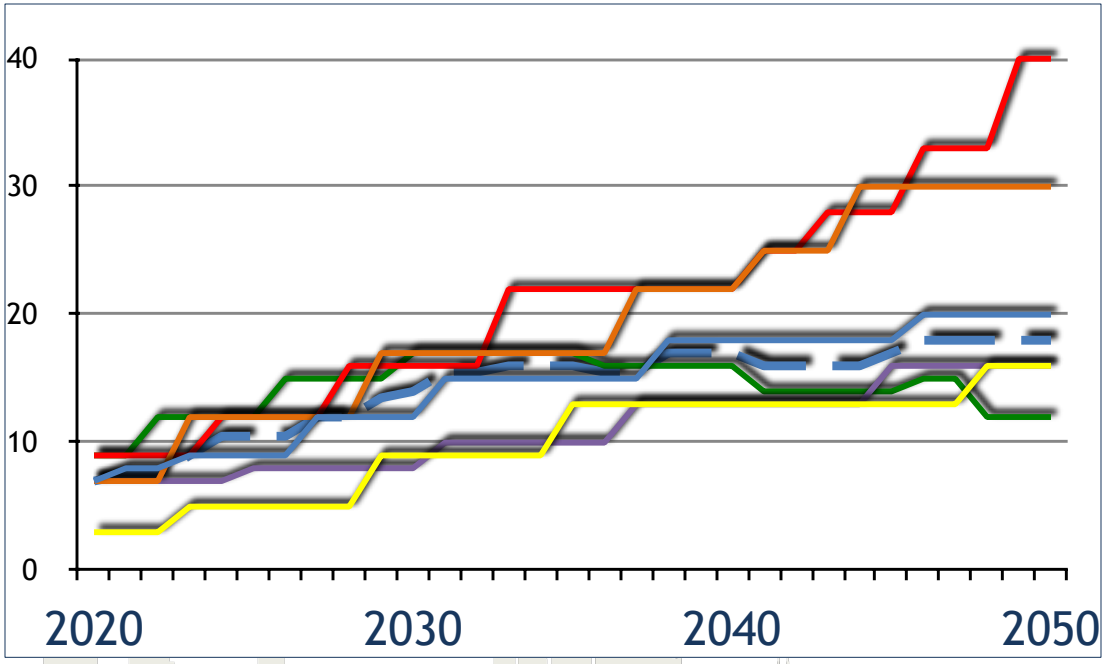
Site plan (zoning, phasing)



McCAFFERY Interests

Computational Models to anticipate design impacts.





Zoning

Phasing

Climate Change Scenario A

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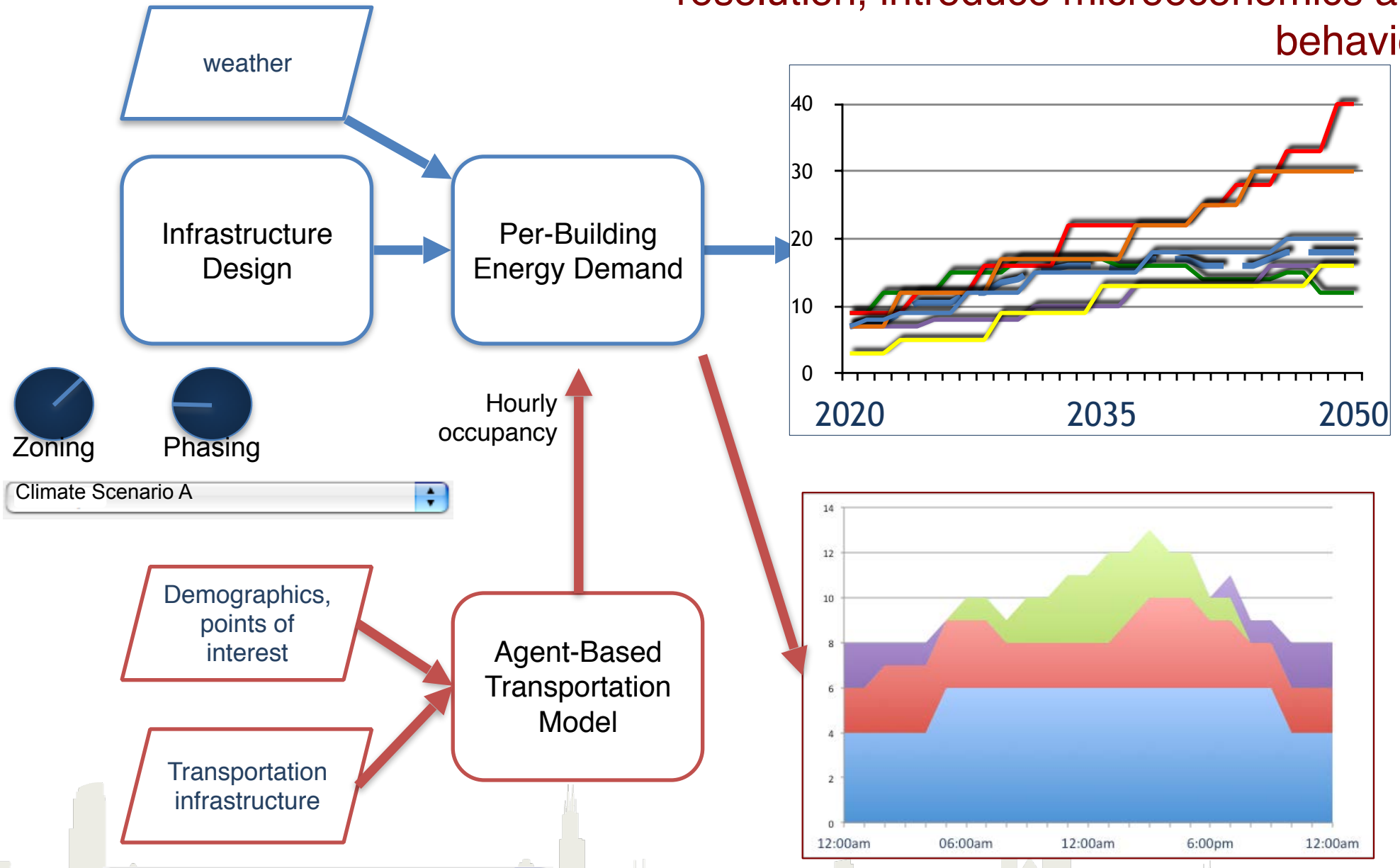
Agent-Based Models to increase temporal resolution, introduce microeconomics and behavior.



Necessary to understand daily demand when renewable energy source capacity varies throughout the 24h day.

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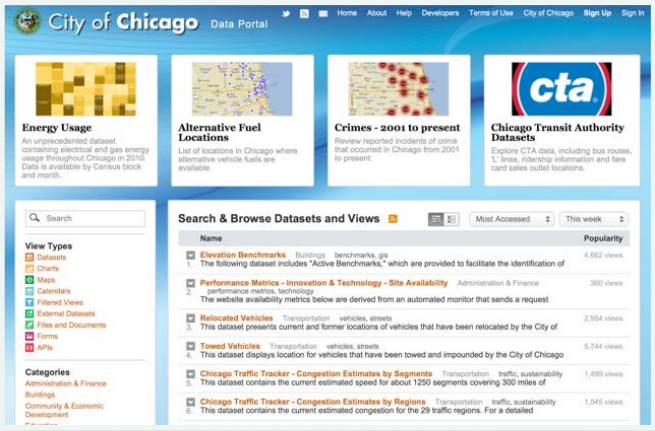

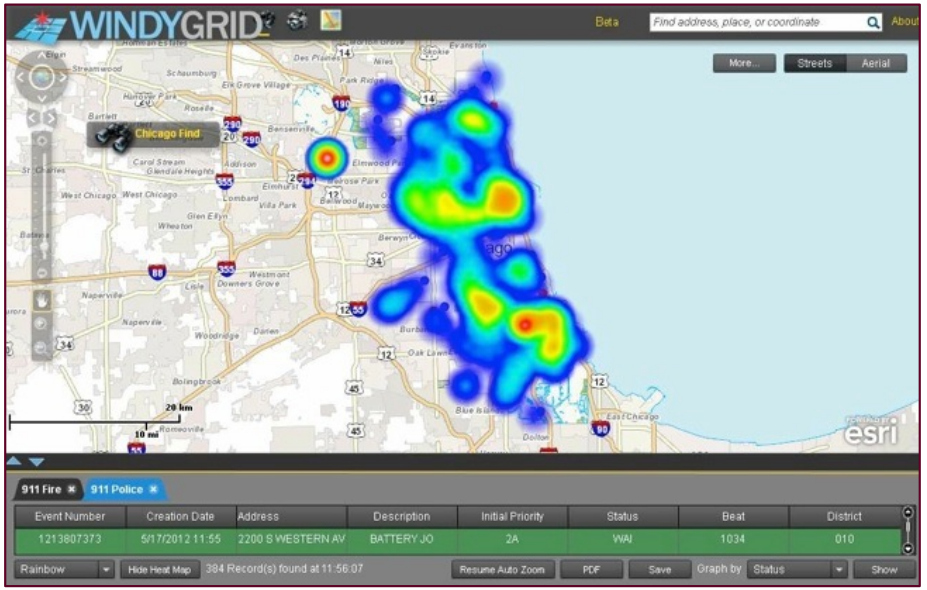

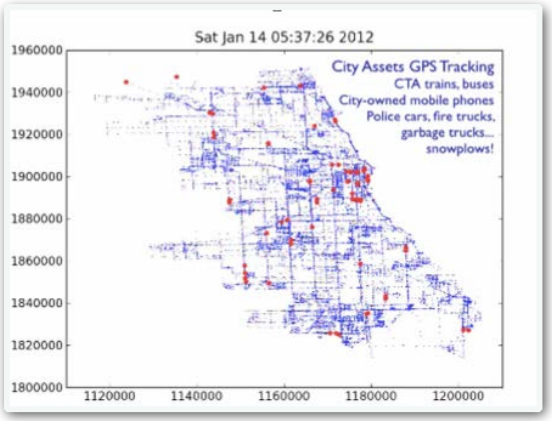

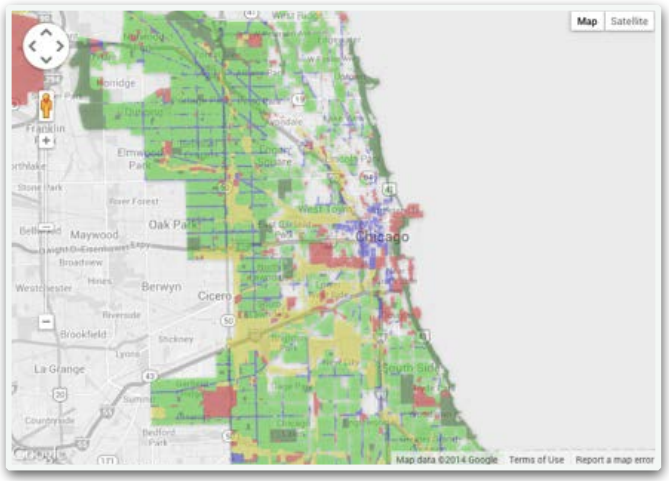

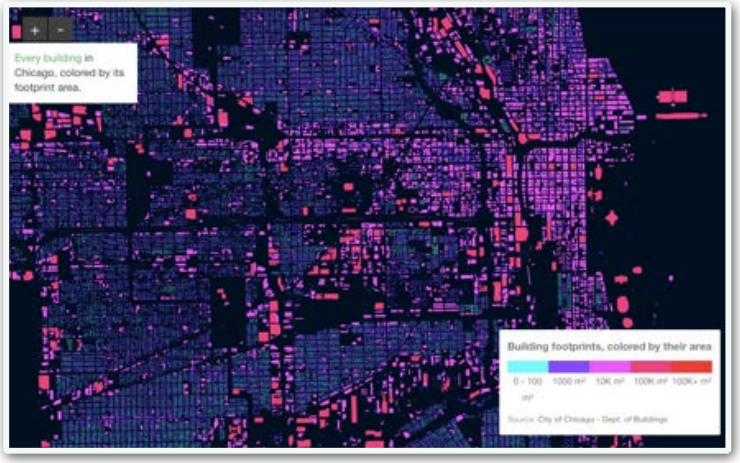

Open Data 1.0 – data portals to enable step one – visualization, mapping, correlating….

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- Predicting high rates of EMS calls and contributing factors
- Populate a unique building ID across datasets
- **Creating 'neighborhood health index'**
- **Predicting movements in the neighborhood health index**
- **Predicting locations of abandoned buildings / vacant lots**
- Visual recognition of neighborhood improvement or retrograde
- Route optimization for routine city vehicle routes (snow plows, garbage collection, tree trimming) and for emergency routes as well.
- Estimate increases in crime incidents
- Prediction of restaurants which will fail food inspections
- **Estimate economic health ("micro-GNP") of neighborhoods and sub-neighborhoods**
- Generate industrial profiles for neighborhoods
- Financial fraud detection (from city transactions)
- Payment error detection (from city transactions)
- Measuring satisfaction with agencies through social media
- Identify delays in fulfilling 311 service requests
- M/WBE (minority/women owned) companies that attempt to skirt procurement regulations

**(June 2013) From Brett Goldstein, City of Chicago Chief Data Officer and Commissioner, Dept. of Innovation and technology.*

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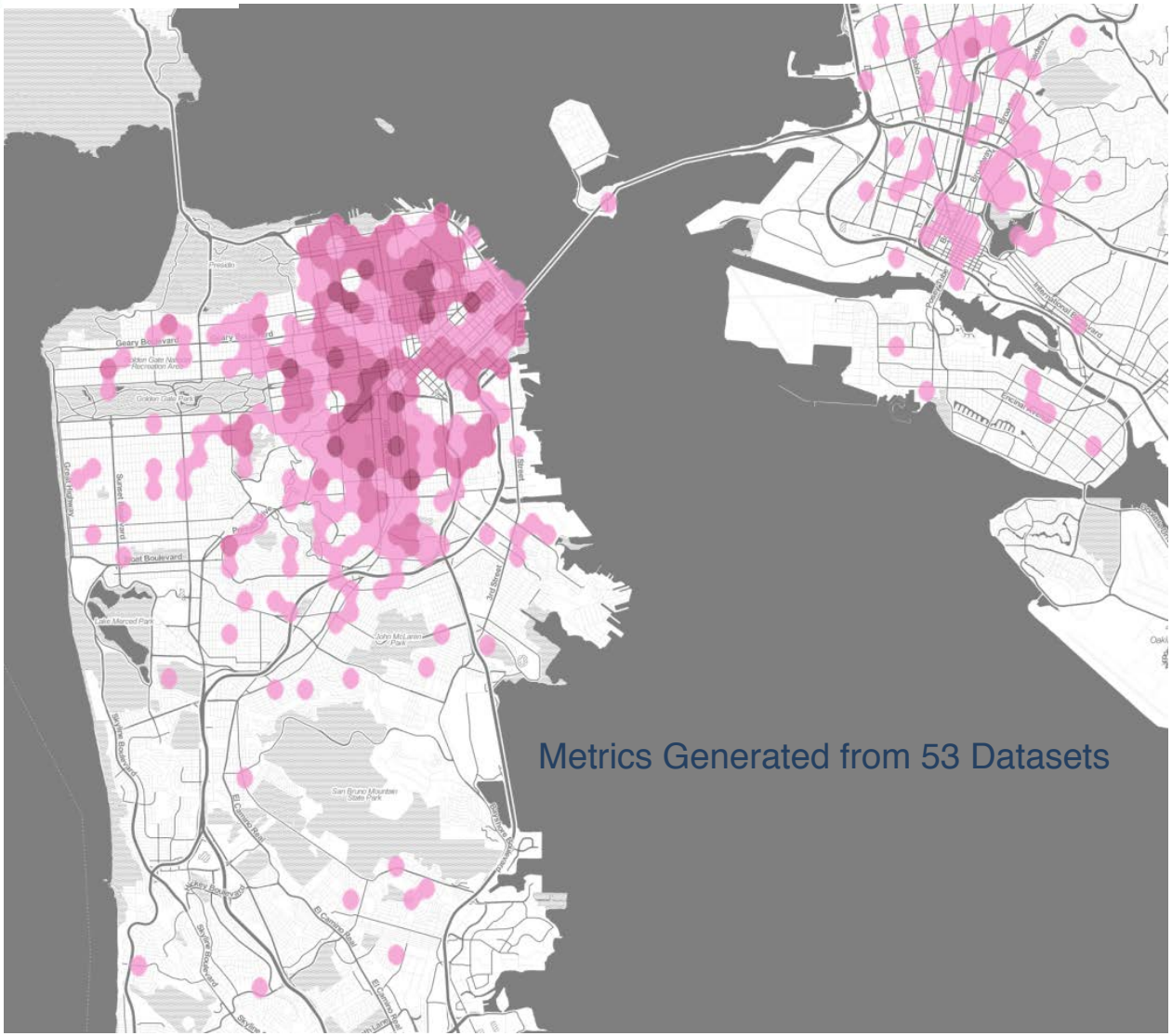


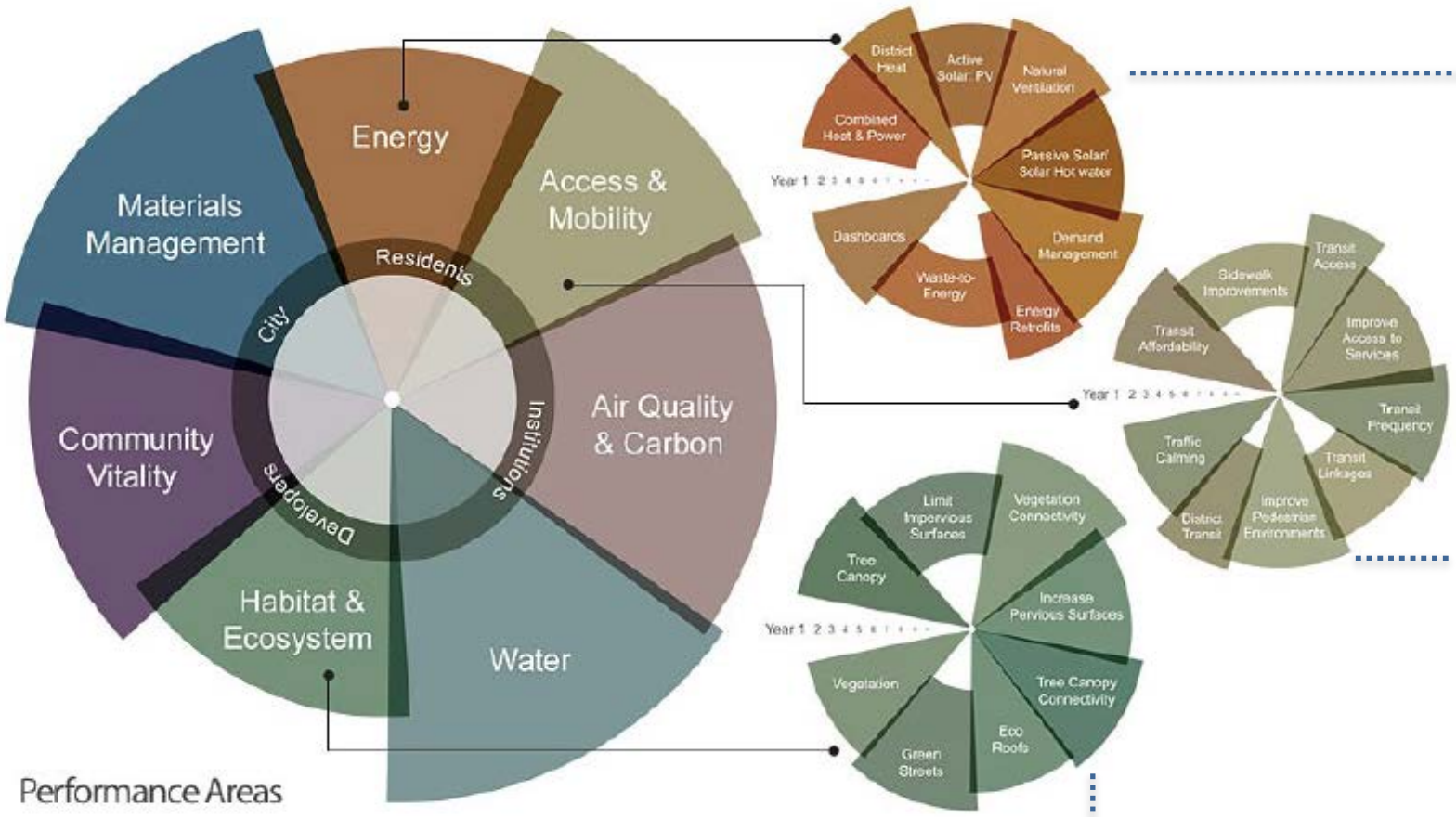
- Built Environment
- Neighborhood Assets
- Housing and Rental Prices
- Building-level Energy Use
- Solar installations
- Renewables generation
- Longitudinal Surveys
- Employment records
- Waste tonnage by block
- Transportation
- Traffic density
- Air quality
- Emissions

- *Energy*
- *Materials Management*
- *Access and Mobility*
- *Air Quality and Carbon*
- *Water*
- *Habitat and Ecosystem*
- *Community Vitality*

Developing methods to "measure" composite sustainability factors…

...and to identify "neighborhoods" that are "similar" (control groups for evaluation).

Matt Gee, UChicago
Kate McGee, City of San Francisco

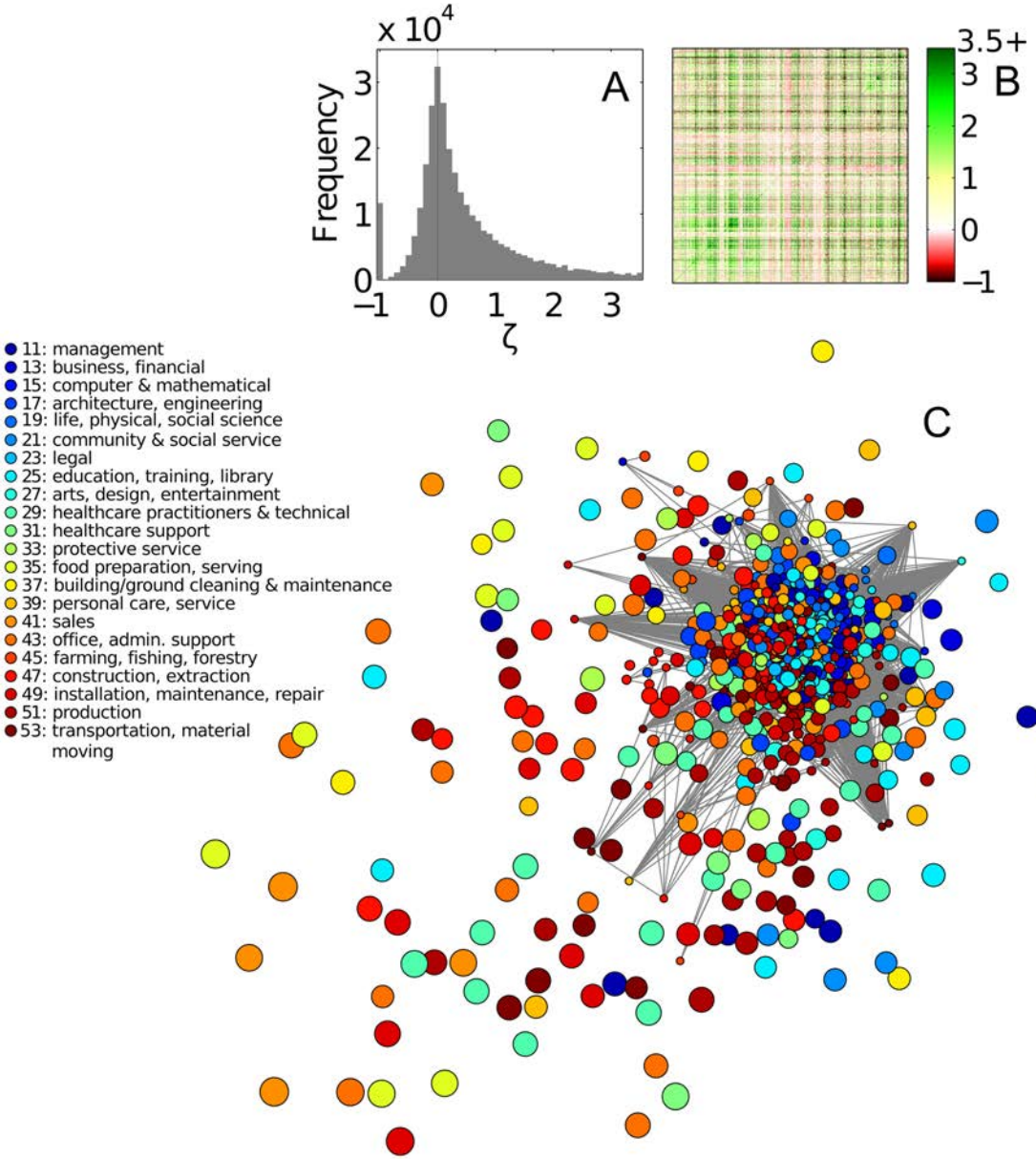


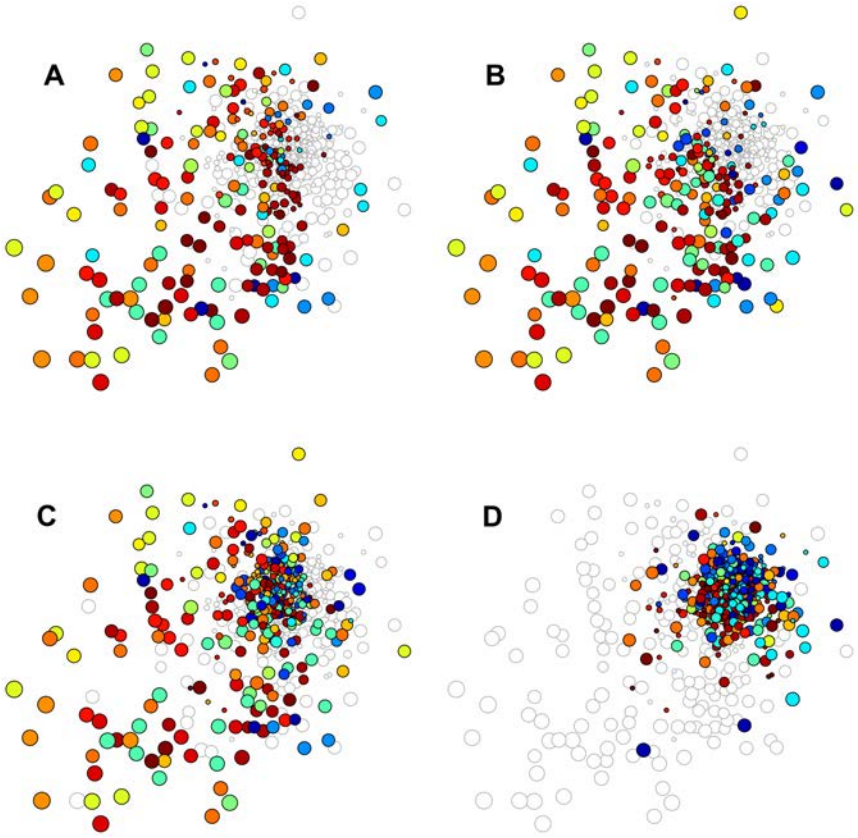
Combined Heat & Power
District Heat
Active Solar PV
Natural Ventilation
Passive Solar Hot Water
Demand Management
Energy Retrofits
Waste-to-Energy
Dashboards

Transit Affordability
Sidewalk Improvements
Transit Access
Improve Access to Services
Transit Frequency
Transit Linkages
Improve Pedestrian Environment
District Transit
Traffic Calming

Tree Canopy
Limit Impervious Surfaces
Vegetation Connectivity
Increase Pervious Surfaces
Tree Canopy Connectivity
Eco Roofs
Green Streets
Vegetation

Source: Central Corridor Eco-District: An Introduction
(March 2012, City of San Francisco)





Four classes of MSAs, categorized by per capita GDP

Muneepeerakul, R., J. Lobo, S. T. Shutters, A. Goméz-Liévano and M. R. Qubbaj. 2013. Urban economies and occupation space: Can they get "there" from "here"?. PLOS One 8(9):e73676. DOI: 10.1371/journal.pone.0073676.

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Table 1. Scaling exponents for urban indicators vs. city size

	Y	β	95% CI	Adj-R^2	Observations	Country–year
Super-linear	New patents	1.27	[1.25,1.29]	0.72	331	U.S. 2001
	Inventors	1.25	[1.22,1.27]	0.76	331	U.S. 2001
	Private R&D employment	1.34	[1.29,1.39]	0.92	266	U.S. 2002
	"Supercreative" employment	1.15	[1.11,1.18]	0.89	287	U.S. 2003
	R&D establishments	1.19	[1.14,1.22]	0.77	287	U.S. 1997
	R&D employment	1.26	[1.18,1.43]	0.93	295	China 2002
	Total wages	1.12	[1.09,1.13]	0.96	361	U.S. 2002
	Total bank deposits	1.08	[1.03,1.11]	0.91	267	U.S. 1996
	GDP	1.15	[1.06,1.23]	0.96	295	China 2002
	GDP	1.26	[1.09,1.46]	0.64	196	EU 1999–2003
	GDP	1.13	[1.03,1.23]	0.94	37	Germany 2003
	Total electrical consumption	1.07	[1.03,1.11]	0.88	392	Germany 2002
	New AIDS cases	1.23	[1.18,1.29]	0.76	93	U.S. 2002–2003
	Serious crimes	1.16	[1.11, 1.18]	0.89	287	U.S. 2003
~Linear	Total housing	1.00	[0.99,1.01]	0.99	316	U.S. 1990
	Total employment	1.01	[0.99,1.02]	0.98	331	U.S. 2001
	Household electrical consumption	1.00	[0.94,1.06]	0.88	377	Germany 2002
	Household electrical consumption	1.05	[0.89,1.22]	0.91	295	China 2002
	Household water consumption	1.01	[0.89,1.11]	0.96	295	China 2002
Sub-linear (economies of scale)	Gasoline stations	0.77	[0.74,0.81]	0.93	318	U.S. 2001
	Gasoline sales	0.79	[0.73,0.80]	0.94	318	U.S. 2001
	Length of electrical cables	0.87	[0.82,0.92]	0.75	380	Germany 2002
	Road surface	0.83	[0.74,0.92]	0.87	29	Germany 2002

Data sources are shown in *SI Text*. CI, confidence interval; Adj-R^2, adjusted R^2; GDP, gross domestic product.

Growth, innovation, scaling, and the pace of life in cities

Bettencourt L M A et al. PNAS 2007;104:7301-7306

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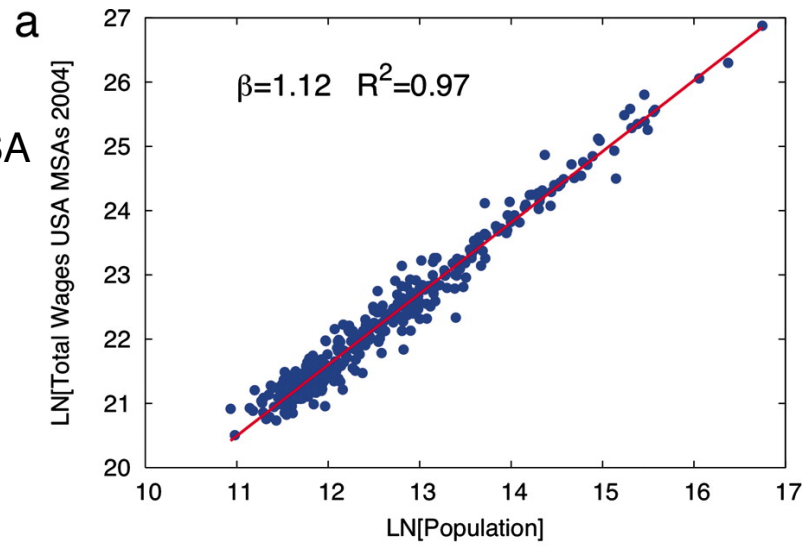
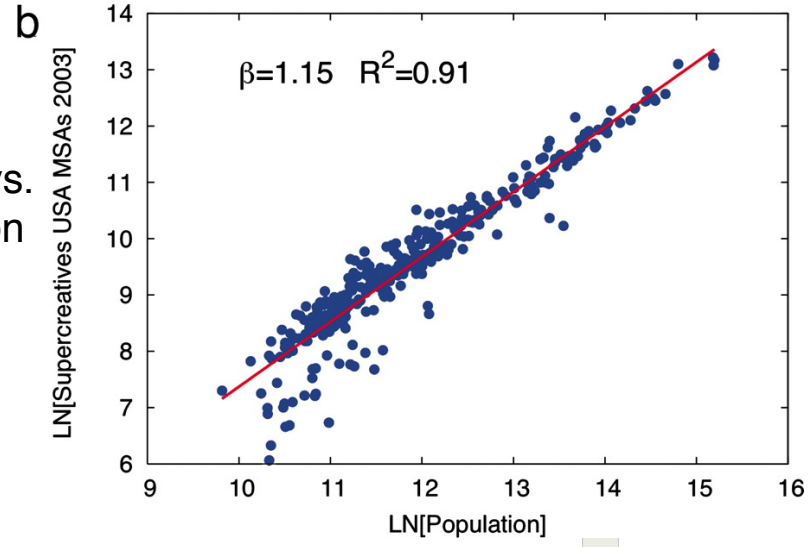
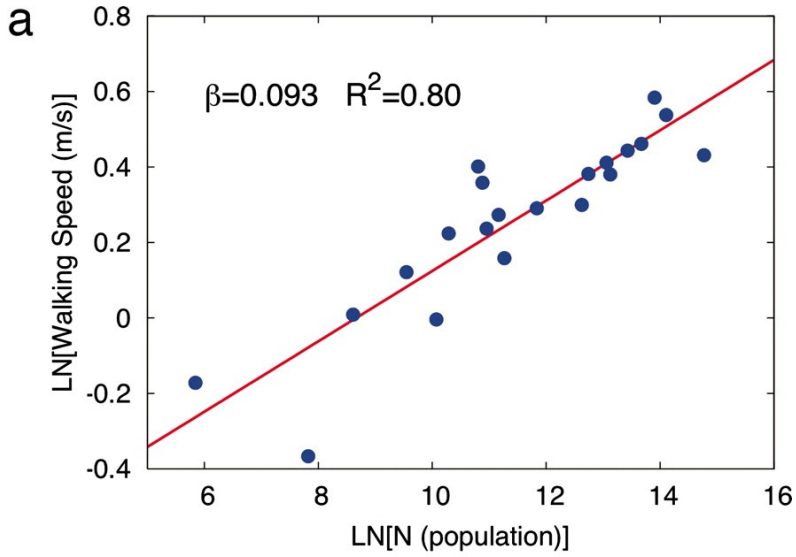
The pace of urban life increases with city size in contrast to the pace of biological life, which decreases with organism size.

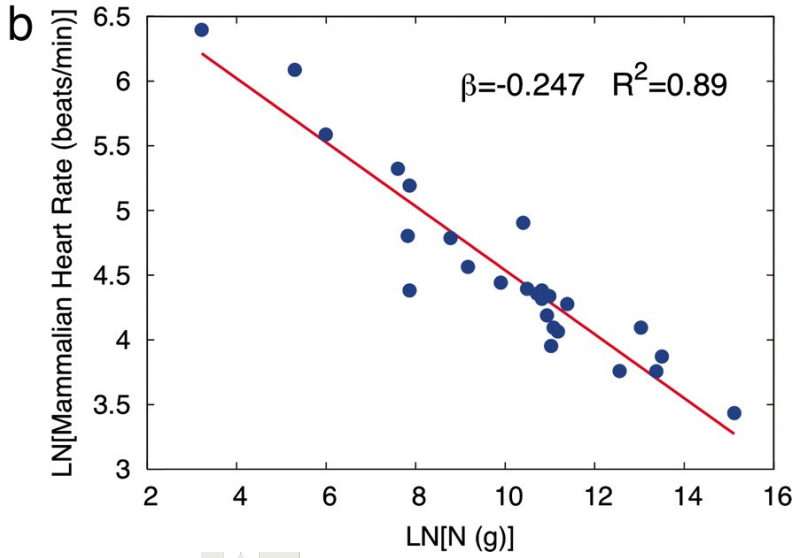
Wages vs. MSA Population (2004)



"Supercreative employment" vs. MSA Population (2003)







Growth, innovation, scaling, and the pace of life in cities

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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.

Urban heat islands
Air quality
Pedestrian flow
Vehicle flow
Climate boundary layer
New interactions
...

13 Universities
Four science teams

NSF MRI proposal submitted January 2014 for 500-1000 node deployment over 30 months in partnership with City of Chicago..

High-frequency phenomena require new sources of measured data.

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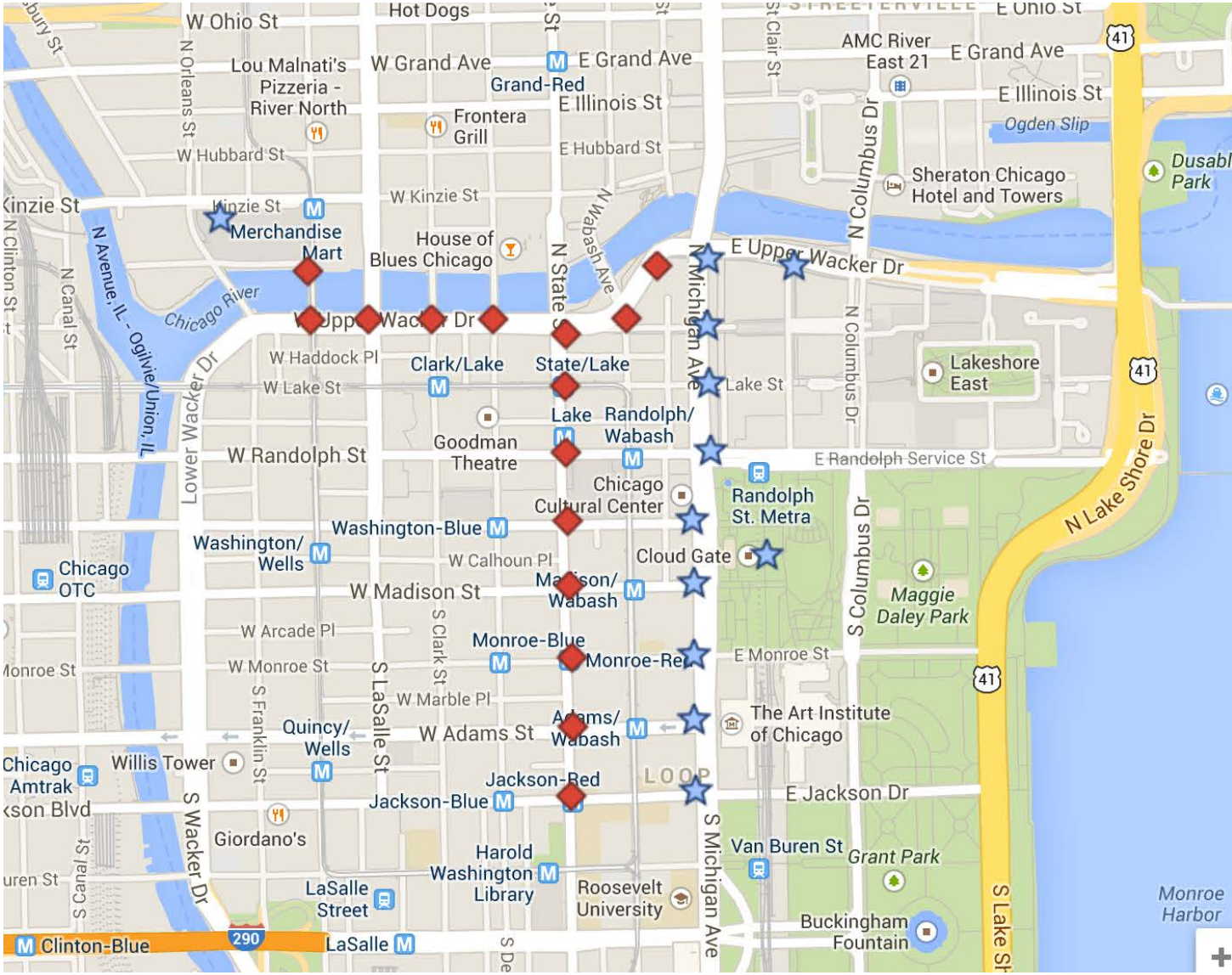
Prototype v1

Temperature
Humidity
Barometric Pressure
CO
NO2
Light
Sound
IR
Vibration

Prototype v2

CO2
NOX
Precipitation
Wind



August 2014 December 2014

A pilot project of the City of Chicago, Argonne National Laboratory, and the University of Chicago (Computation Institute)

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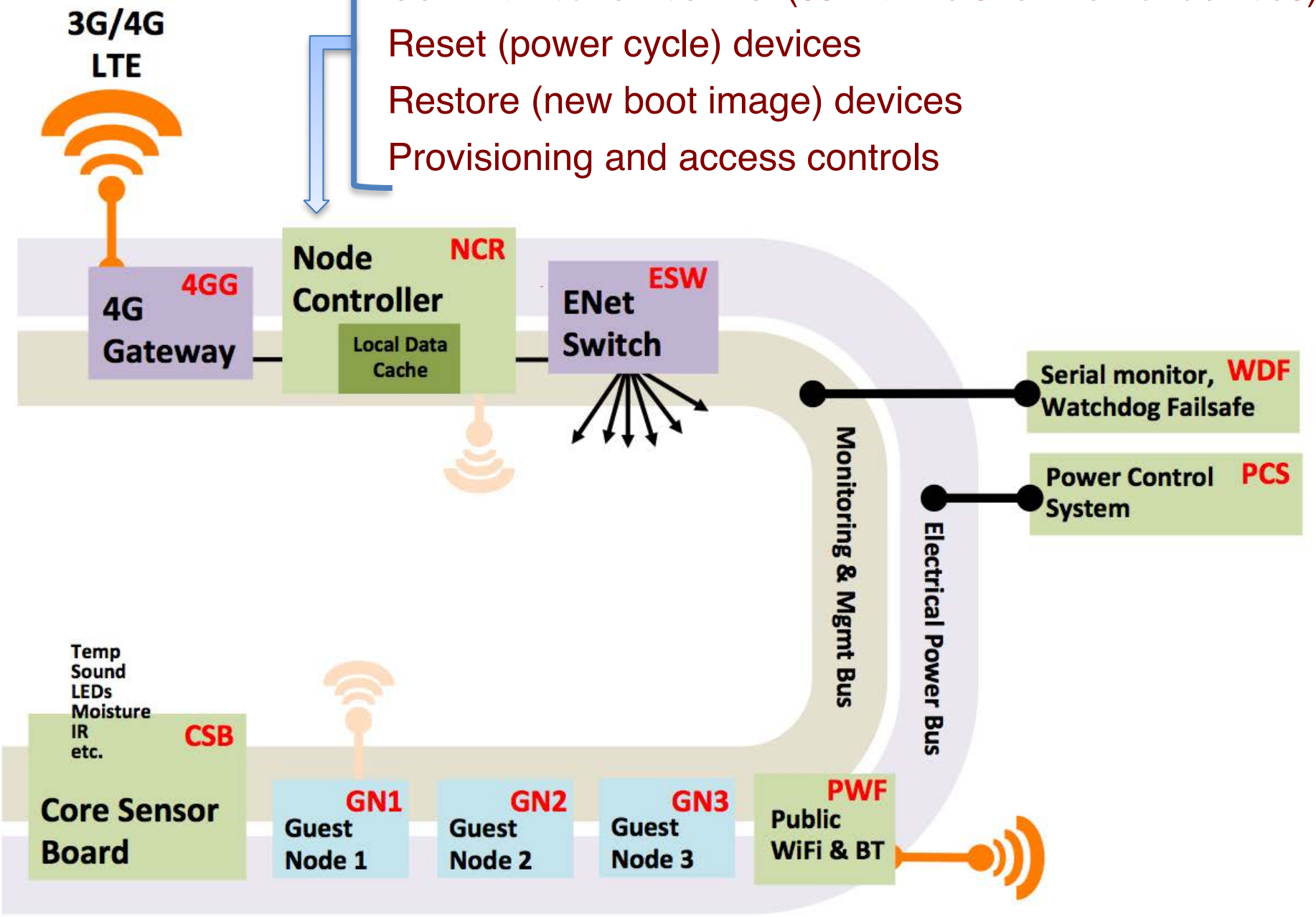
Instrumentation/Diagnostics (stats, counters…)

Communication control (ssh tunnels to internal devices)

Reset (power cycle) devices

Restore (new boot image) devices

Provisioning and access controls



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Internal protective enclosure.

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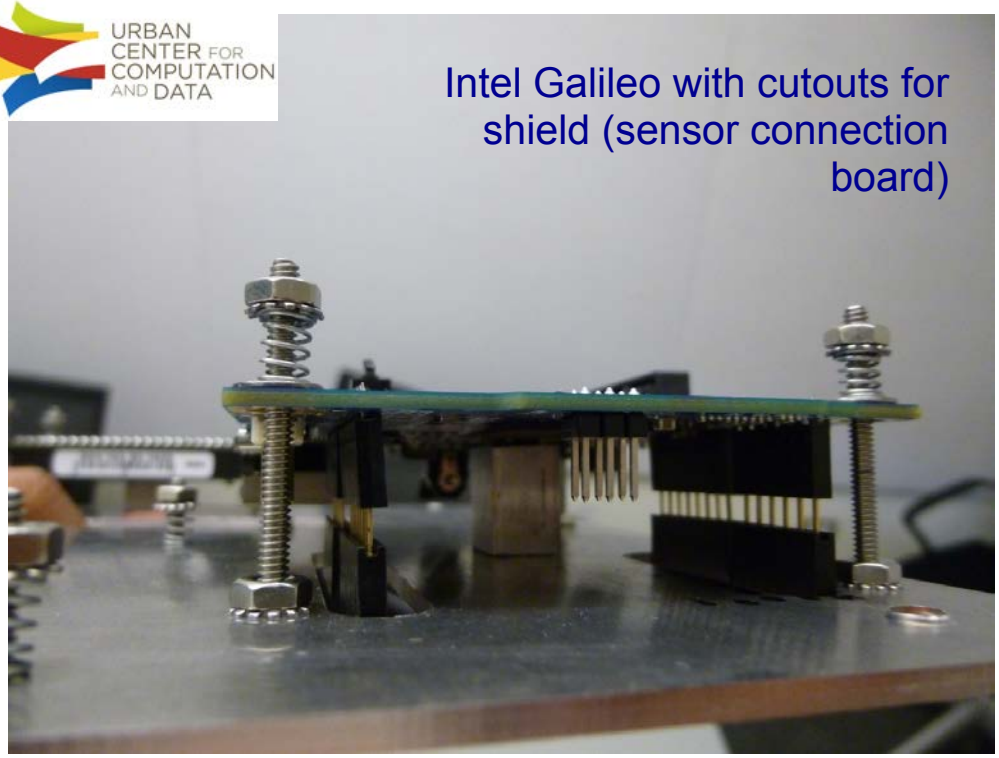
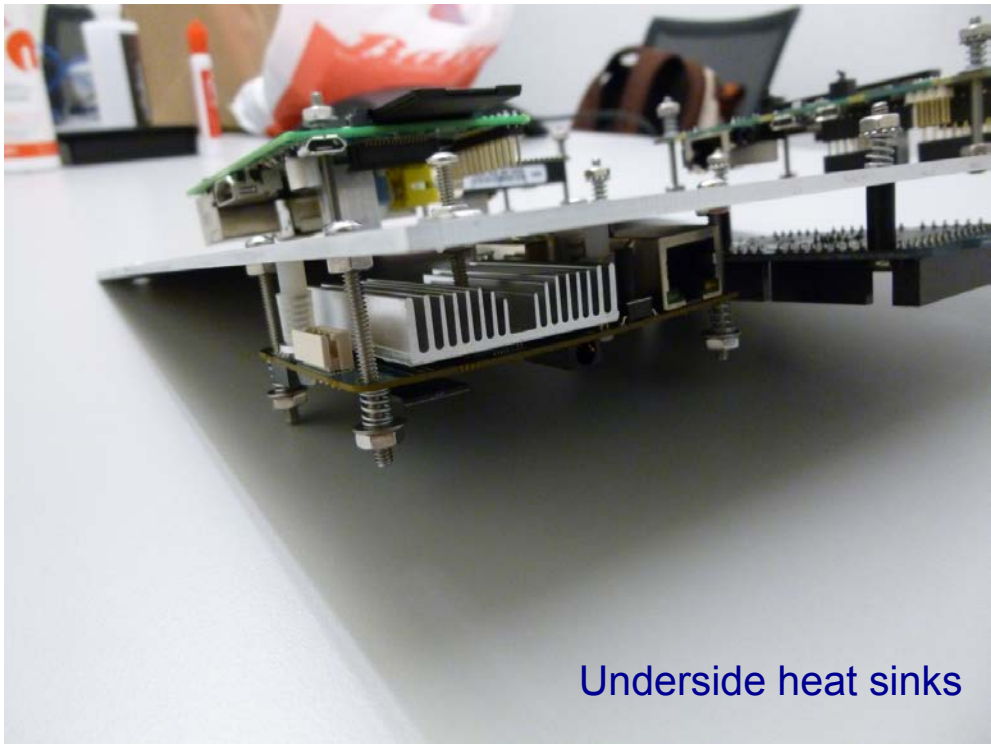
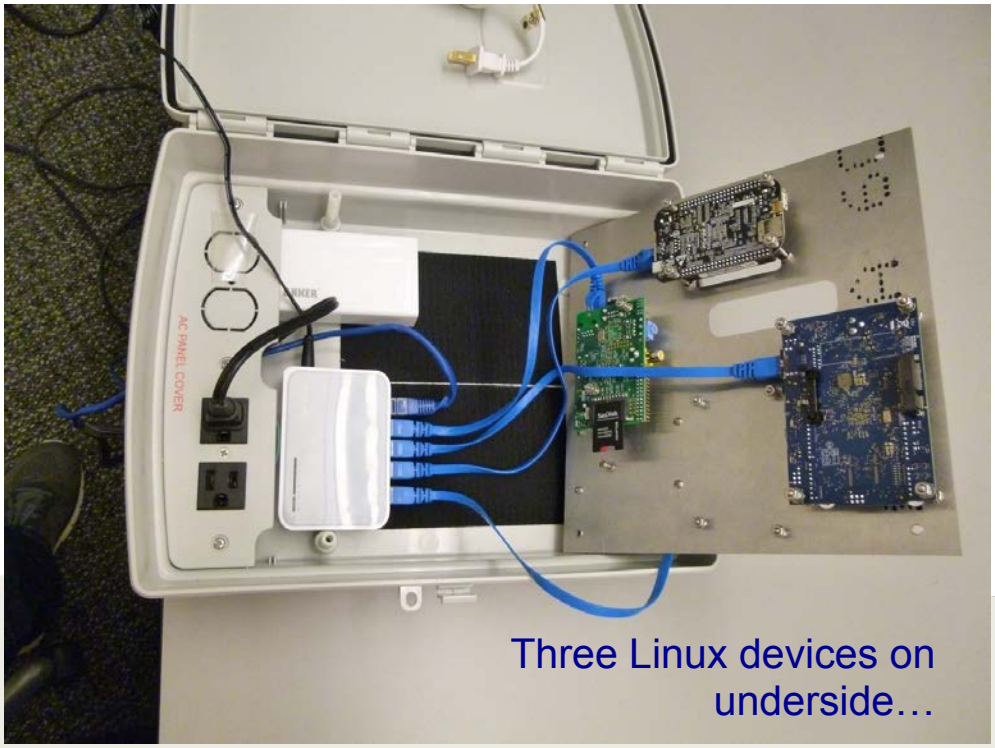


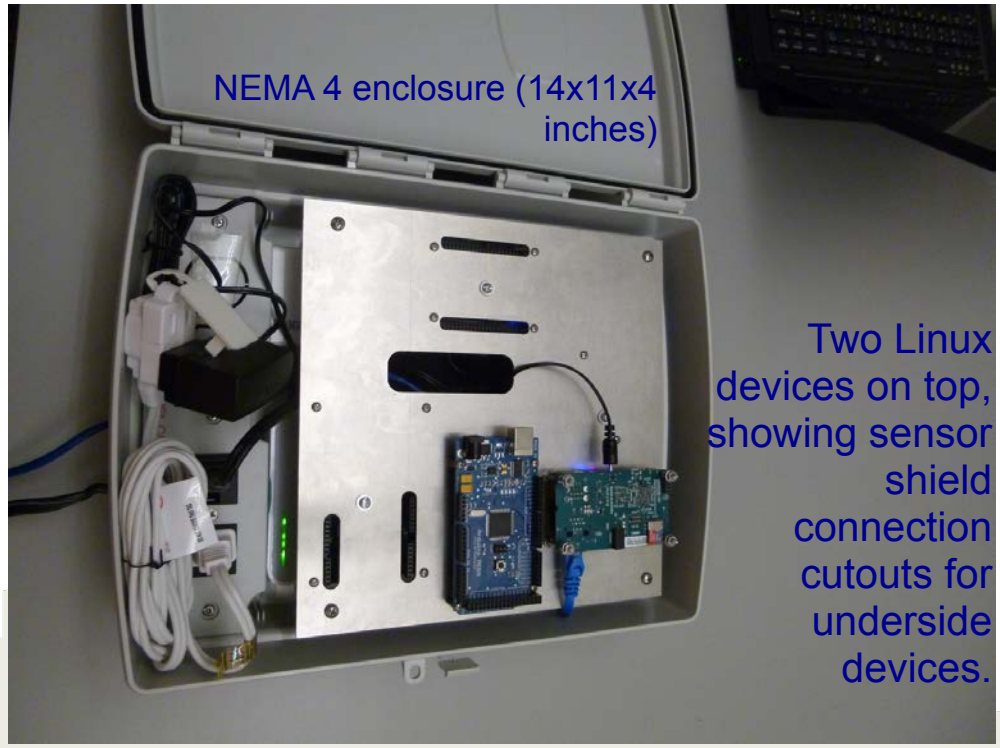
Intel Galileo with cutouts for shield (sensor connection board)



Underside heat sinks



Three Linux devices on underside…



NEMA 4 enclosure (14x11x4 inches)

Two Linux devices on top, showing sensor shield connection cutouts for underside devices.

UrbanCCD is a partner in City of Big Data a public exhibit of the Chicago Architecture Foundation (May 2014 – Sep 2015). The exhibit includes a 50% scale operational AoT node (insets).