Sensing and Visualizing Human Behavior Through City Infrastructure

Workshop on Visualization Technologies to Support Research on Human-Environment Interactions
SeSync: National Socio-Environmental Synthesis Center
July 23-24, 2012, Annapolis, Maryland

Human Computer Interaction Laboratory

@jonfroehlich
Assistant Professor Computer Science

University of Maryland


bicing
902 31 55 31 www.bicing.com
16173
19438
9043


105
estacions
2178


217
estacions


10
Assegura't de tornar la bicicleta correctament!
10


4
4

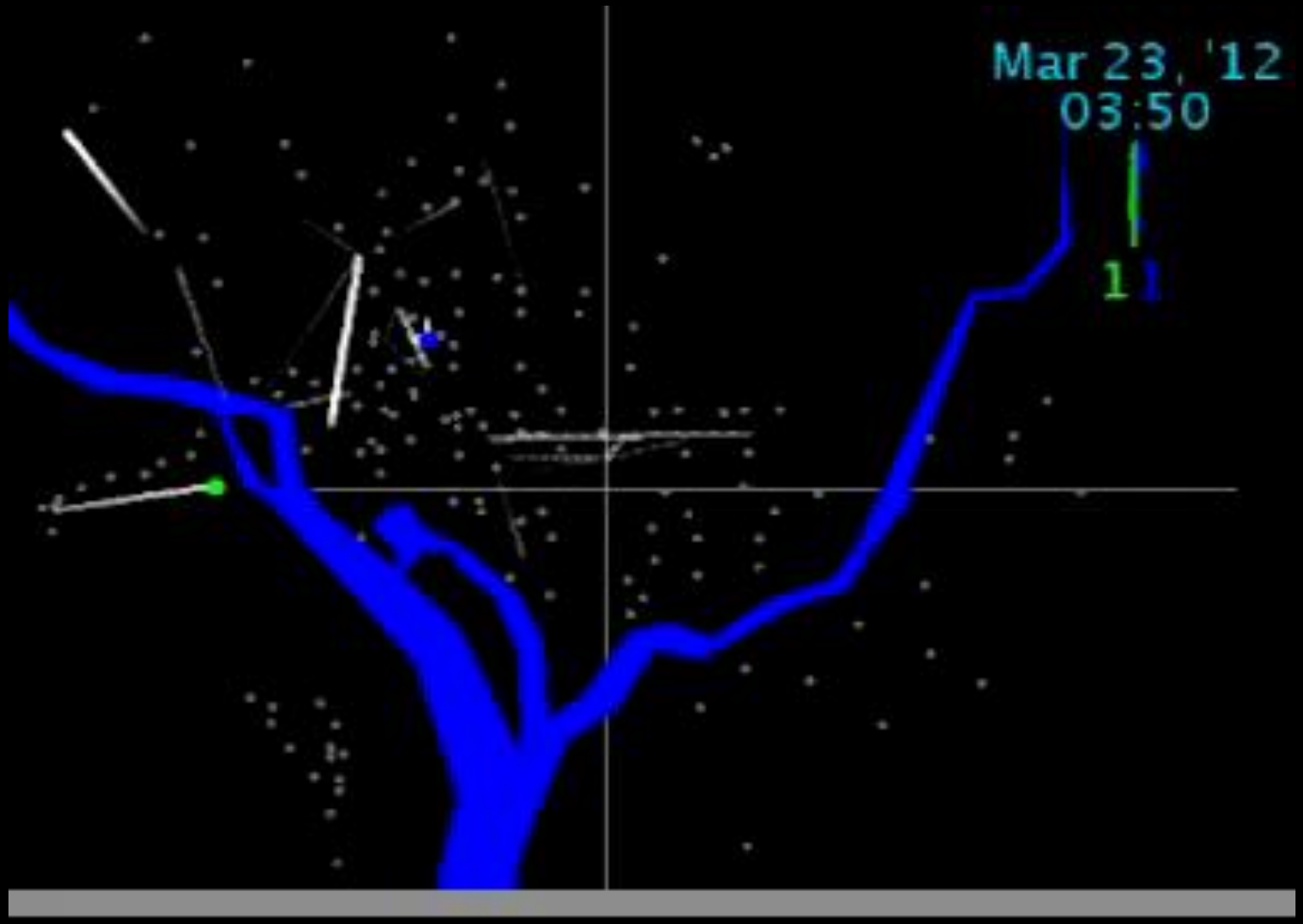

bicing
Servei de Manteniment
17
bicing
bicing
CLEAR CHANNEL
Ajuntament de Barcelona
CLEAR CHANNEL

How can we use machine learning and visualization to understand, encourage, and optimize shared bicycling?

What can we learn about a city from shared bicycling?

[Froehlich et *al.*, UrbanSense2008; IJCAI2009]

Washington DC, Capital Bikeshare (CaBi) Flows



[MV Jantzen, http://www.youtube.com/watch?v=-h0rV7tw1Eo]

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i study human behavior

how human behavior can be sensed

modeled

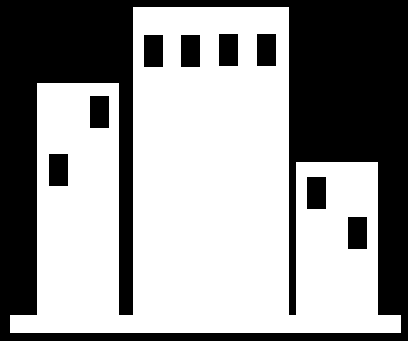
predicted

visualized

changed

individual

household



city

earth

scale

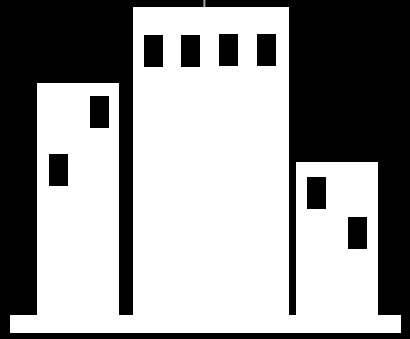
ubigreen

reflect$_2$O

smartcities

individual

household



city

earth

scale

ubigreen

reflect$_2$O

eco-feedback

sensing and visualizing behavior to reduce environmental impact

toyota prius

toyota prius

The Washington Post

washingtonpost.com > Nation > Green

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For Hybrid Drivers, Every Trip Is a Race for Fuel Efficiency

By Michael S. Rosenwald
Washington Post Staff Writer
Monday, May 26, 2008

Evan Hirsche averages 43 mpg with his Prius, while Katie Sebastian, shown with her son, Cole, averages 41 mpg. The drivers have friendly rivalry over their mpg scores, fueled by the Prius hybrid's real-time mileage readings. (By Kevin Clark -- The Washington Post)

Buy Photo

Katie Sebastian accuses her friend Evan Hirsche of getting better mileage than she does because he lives in Bethesda and has flatter everyday trips than she encounters in hilly Takoma Park. She suspects the Hirsche family of taking frequent long drives out of town, which also helps them.

"They claim they haven't been out of town in a while," she said, "but I know they have."

Hirsche retorts: "It is well known that Katie is a lead-footer."

Their friendly rivalry stems from the Prius effect. Both drive a Prius, the Toyota hybrid with an elaborate dashboard monitor that constantly informs drivers how many miles per gallon they are getting and whether the engine is running on battery or gasoline power. That can change driving in startling ways, making drivers

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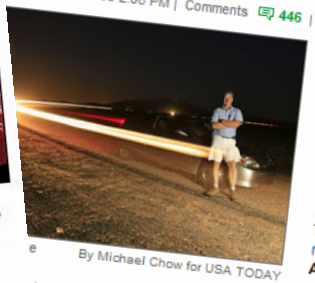
100 mpg? For 'hypermilers,' that sounds about right

Updated 6/27/2008 2:06 PM | Comments 446 | Recommend 103 E-mail | Save | Print | Reprints & Permissions | RSS



By Michael Chow for USA TODAY

in of Gilbert, Ariz., squeezes as much an get from his 2000 Honda Insight.

By Chris Woodyard, USA TODAY

GILBERT, Ariz. — After a 29-mile jaunt from his Phoenix office to his home here, Louis Hudgin proclaimed his gas mileage "pitiful."

He averaged just 88.3 miles per gallon.

MAXIMIZING MPG: What experts think of hypermiler techniques
TELL US: How do you squeeze the most miles out of every gallon?
ACROSS THE USA: Drivers slow down as costs accelerate

Most drivers would take a victory lap if they managed to squeeze that kind of mileage out of increasingly precious gasoline. Even on this, a bad day, Hudgin coaxed 28 mpg more out of his 2000 Honda Insight hybrid than its federal highway mpg rating.

Hudgin's disappointment — he usually averages about 100 mpg this time of year — stems from his pride in being no ordinary driver.

He's a hypermiler, part of a loose-knit legion of commuters who've made racking up seemingly unattainable mpg an art. And a sport.

Hypermilers practice such unorthodox techniques as coasting for blocks with their car's engine turned off, driving far below speed limits on the freeway, pumping up tire pressure far beyond car and tire makers' recommendations

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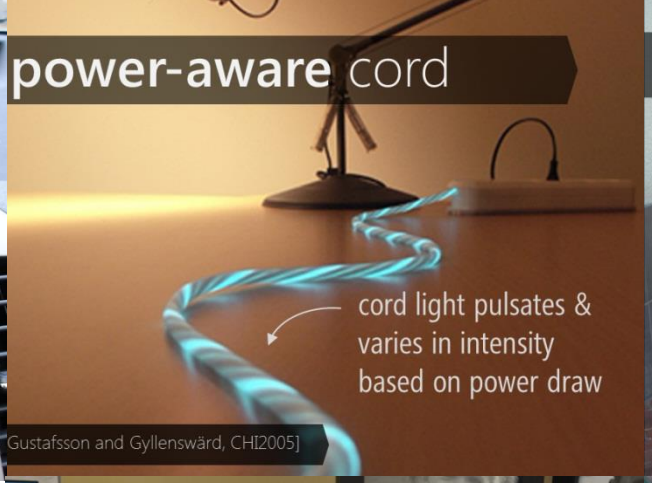
THE DISCUSSION

price of a
ar gasoline
low has
ted you?
sion at
Fuel
stories
g tips
rs.

eco-feedback

sensing and visualizing behavior to reduce environmental impact


toyota prius
Consumption
MPG
Current
Energy
60.5 MPG
204 miles
Reset


power-aware cord
cord light pulsates & varies in intensity based on power draw
Gustafsson and Gyllenswärd, CHI2005]


jetsam
visualization allows pedestrians to view amount and type of garbage at-a-glance
[Paulos and Jenkins, CHI2005]


microsoft hohm
Energy Charts
Electricity Usage


the energy detective
Real-Time Use
$ 0.40 per Hour
2,480 kilowatts
TED

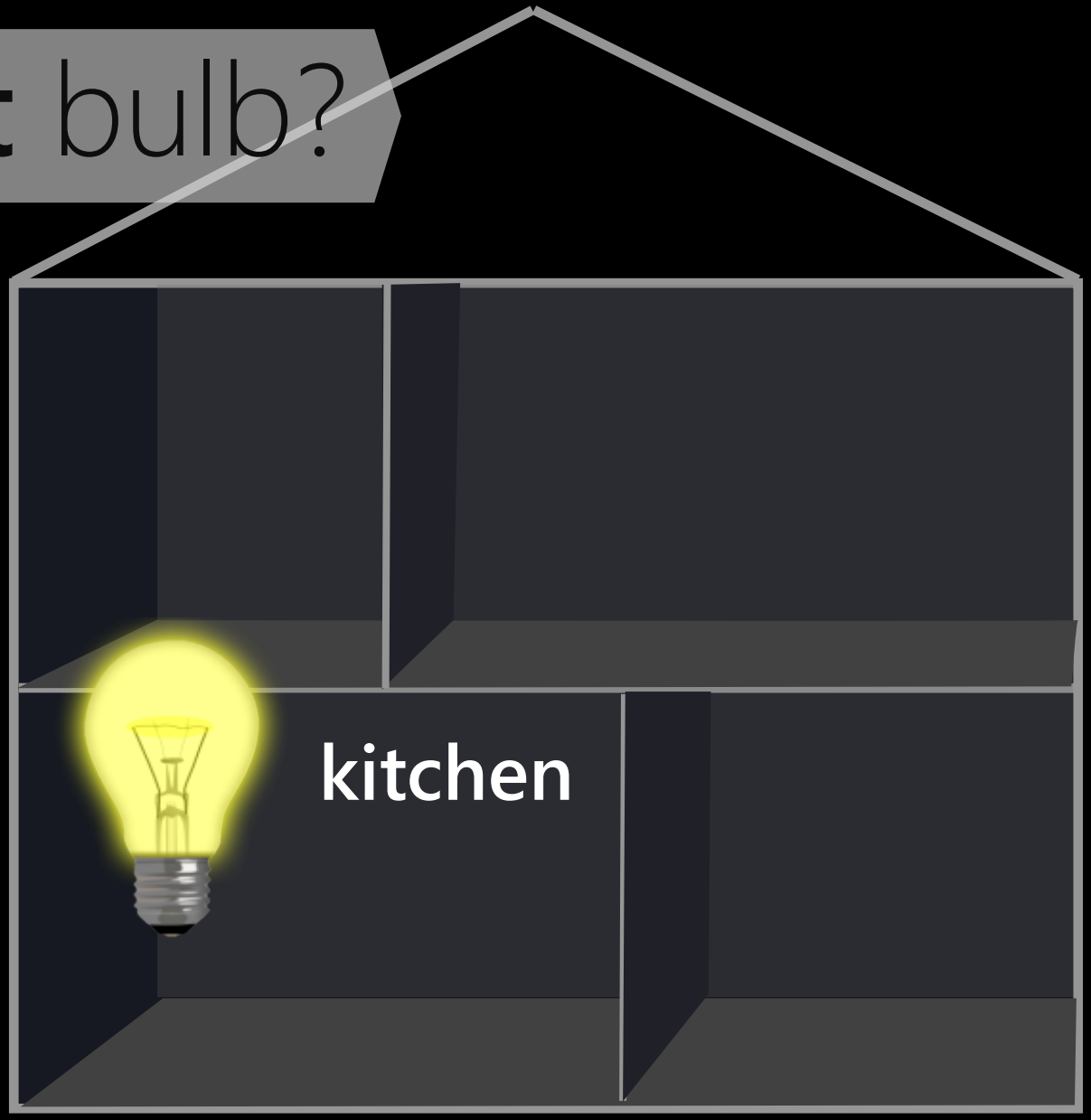

wattson


control4 dashboard
Menu
Thursday, January 6
My Home Now
Price Per kWh
$0.00
5:30 pm
0.1 kW
78°
My Cost Per Hour
$0.01
62°
So Far Today 0.6 kWh
Control4

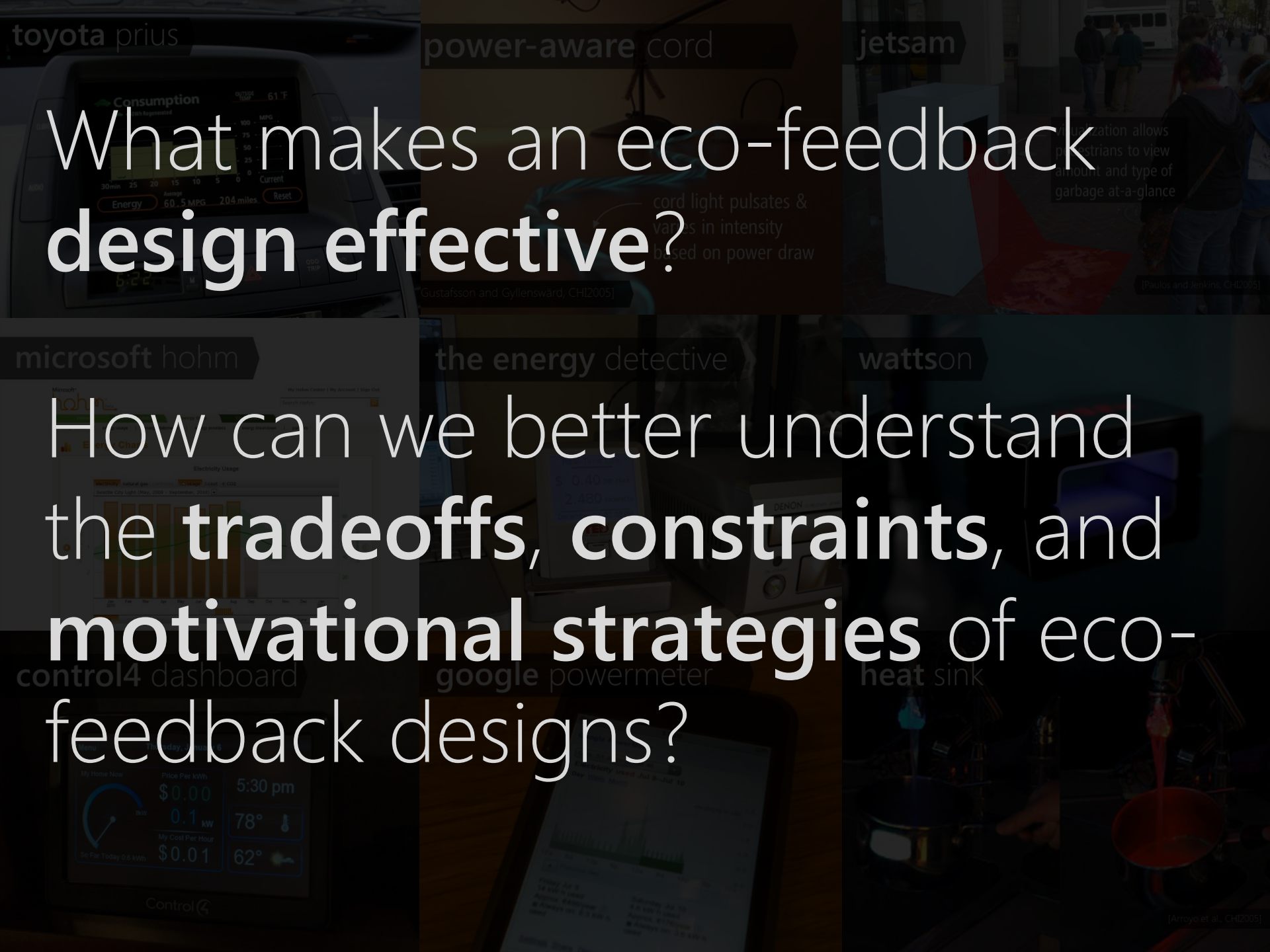

google powermeter
Google PowerMeter
Electricity used Jul 9–Jul 10


heat sink
[Arroyo et al., CHI2005]

light bulb?



[Kohlenberg et al., J. of Applied Behavior Analysis, 1976]



What makes an eco-feedback **design effective**?

How can we better understand the **tradeoffs**, **constraints**, and **motivational strategies** of eco-feedback designs?

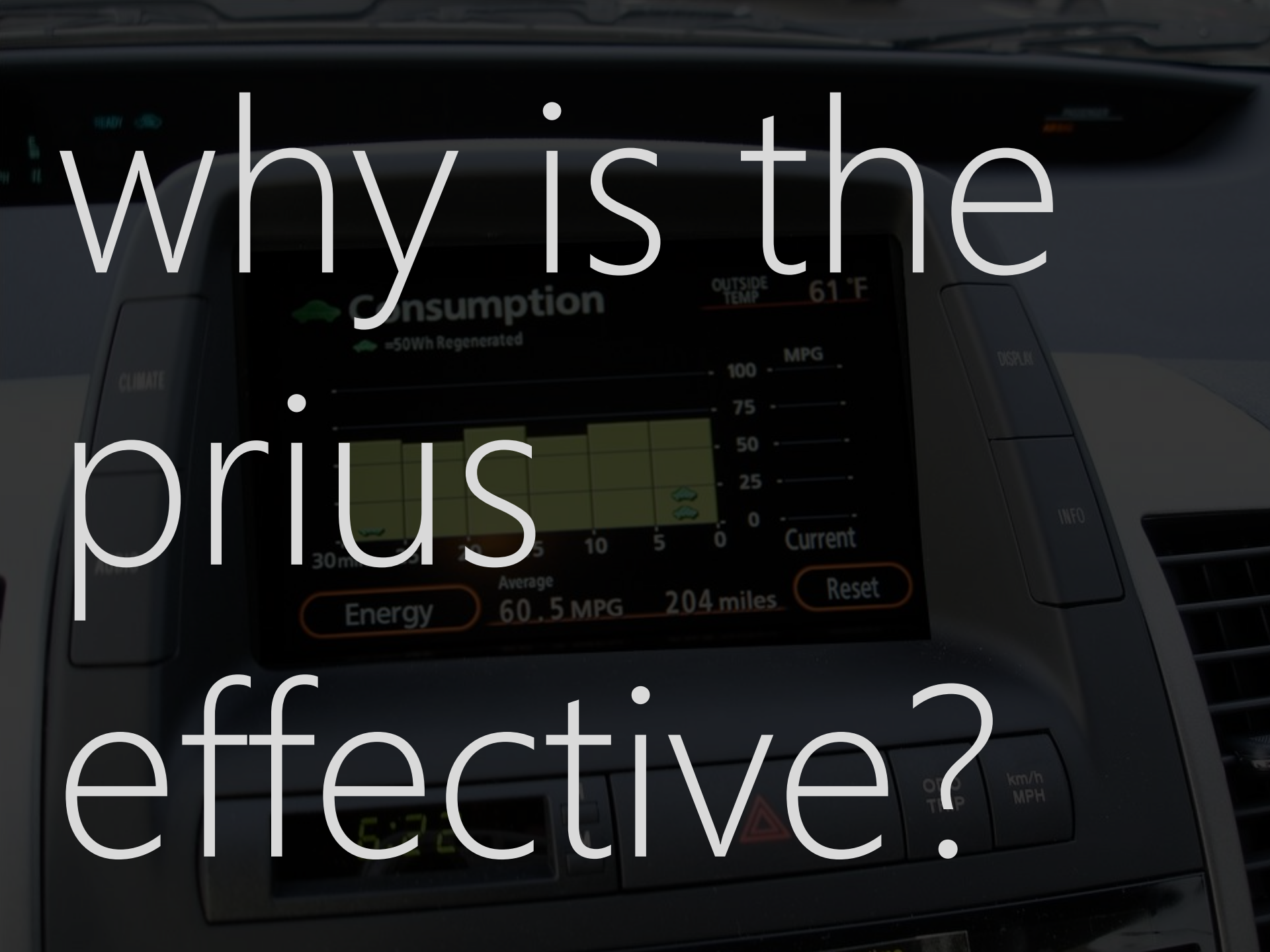
advances in **sensing** and **machine learning**

philips directlife
activity sensor

plethora of **display mediums**

how can we design and evaluate  systems?

[Froehlich *et al.*, HCIC2009; CHI2010; UW PhD Dissertation 2011]



why is the prius effective?

- Graphical
- Textual
- Temporal

data representation

- Real-time
- Spatially co-located
- Constrained environment

information access

- Real-time mpg

inputs

- In-car display

display medium

behavioral models

comparison

- Educates
- Reason to care

social

- To self

actionability

motivational strategies

- Informs only one action

data representation

information access

inputs

display medium

behavioral models

comparison

social

actionability

motivational strategies

data representation

information access

inputs

display medium

behavioral models

comparison

social

actionability

motivational strategies

comparison

historic average
last 30 mins

to self
past
projected

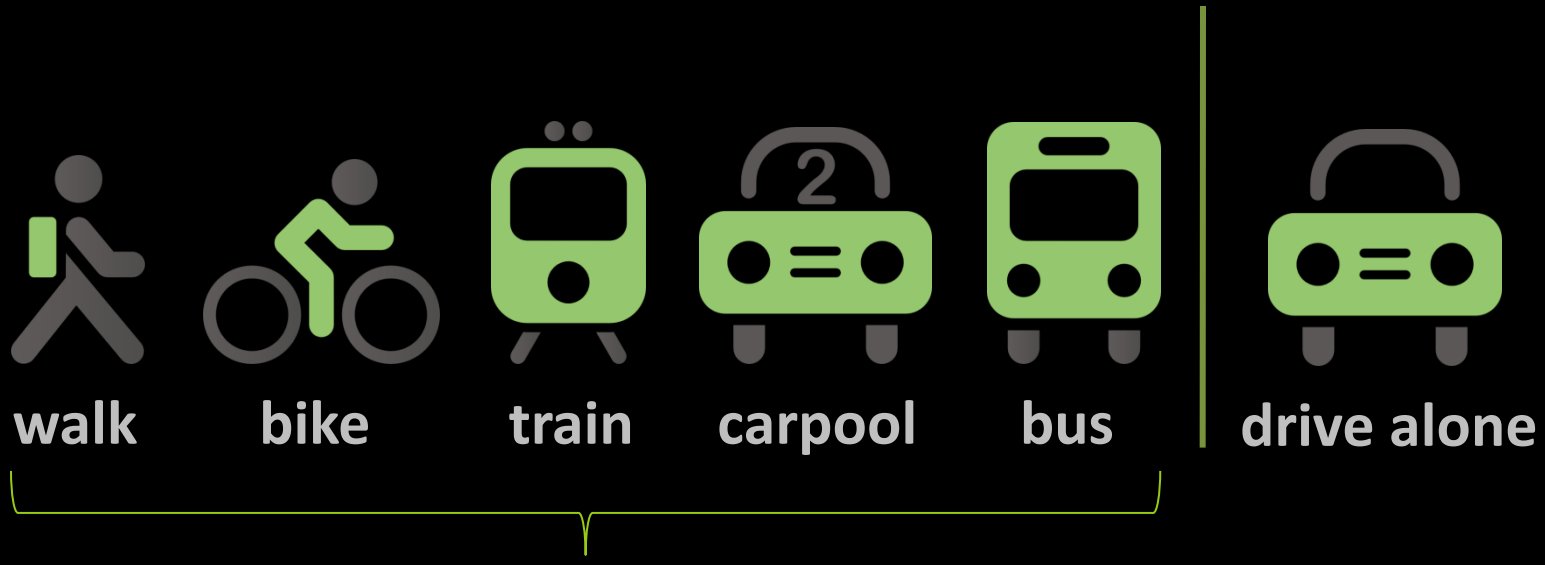
to others
past
projected

to a goal
easy
challenging

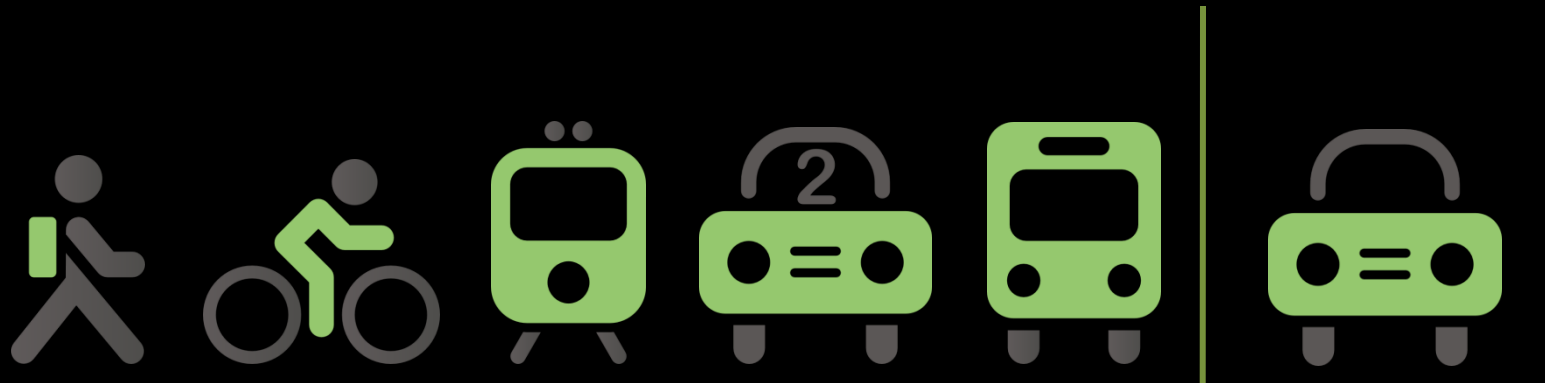
ubigreen

[Froehlich *et al.*, CHI 2009]

ubigreen activities



ubigreen activities
transit sensing infrastructure



mobile sensing platform

cell towers

+

user


43
VIA
U DISTR
ubigreen eco-feedback
mobile sensing platform

ubigreen

personal ambient display

current activity

phone background (wallpaper)

value icon bar

evolving image

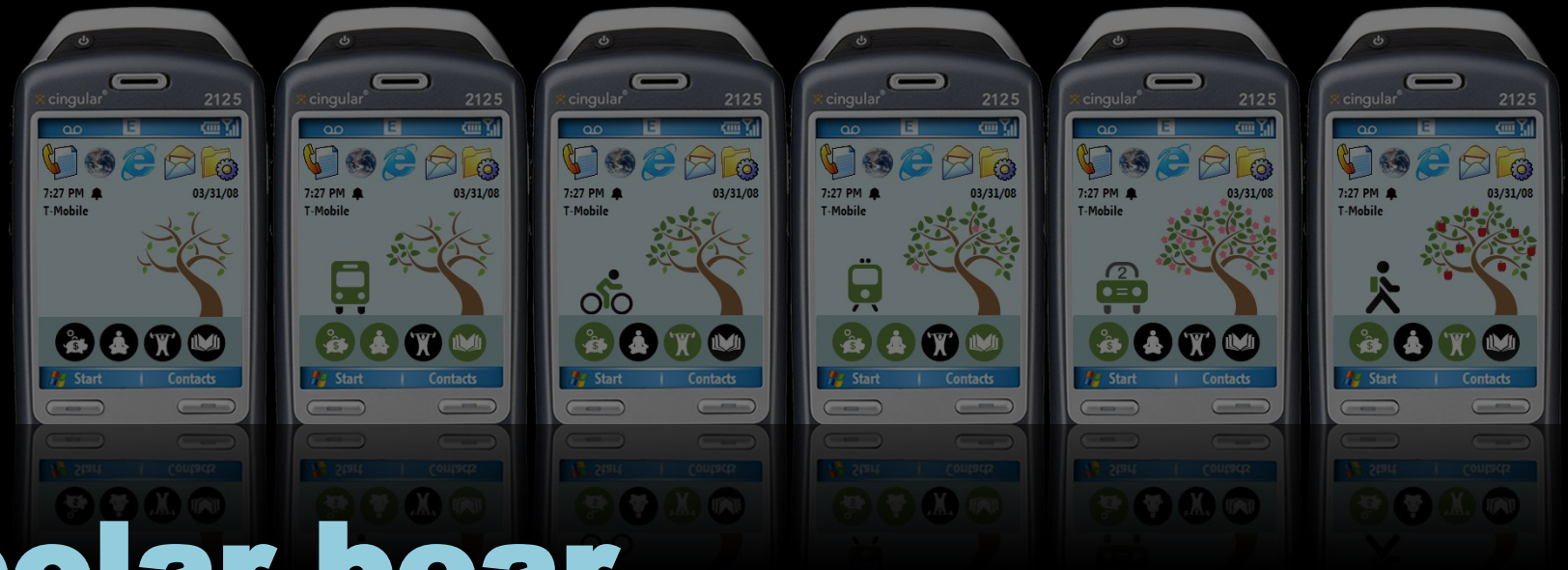
ubigreen

personal ambient display

tree design:

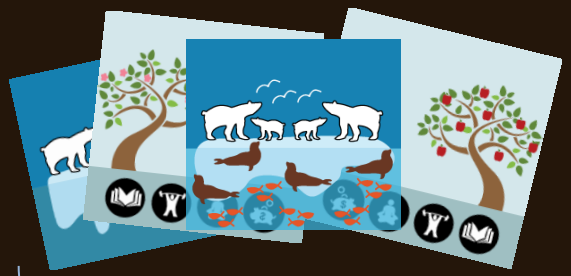
everything resets on sunday

tree

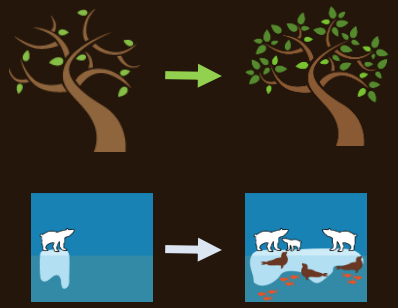


polar bear

motivational strategies



playful



measured progress

role playing

rewards

levels

ubigreen
study results

"i liked the tree because it was, to my mind, a pretty progress bar. i could tell the difference at a glance" [p11]

"i liked how stories were used" [p8]

"i want different stories every week" [p8]

"i would like to see some graph or raw data—a breakdown of transit activity by type for the week" [p13]

"it would be nice to see your carbon footprint" [p15]

ubigreen
study results

"i liked that we didn't know what the background was going to do" [p15]

"negative feedback would also be good; maybe my polar bear should drown if i don't take green transit" [p14]

"i wanted to see the final stage i could get to" [p7]

"i don't like incentives for getting points artificially by taking unnecessary green trips" [p11]

"if i didn't get a leaf or a flower after, i felt like I was getting cheated out of my points" [p15]

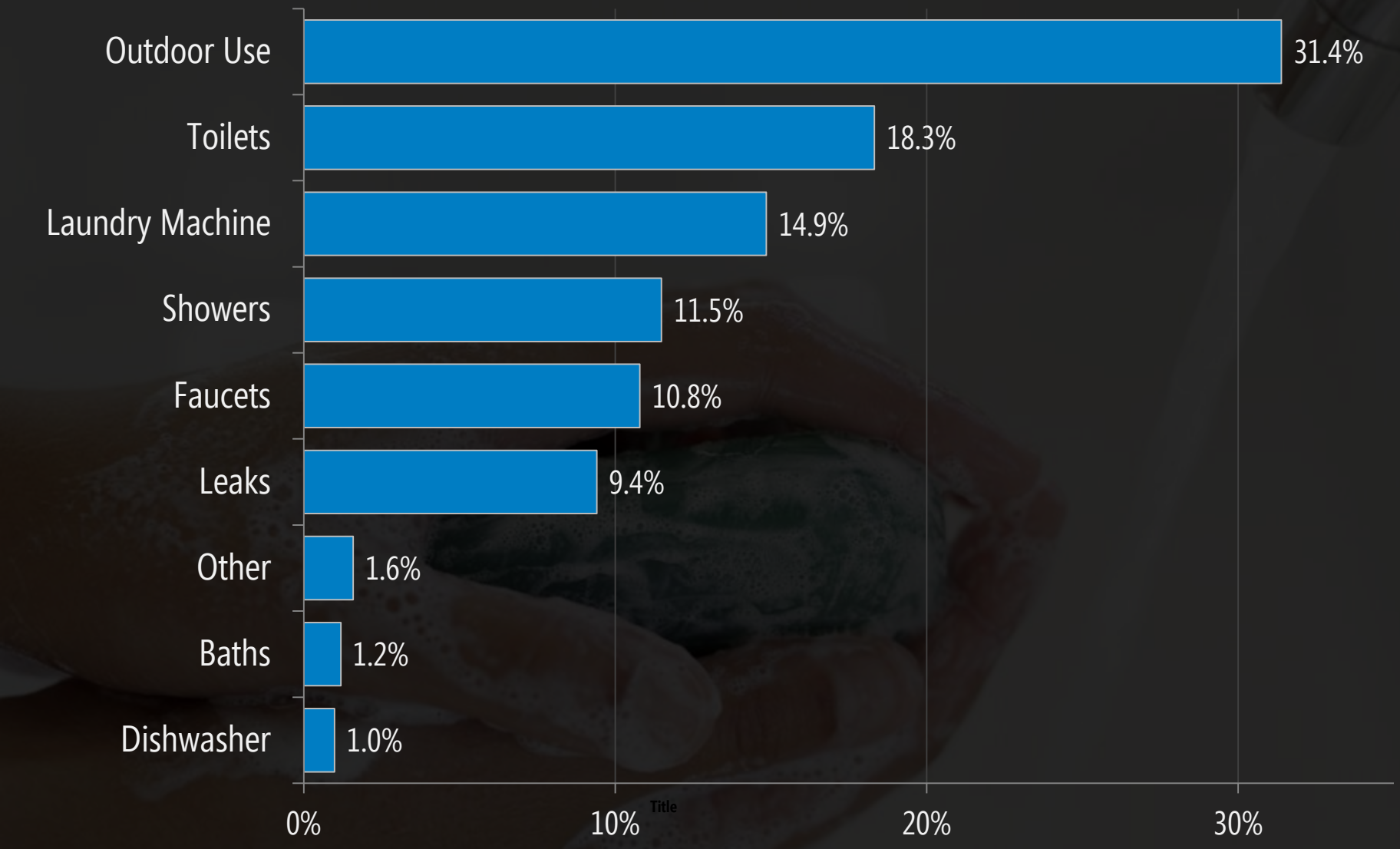
reflect$_2$O

[Froehlich *et al.*, CHI 2011]

what

are the most water consuming activities in the average North American home?

Top Water Usage Activities



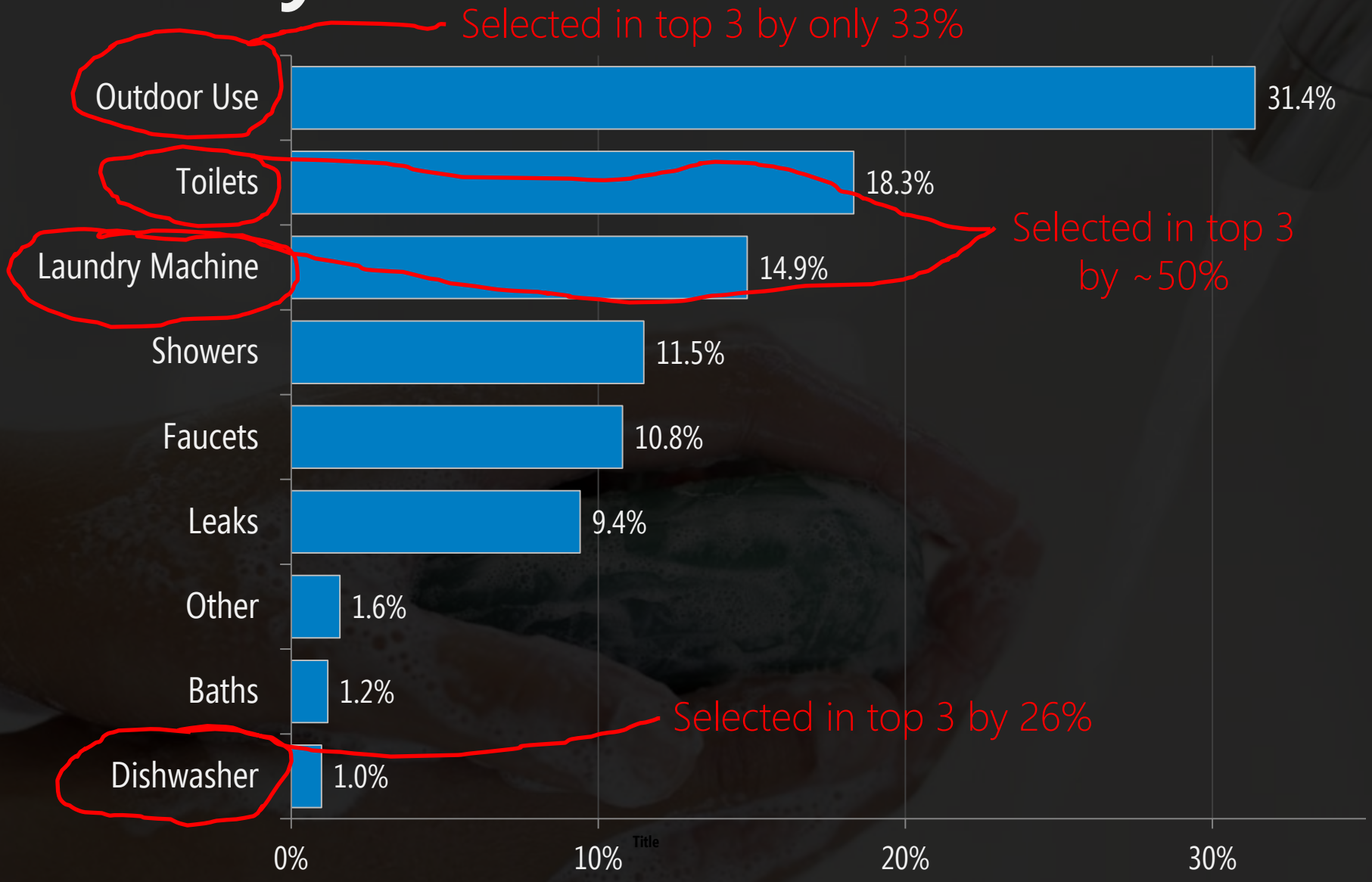
[Vickers, Handbook of Water Use and Conservation, 2001]

we asked **656 people** the same thing

select the top 3 most water consuming activities in an average home

[Froehlich, PhD Dissertation, 2011]

Survey Results



why the disconnect?

water sensing

Municipal Services Statement

City of Tempe
P.O. Box 29617
Phoenix, AZ 85038-9617
480-350-8361
480-350-8400 (TDD)

0000127520000000010068700154711 8

LINDER HOLLINQUEST
7450 S KENWOOD DR
TEMPE AZ 85283-4921

Mark if address change requested on reverse side

Account Number: 100687-00154711
Utility Amount Due: 127.52
Voluntary Donation: 1.00
Total + Voluntary Donation: 128.52
Date Due: 1/8/2007
Enter Amount Paid:

Make checks payable to the City of Tempe.

PLEASE FOLD BEFORE TEARING

Return the top portion of this statement with your payment.

Keep the bottom portion of this statement for your records.

See reverse side for important information.

Account Number: 100687-00154711
Current meter reading: 16507
Billing period: 12/2006
Previous meter reading: 16305
Service Address: 7450 S KENWOOD LN
Meter read date: 11/20/2006
Gallons delivered: 20,200
Days of service: 27

Account Activity

Date	Description	Amount
	Payments Received Thank You	100.00
12/12	Water Quality Fee	0.13
12/12	Tempe City Tax	0.61
12/12	State Tax	2.15
12/12	Sewer Service Charge	7.28

Date	Description	Amount
12/12	Water Consumption	20.11
12/12	Water Service Charge	13.99
12/12	1% Delinquent Fee	0.40
12/12	Sewer Charge	11.48
12/12	Residential Refuse	17.41

Date Due: 1/8/2007

The due date on this ... applies ONLY to current charges.
... Discover payments accepted, call 480-350-8361

Previous Balance	...	...	...	...	+ Other Debits	=Utility Amount Due
153.96	100.00	0.00	53.96	73.56	0.00	127.52

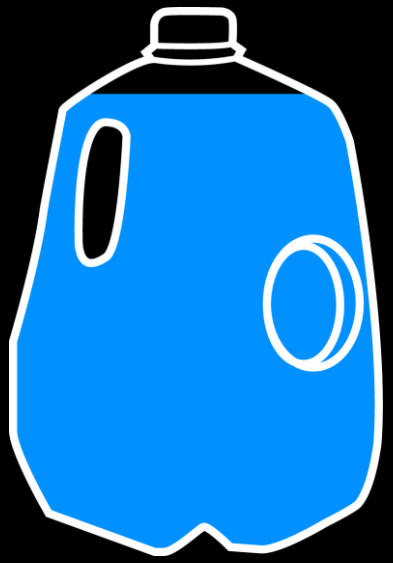
+ Voluntary Donation	= Total Including Voluntary Donation
1.00	128.52

Year to Date Voluntary Donation Thank You: 0.00

Help to Others voluntary donation program makes it easier to help neighbors in need. Help to Others supports essential human service programs for children, families and seniors. If you do not wish to contribute to this program, simply pay only the "Utility Amount Due."

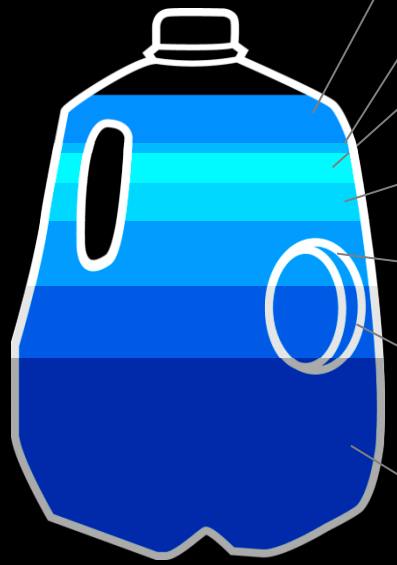
water feedback

10,230
gallons



[Kempton & Layne, Energy Policy, 1994]

10,230 gallons



Other
1248 gals

Dishwasher
102 gals

Faucets
1105 gals

Showers
1176 gals

Laundry
1,524 gals

Toilets
1,872 gals

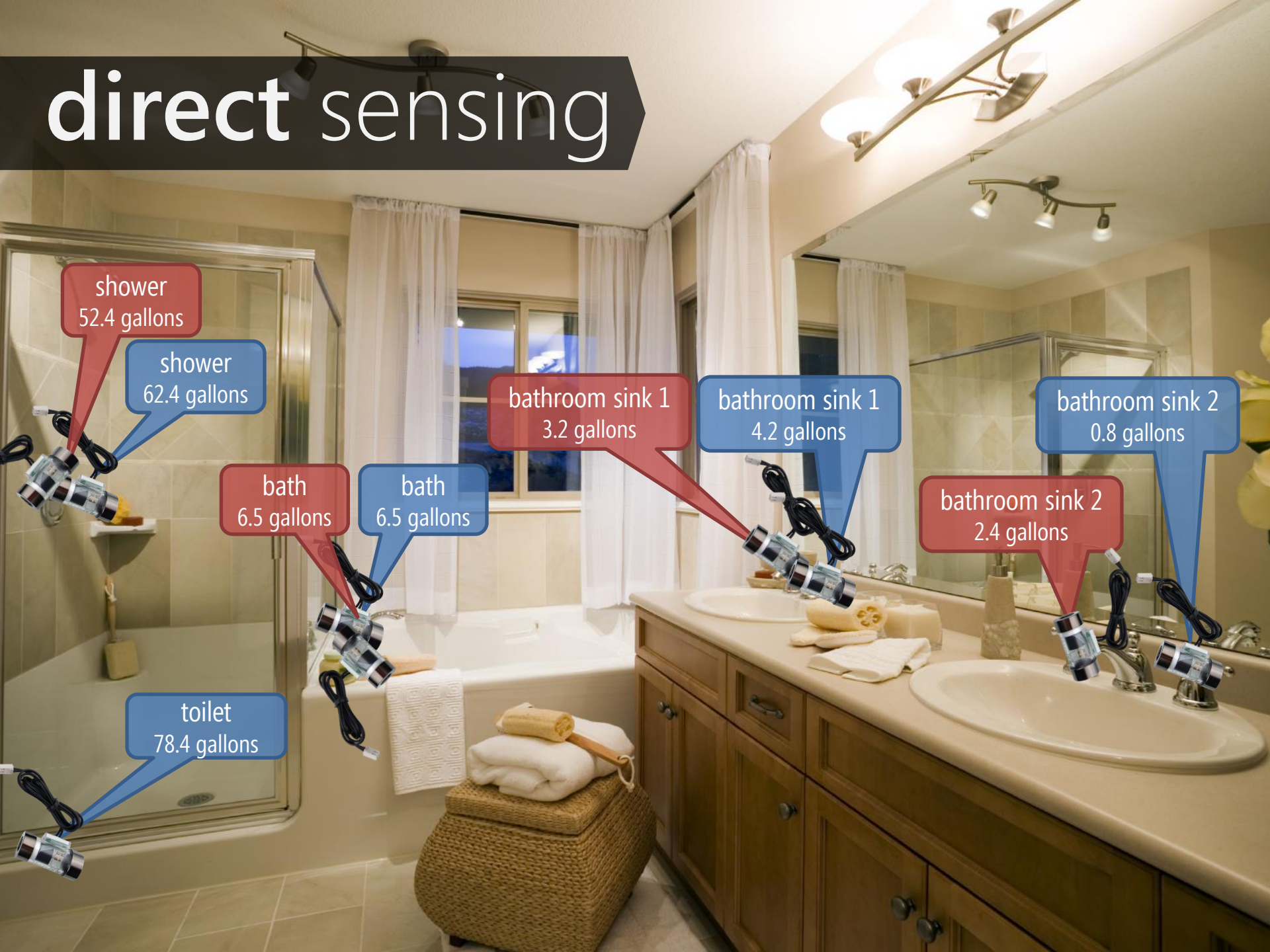
Outdoor
3,212 gals

direct sensing

[Teague Labs, Arduino Water Meter, http://labs.teague.com/?p=722]

direct sensing

direct sensing



indirect sensing

shower
52.4 gallons

shower
62.4 gallons

bath
6.5 gallons

bath
6.5 gallons

toilet
78.4 gallons

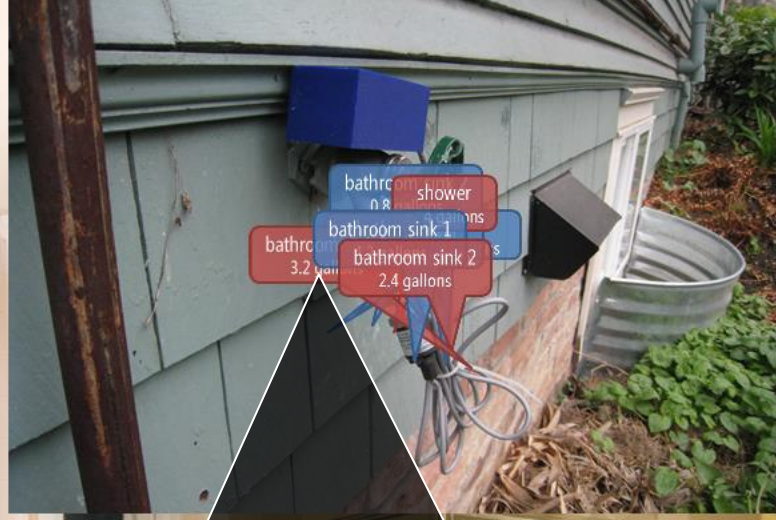
bathroom sink 1
3.2 gallons

bathroom sink 1
4.2 gallons

bathroom sink 2
2.4 gallons

bathroom sink 2
0.8 gallons

indirect sensing



HydroSense attempts to infer fixture-level usage for the entire home from a **single** point.

[Froehlich *et al.*, UbiComp 2009]
[Larson *et al.*, PMC 2010]
[Froehlich *et al.*, Pervasive 2011]

What do we do with all this data?


Daily average consumption by fixture for the month of May
69.3 gallons
of water consumed per day on average
Weekly consumption pattern for the month of May
average consumption for this day of the week
average daily consumption
M T W T F S S
M T W T F S S
M T W T F S S
M T W T F S S
M T W T F S S
M T W T F S S
M T W T F S S

Key Questions

1. **What** are the key gaps in residential water usage understanding amongst home occupants?

2. **What** aspects of disaggregated data are potential users interested in and what sort of reactions do the visualizations provoke?

3. **How** might these visualizations impact behavior?

Key Questions

1. **What** are the key gaps in residential water usage understanding amongst home occupants?

2. **What** aspects of disaggregated data are potential users interested in and what sort of reactions do the visualizations provoke?

3. **How** might these visualizations impact behavior?

Two sets of designs:

1 **Design Dimensions**
Isolate eco-feedback design dimensions in the context of water usage

2 **Design Probes**
Meant to elicit reactions about how displays would fit within a household and investigate issues such as privacy, competition, family dynamics.

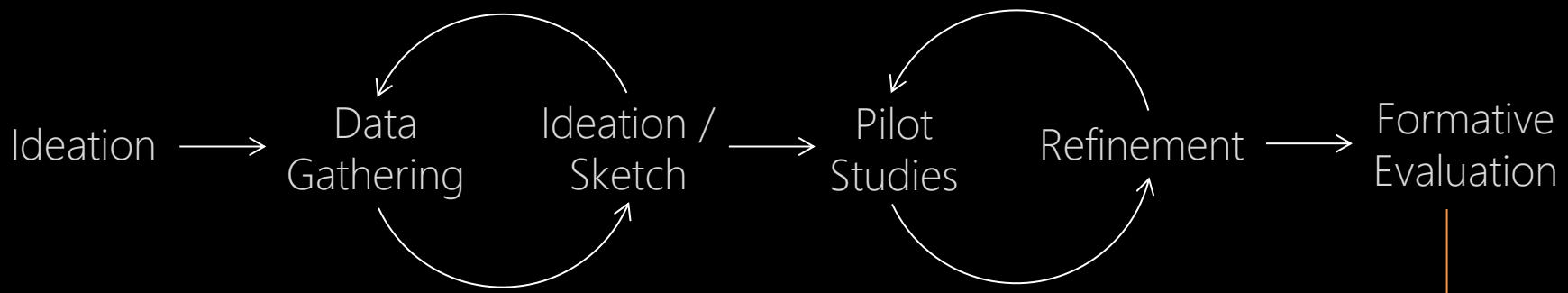
[Froehlich *et al*., CHI2012]

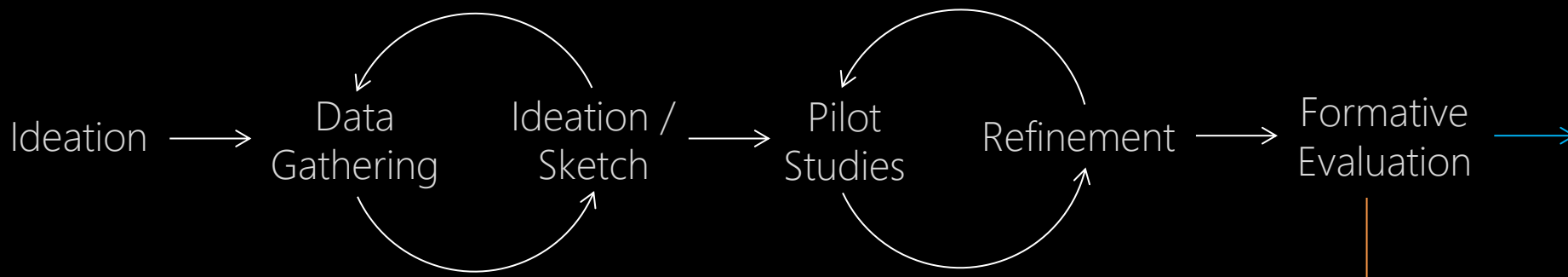
Iterative Design Process

Sketch

Lo-to-Mid Fidelity Mockup

Higher Fidelity Mockup


Ideation
Data Gathering
Ideation / Sketch
Pilot Studies
Refinement
Formative Evaluation
Online interactive survey of designs (N=651 respondents)
In-home interviews (10 households, 20 adults)


Ideation
Data Gathering
Ideation / Sketch
Pilot Studies
Refinement
Formative Evaluation
Online interactive survey of designs (N=651 respondents)
In-home interviews (10 households, 20 adults)

the 

helps structure both our design process and our evaluations

DESIGN SET 1: ISOLATING DESIGN DIMENSIONS

Design Dimensions Explored

1. **Data** Granularity
2. **Time** Granularity
3. **Measurement** Unit
4. **Comparison**

These 3 are sub-dimensions of

Measurement Unit

resource — rate of consumption — cost — time — activity — metaphor

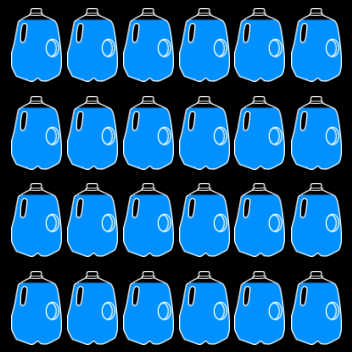
36 gallons of water

3 gpm

9 cents

12 minutes

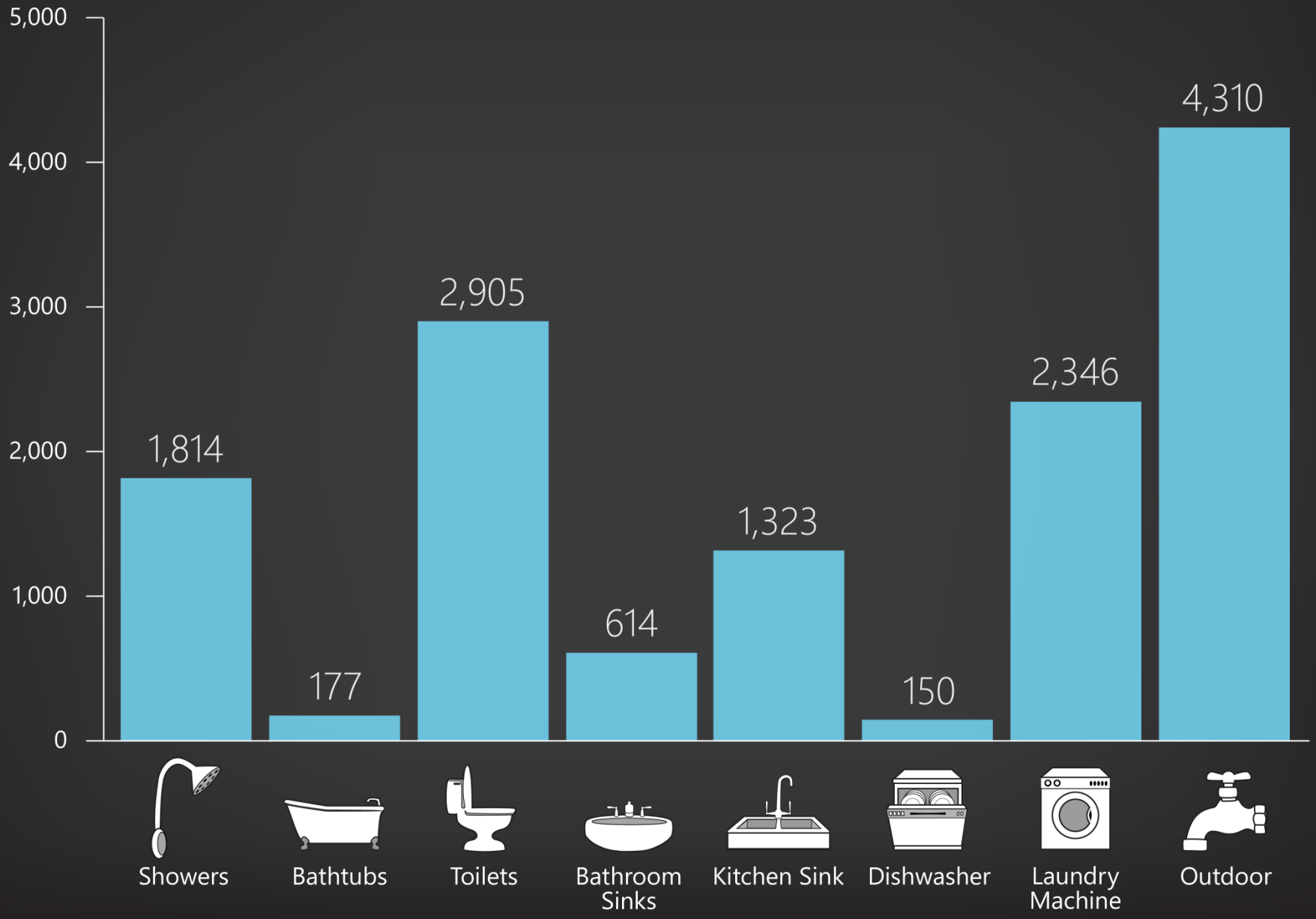
1 shower



This Month's Water Usage

Fixture Category View | In Gallons

Friday June 15th | 9:30 PM

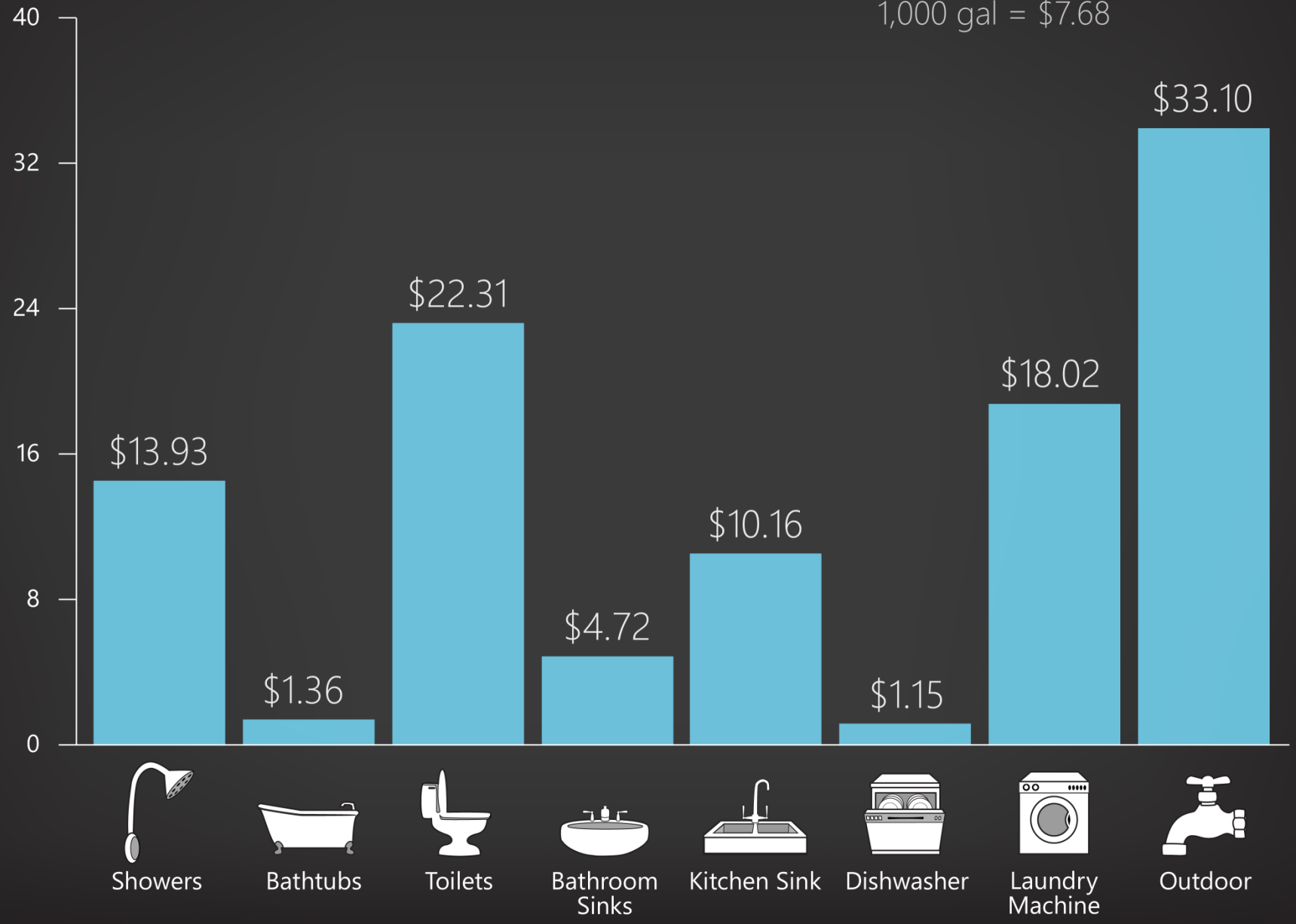


This Month's Water Usage

Fixture Category View | In Dollars

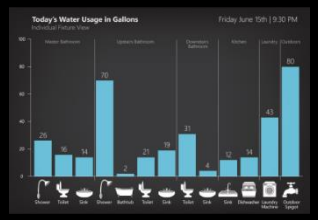
Friday June 15th | 9:30 PM

Your Current Water Rate:
1,000 gal = $7.68

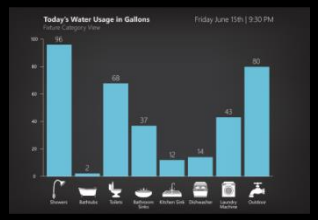


Design Dimensions Explored

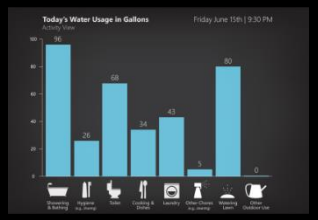
Data Granularity



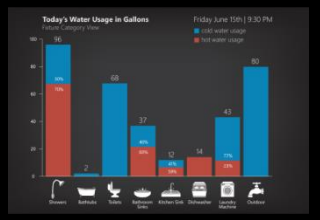
Individual Fixture



Fixture Category

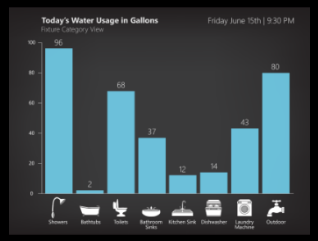


Activity

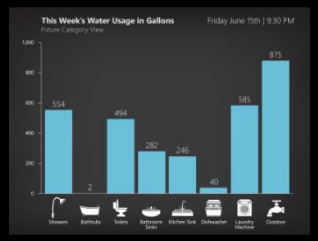


Hot and Cold

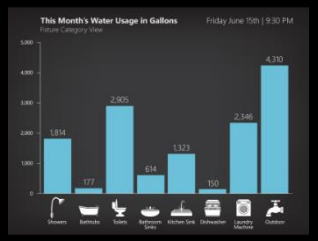
Time Granularity



So Far Today

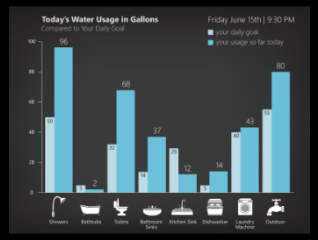


So Far This Week

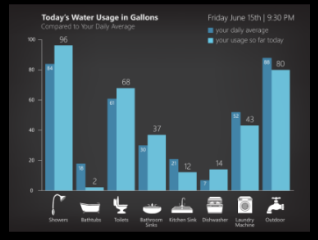


So Far This Month

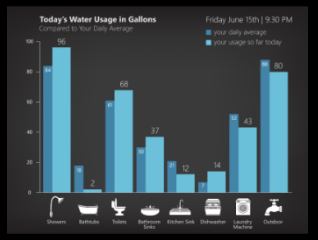
Comparison



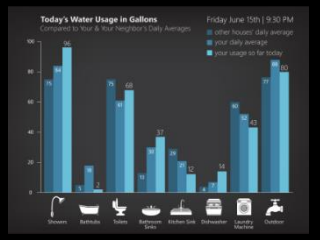
Self Comparison



To Others

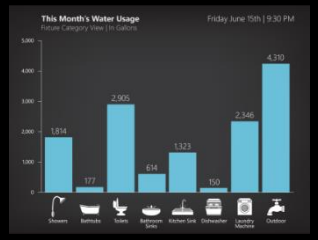


To A Goal

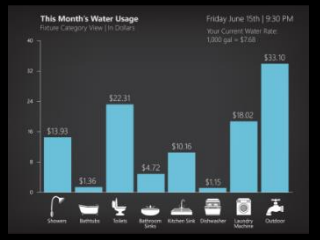


Social/Self

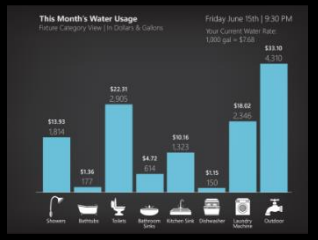
Measurement Unit



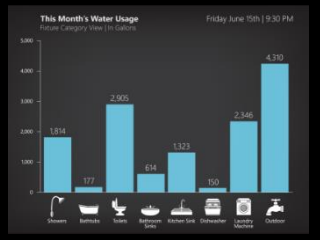
In Gallons



In Dollars



Dollars / Gallons



Including Sewage

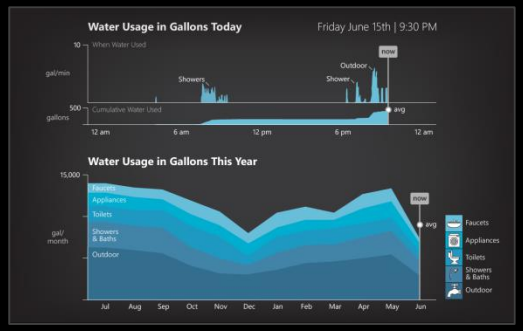
Two sets of designs:

1 **Design Dimensions**
Isolate eco-feedback design dimensions in the context of water usage

2 **Design Probes**
Meant to elicit reactions about how displays would fit within a household and investigate issues such as privacy, competition, family dynamics.

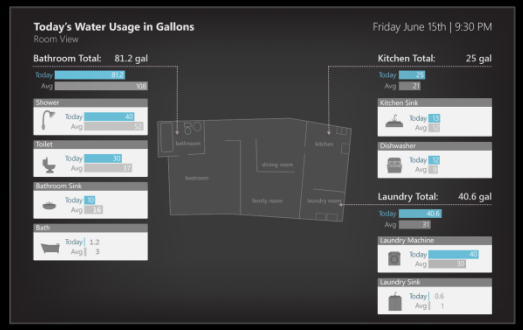
DESIGN SET 2: DESIGN PROBES

Design Probes Explored

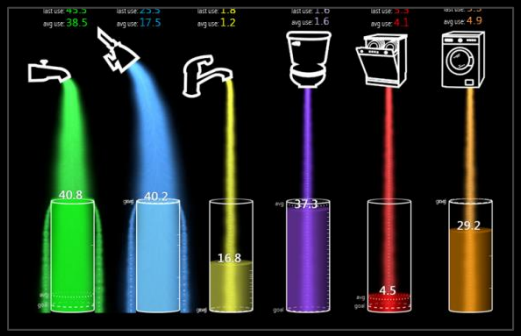


Time-Series

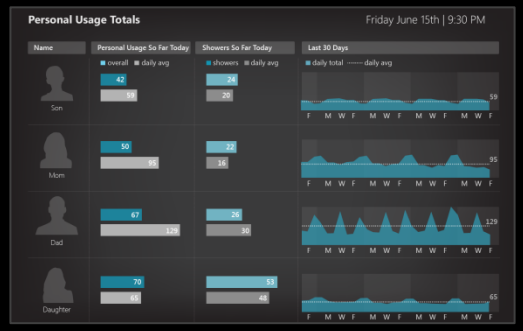
Aquatic Eco-system



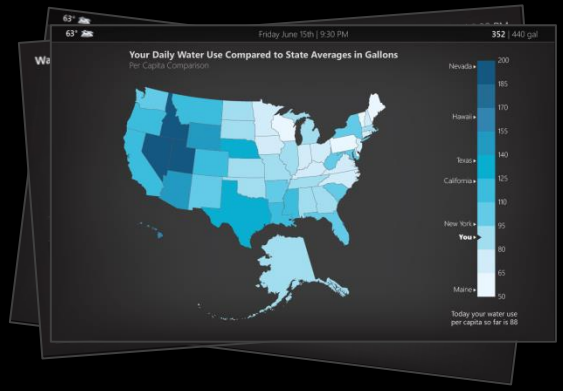
Spatial



Rainflow



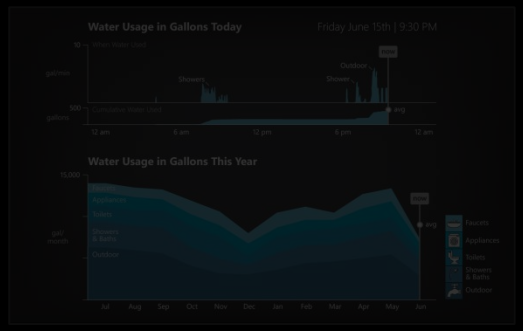
Per-Occupant



Other

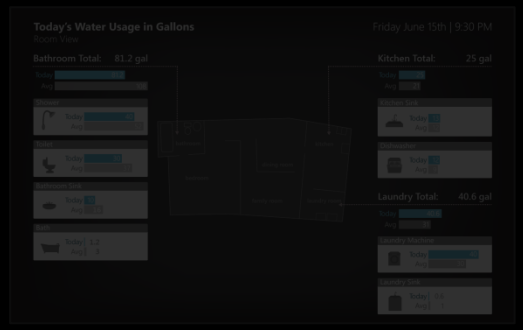
DESIGN SET 2: DESIGN PROBES

Design Probes Explored

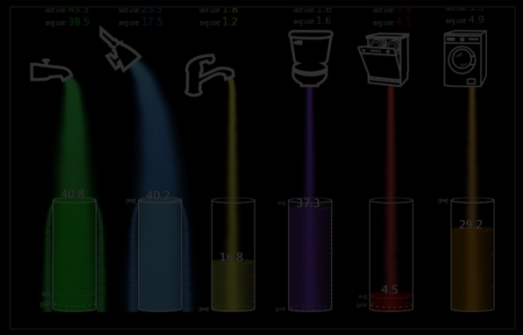


Time-Series

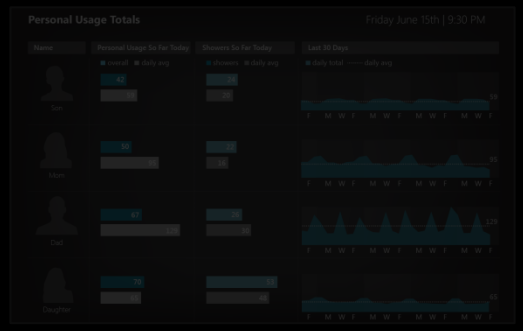
Aquatic Eco-system



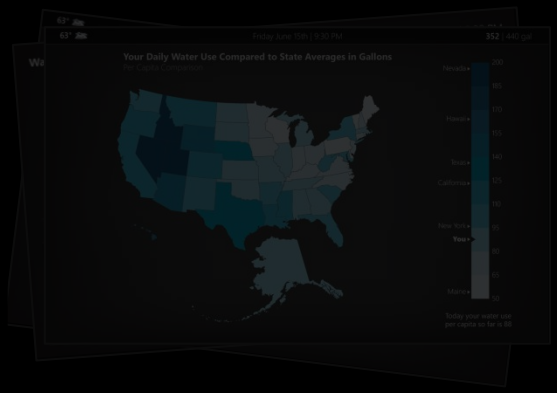
Spatial



Rainflow

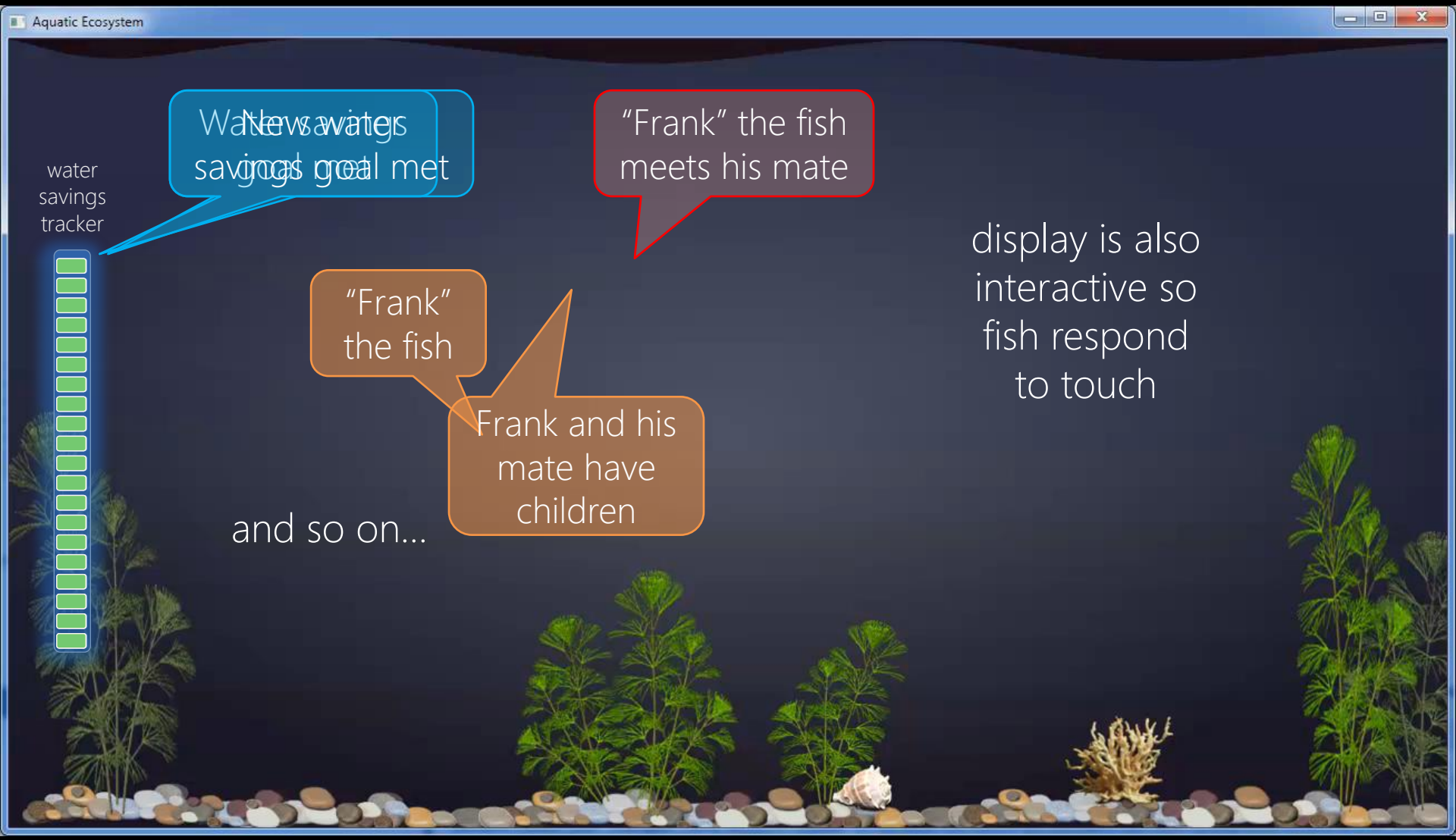


Per-Occupant



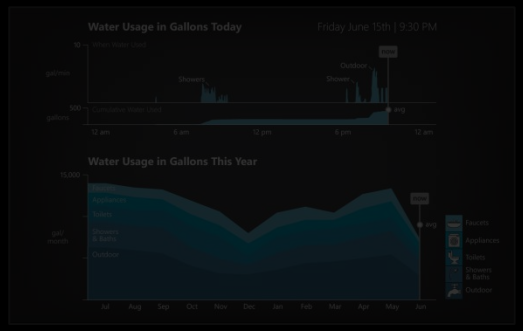
Other

Aquatic Ecosystem View



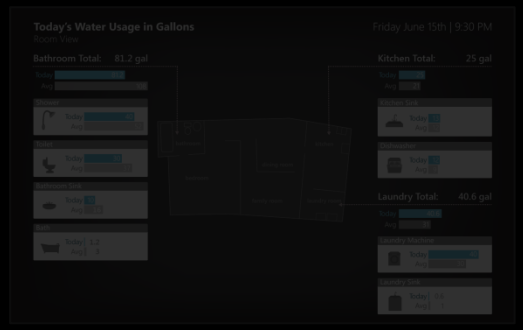
DESIGN SET 2: DESIGN PROBES

Design Probes Explored

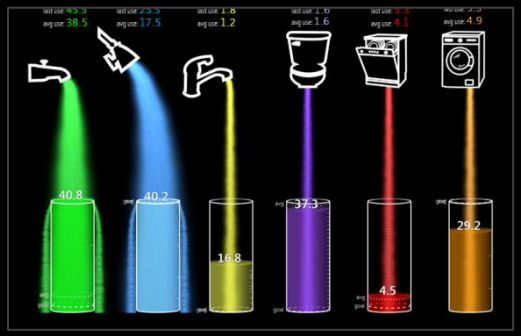


Time-Series

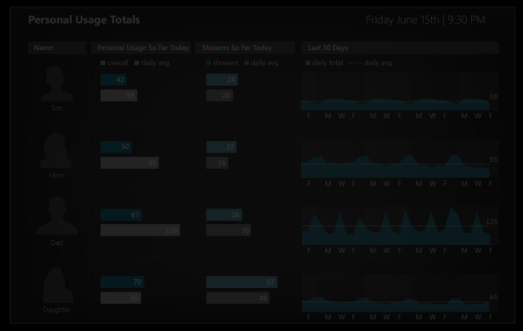
Aquatic Eco-system



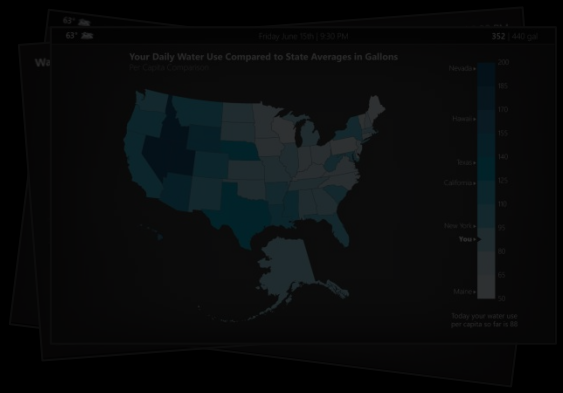
Spatial



Rainflow



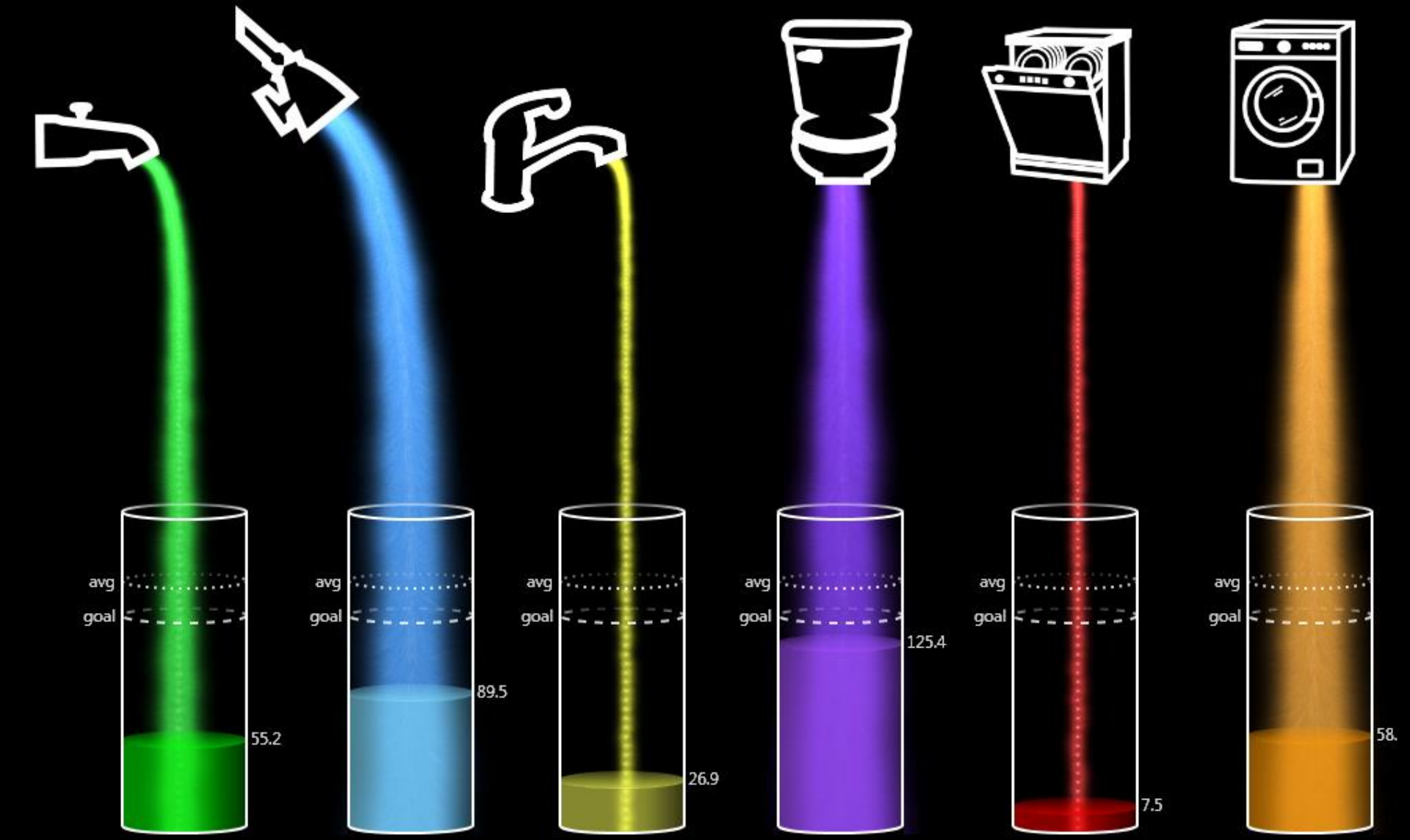
Per-Occupant



Other

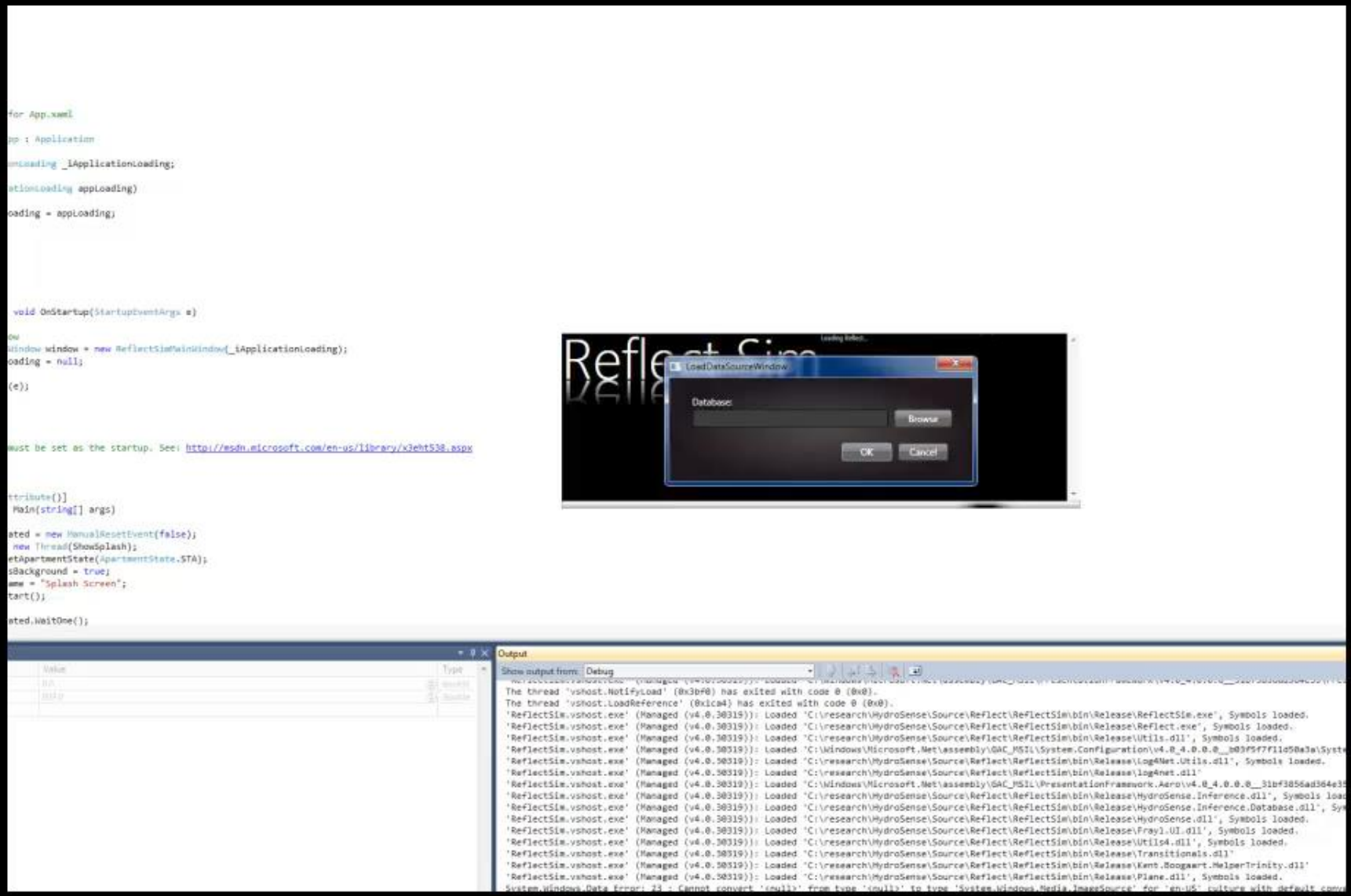
DESIGN SET 2: DESIGN PROBES

Rainflow View



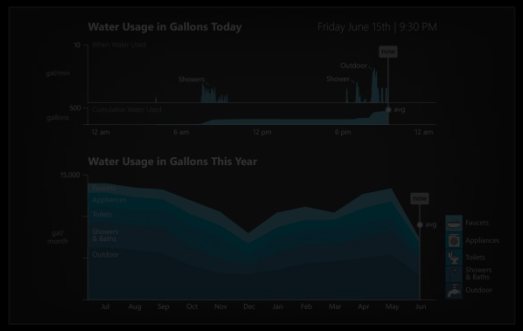
DESIGN SET 2: DESIGN PROBES

Rainflow View Movie



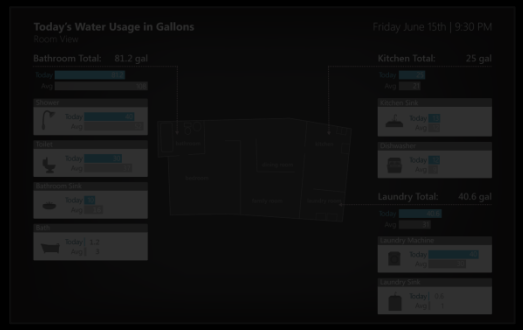
DESIGN SET 2: DESIGN PROBES

Design Probes Explored

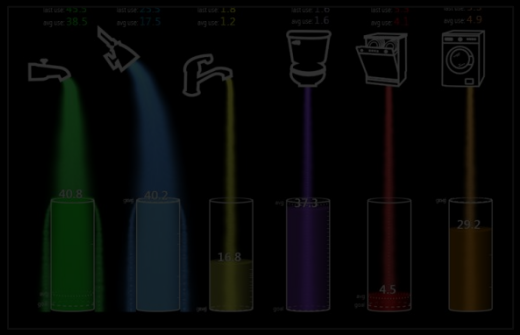


Time-Series

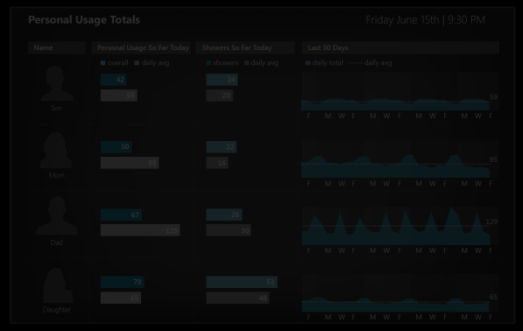
Aquatic Eco-system



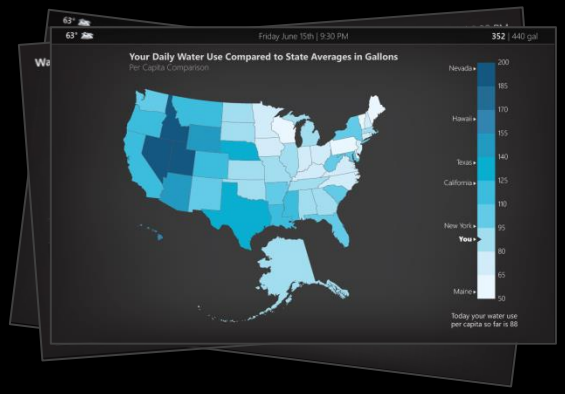
Spatial



Rainflow



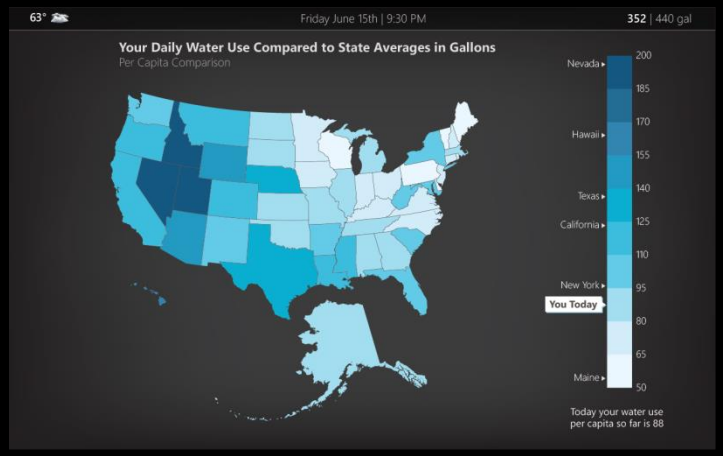
Per-Occupant



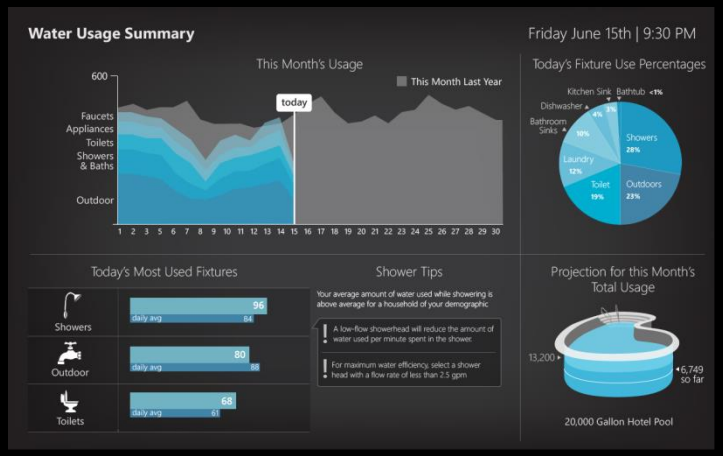
Other

DESIGN SET 2: DESIGN PROBES

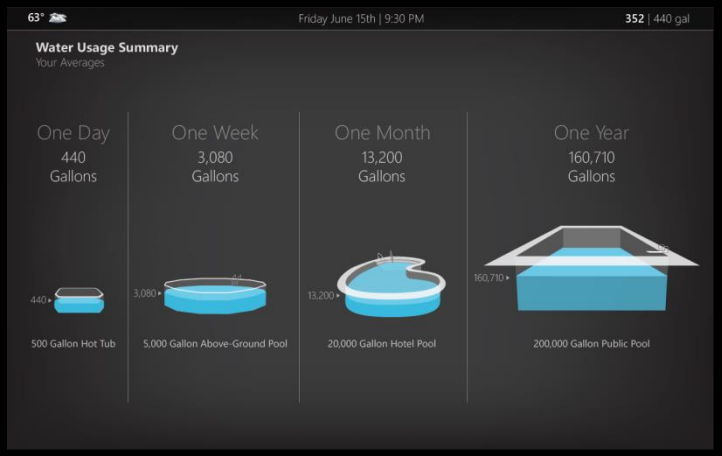
Other Design Probes



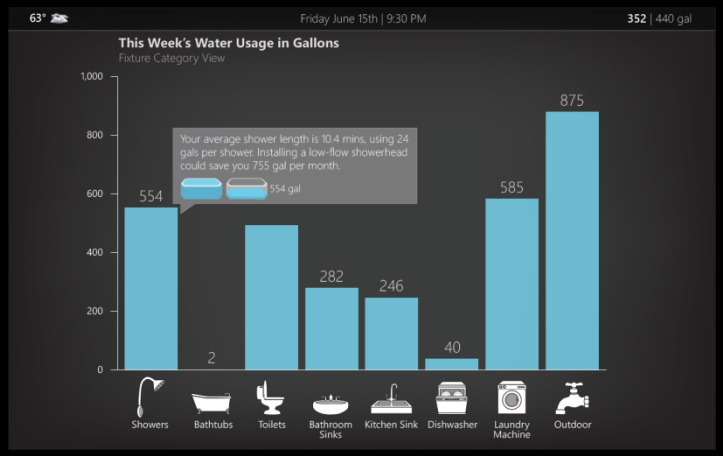
Geographic Comparisons



Dashboards



Metaphorical Unit Designs



Recommendations

Findings

Measurement Unit

71% of respondents preferred to see both gallons and cost

> Seeing the gallon amount triggers the 'save the environment' impulse to conserve, while the dollar amount is helpful because almost everyone is motivated by money to some extent

R143

> I don't think very well in 'thousands of gallons', but $20 I can understand. That's a case of beer down the drain, if you will

R48


Comparisons were the most
uniformly desired pieces of
information of all the dimensions

Self-comparison was most preferred

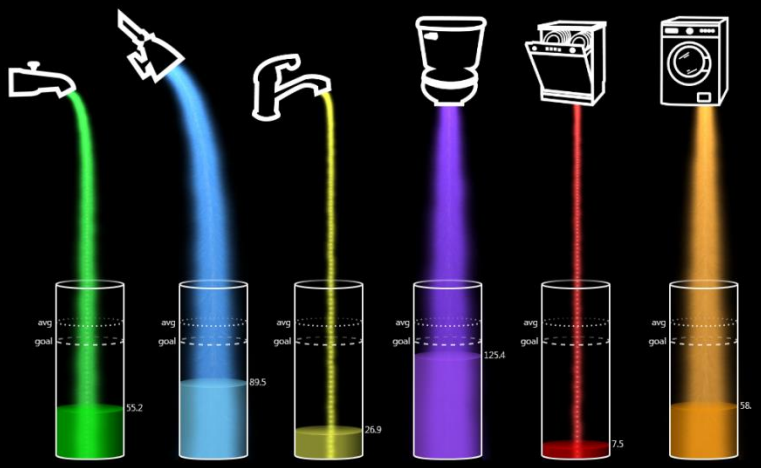
91%

compared with goal-based and social-comparisons

Emergent Themes

1. **Competition** and Cooperation
2. **Accountability** and Blame
3. **Playfulness** and Functionality
4. Sense of **Privacy**
5. **Display** Placement

Playfulness and Functionality



"I like the idea of getting rewards for saving water"

I8.2

"It's like unlocking badges in Foursquare. No matter how trivial it can be to make a fish appear on this screen, you still want to do it"

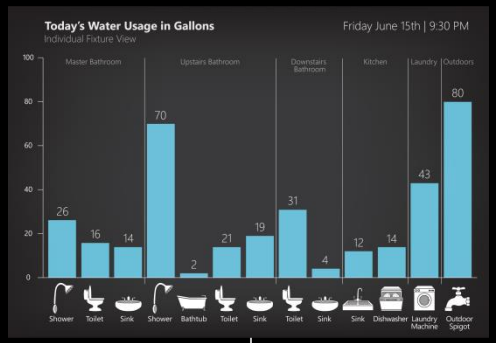
I4.1

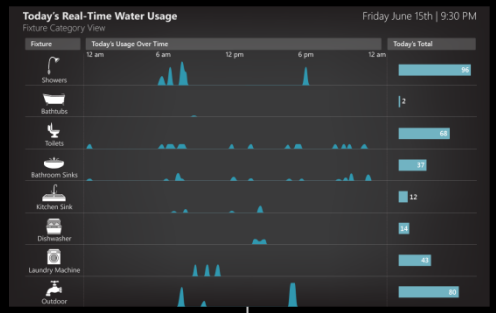
"It doesn't appeal to me as much. I don't do Foursquare. This distracts me a little bit and it doesn't make me think about my usage"

I4.2

Useful as an educational tool?

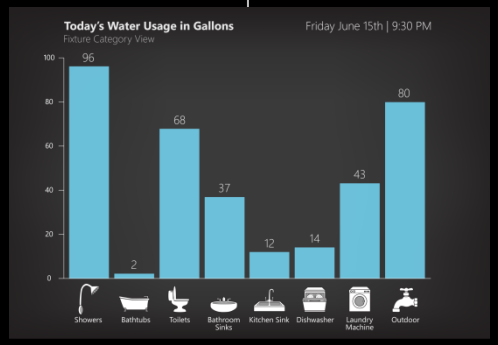
Privacy Spectrum

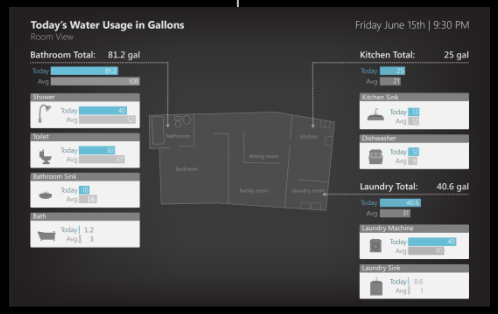




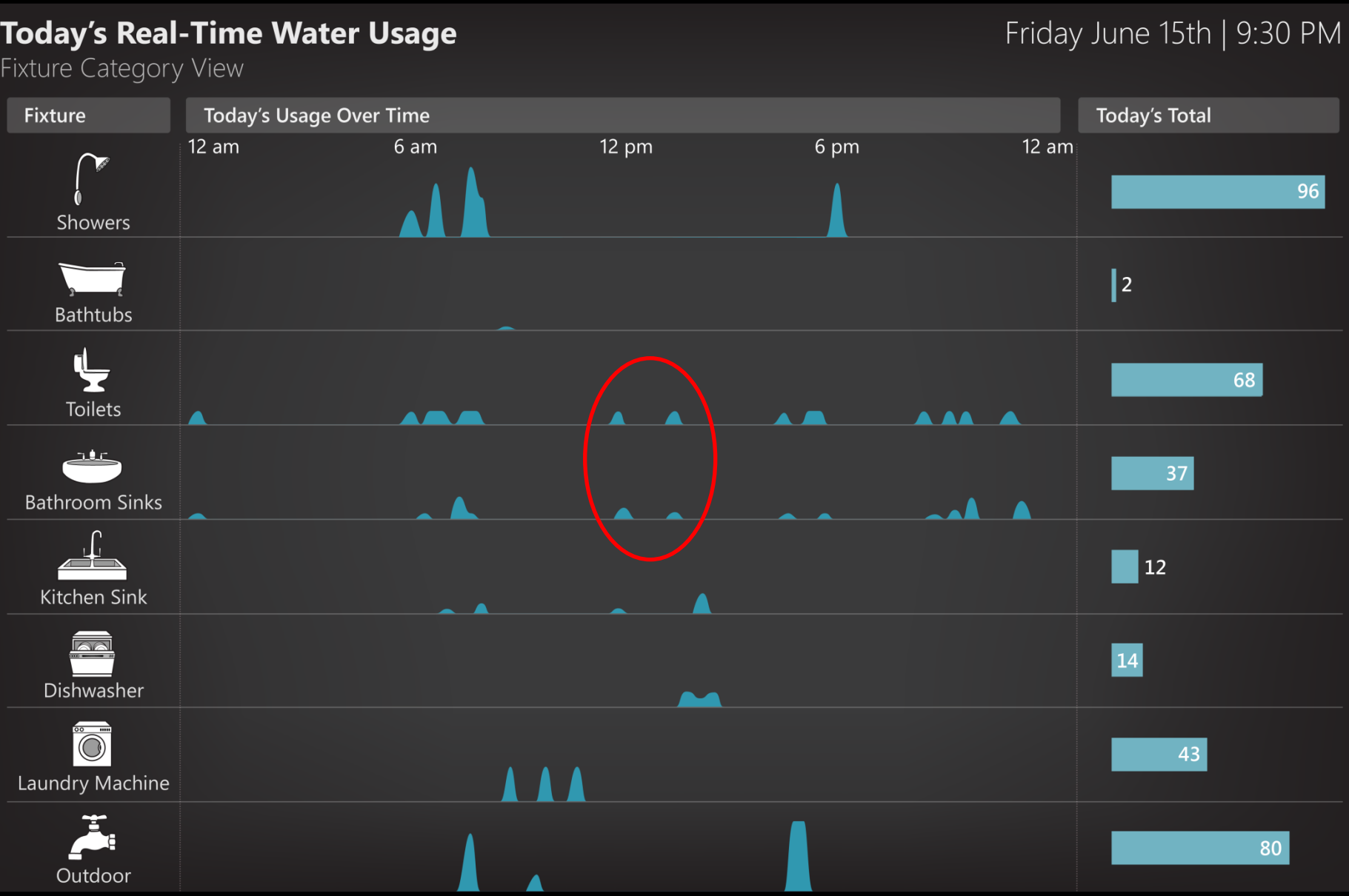
Least Invasive

Most Invasive

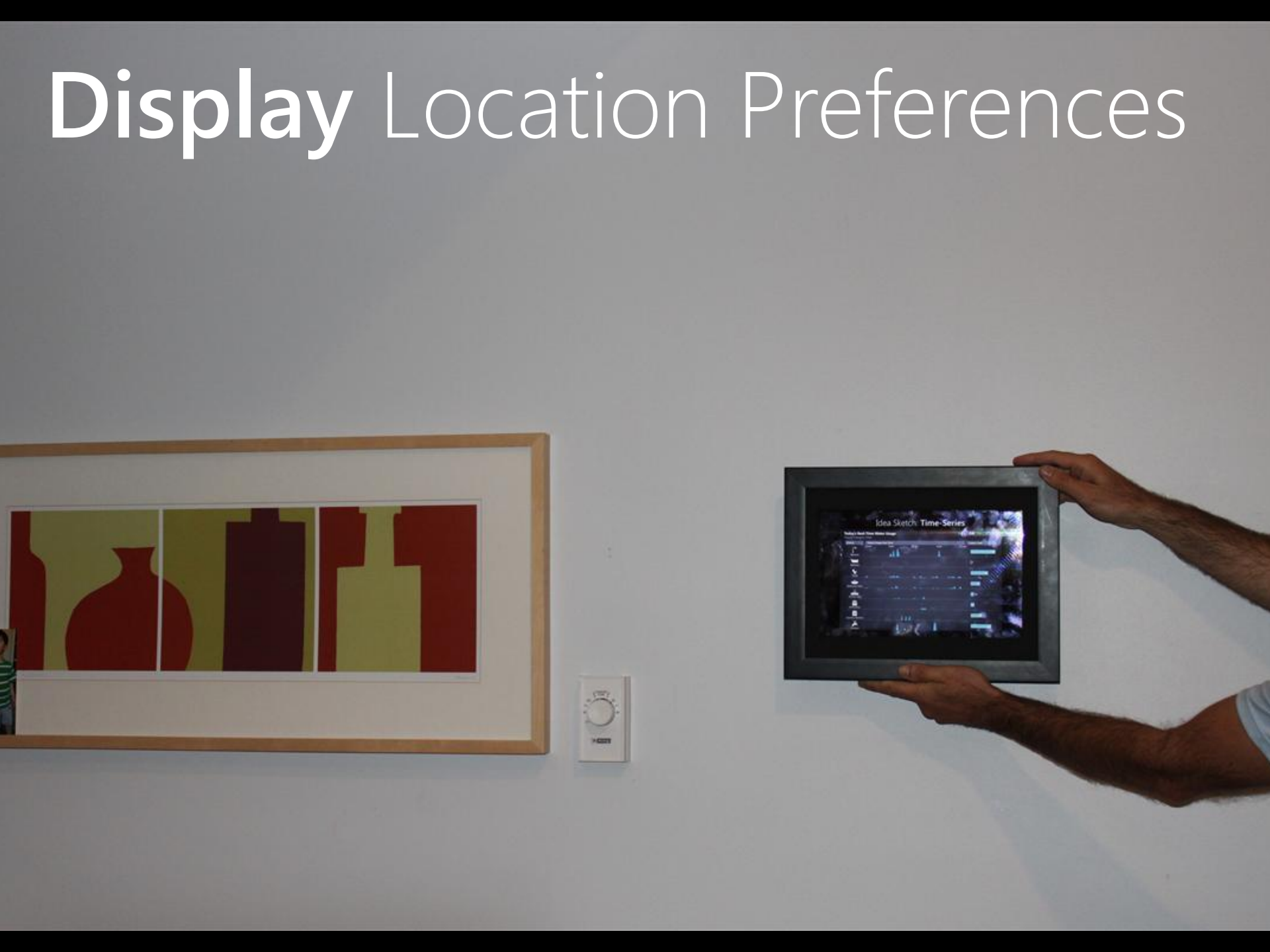




Revealing Activity



Display Location Preferences



“If we placed the display here, the kids couldn’t see it.”

I2.1

Display Location Preferences

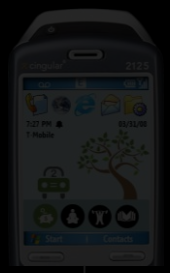
kitchen

near thermostat

high traffic areas

accessible when needed

ubigreen

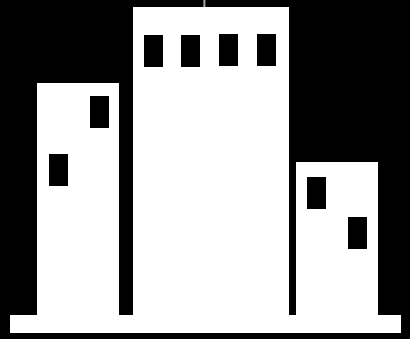


reflect$_2$O

smartcities

individual

household



city

earth

scale


GOOD FOR ONE FARE


扉にご注意！
かけこみは おやめください

“The social sciences can finally have access to masses of data that are of the same order of magnitude of their older sisters, the natural sciences”

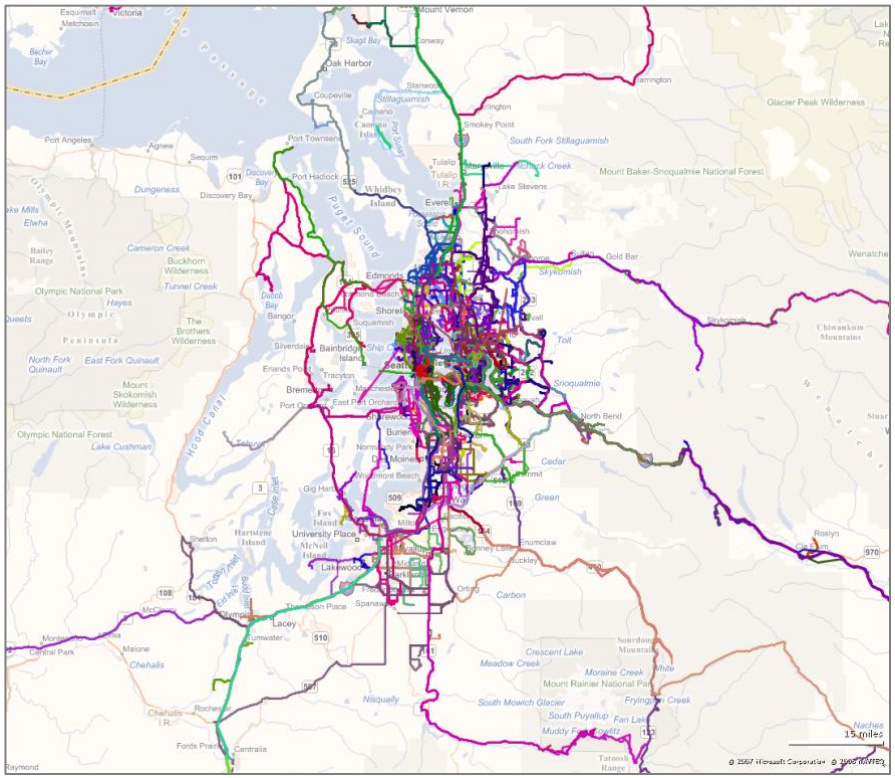
Bruno Latour, 2007
French philosopher and sociologist

Route Prediction from Trip Observations

14,468 trips / 240 subjects

Description	Average	Median
trip distance (miles)	7.7	4.2
trip time (min)	16.3	11.5
num trips / day	4	3.9
num trips / subject	60.3	50
num days of data / subject	15.1	13

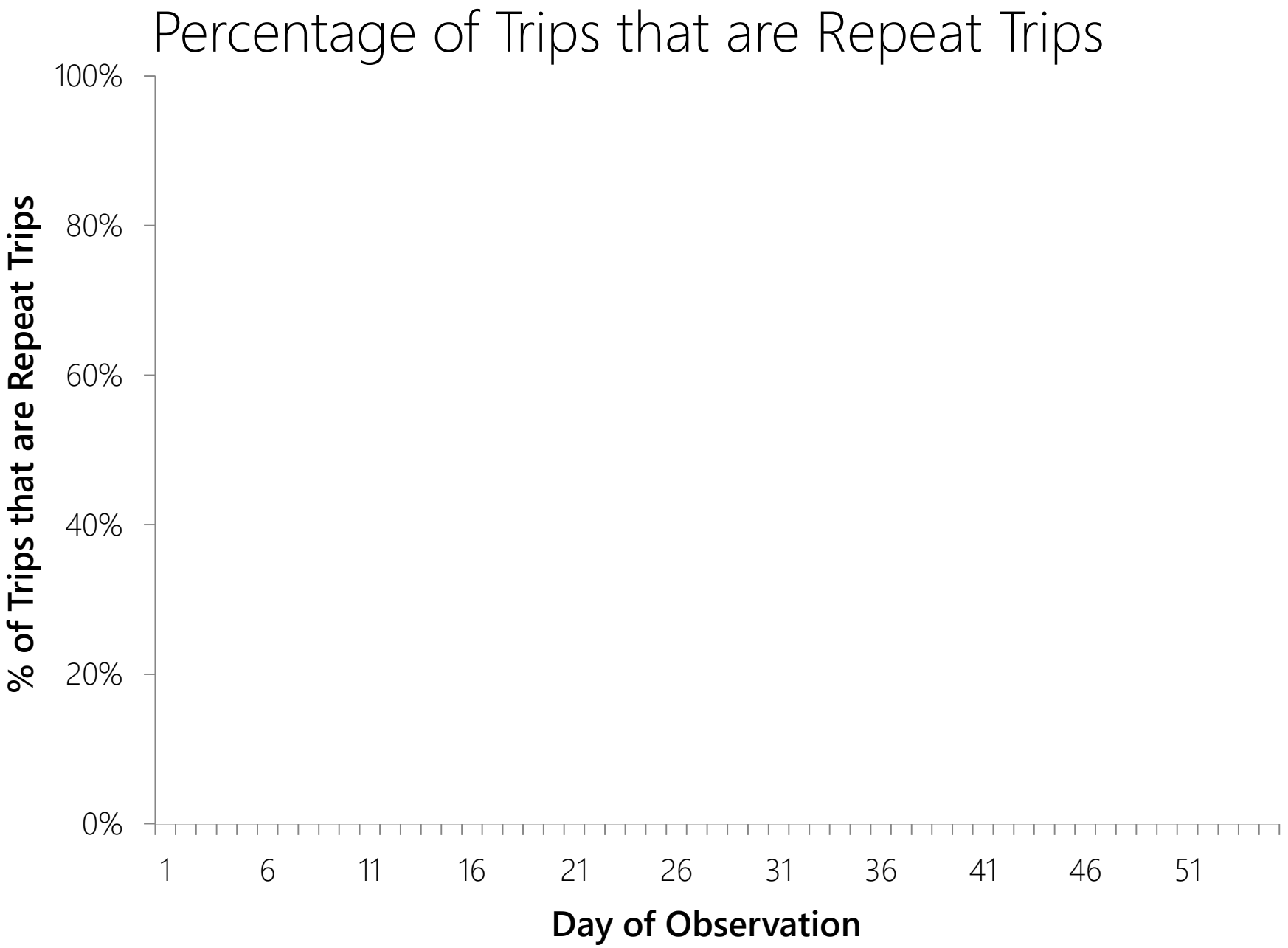
High Level Trip Stats

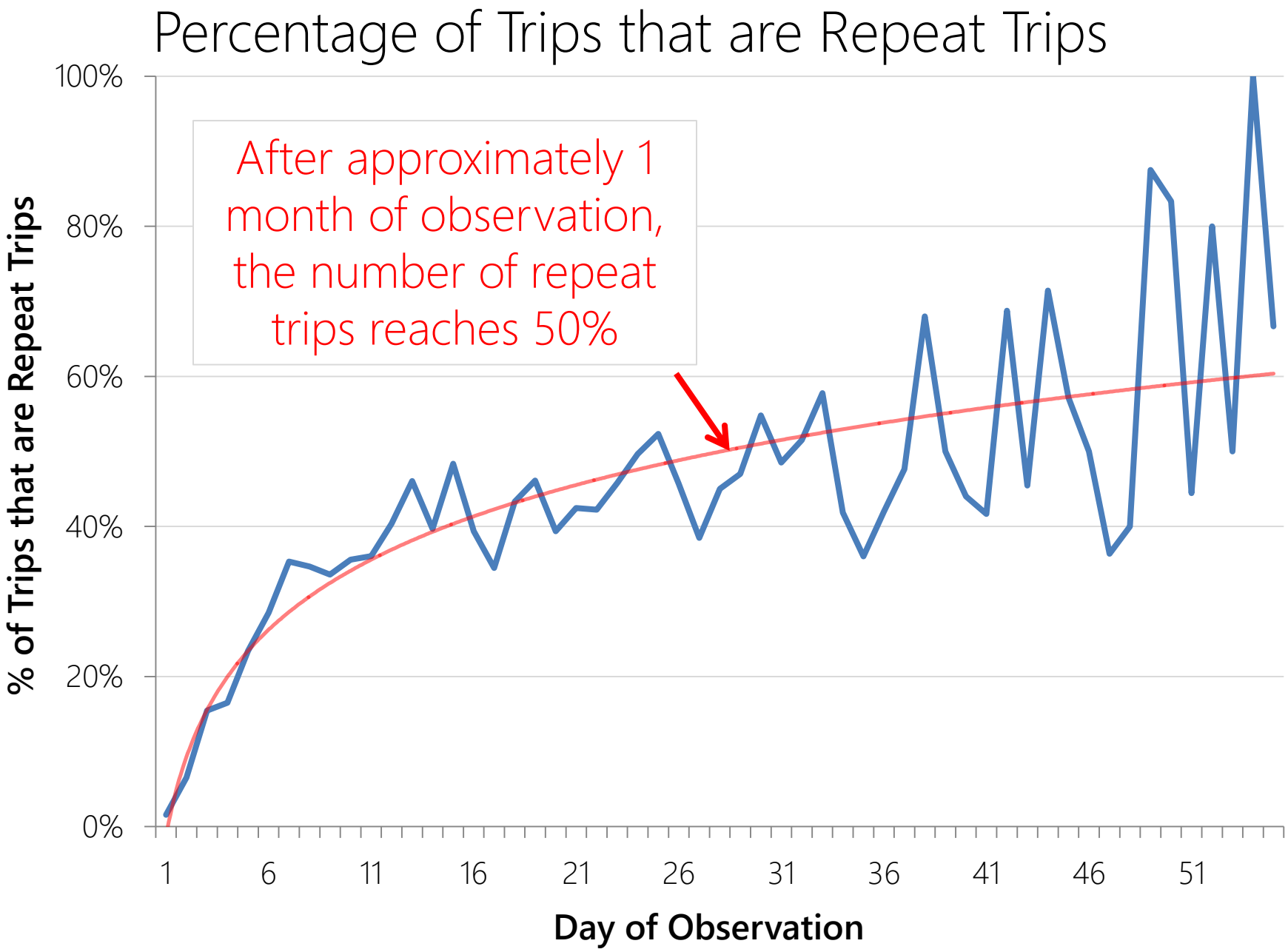


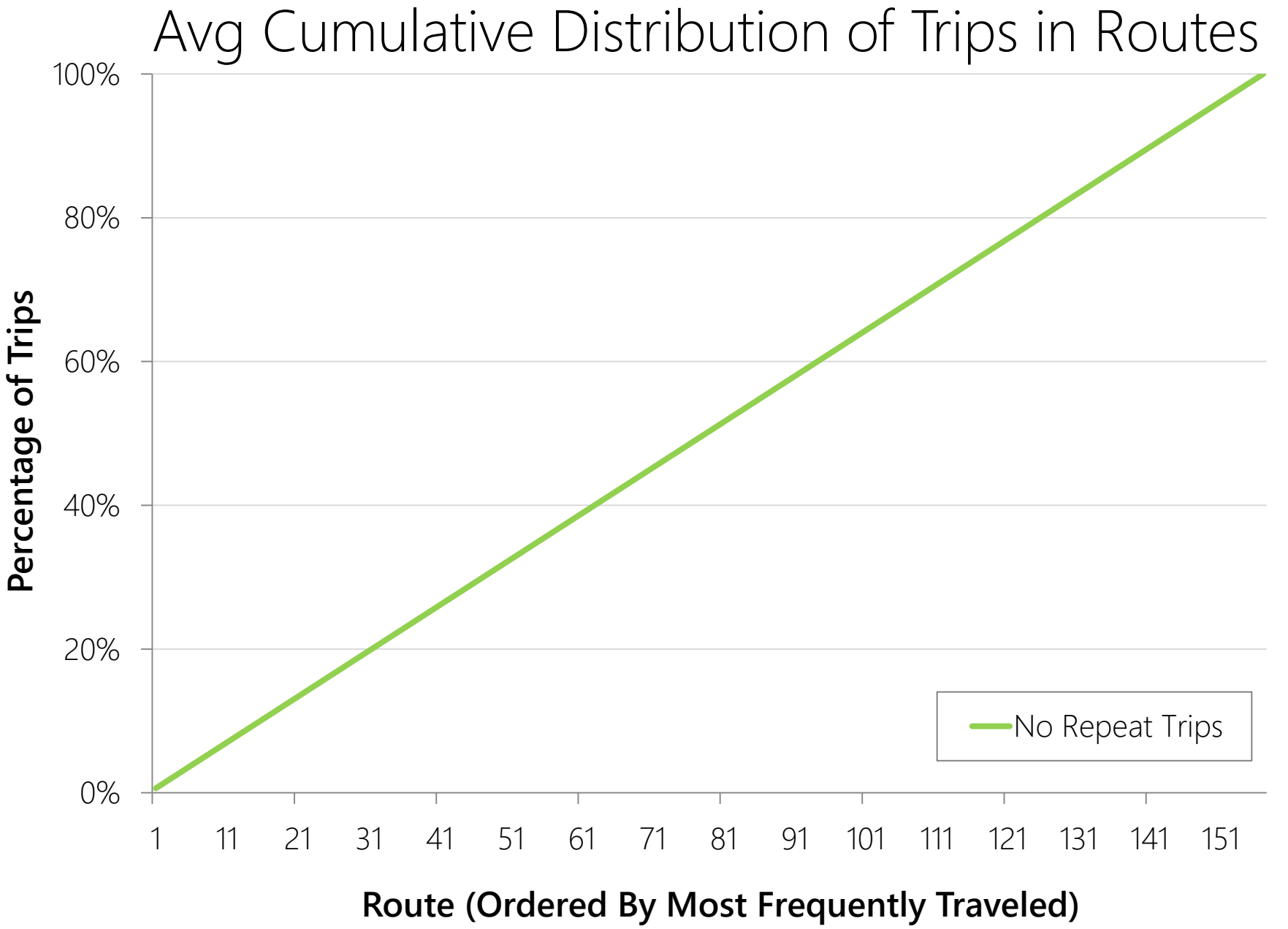
Greater Seattle Area

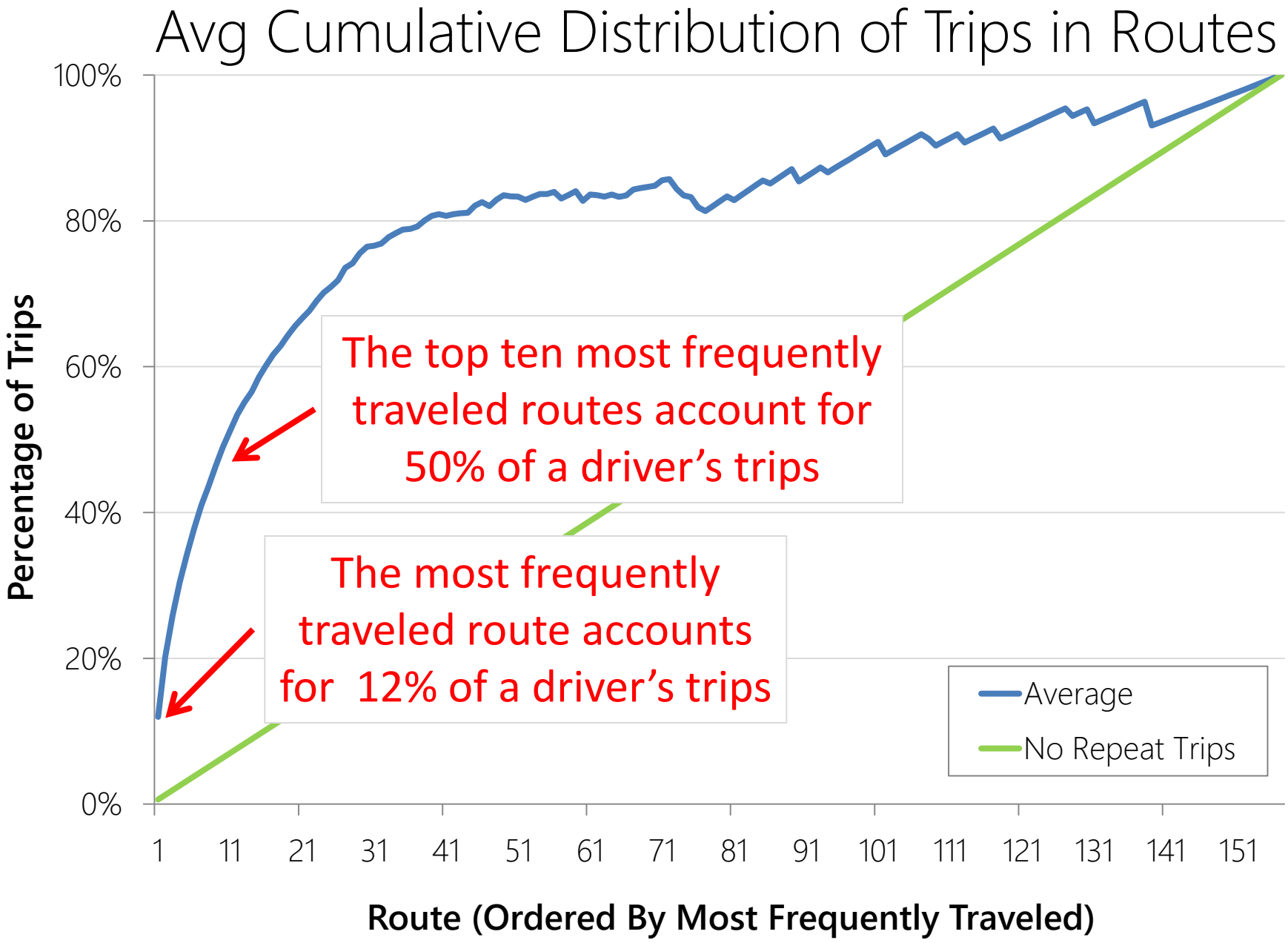
[Froehlich & Krumm, *Route Prediction From Trip Observations*, SAE 2008]

if we can predict where you're going, we can suggest more sustainable forms of transit or better optimize your route


Percentage of Trips that are Repeat Trips
100%
80%
60%
40%
20%
0%
% of Trips that are Repeat Trips
1
6
11
16
21
26
31
36
41
46
51
Day of Observation

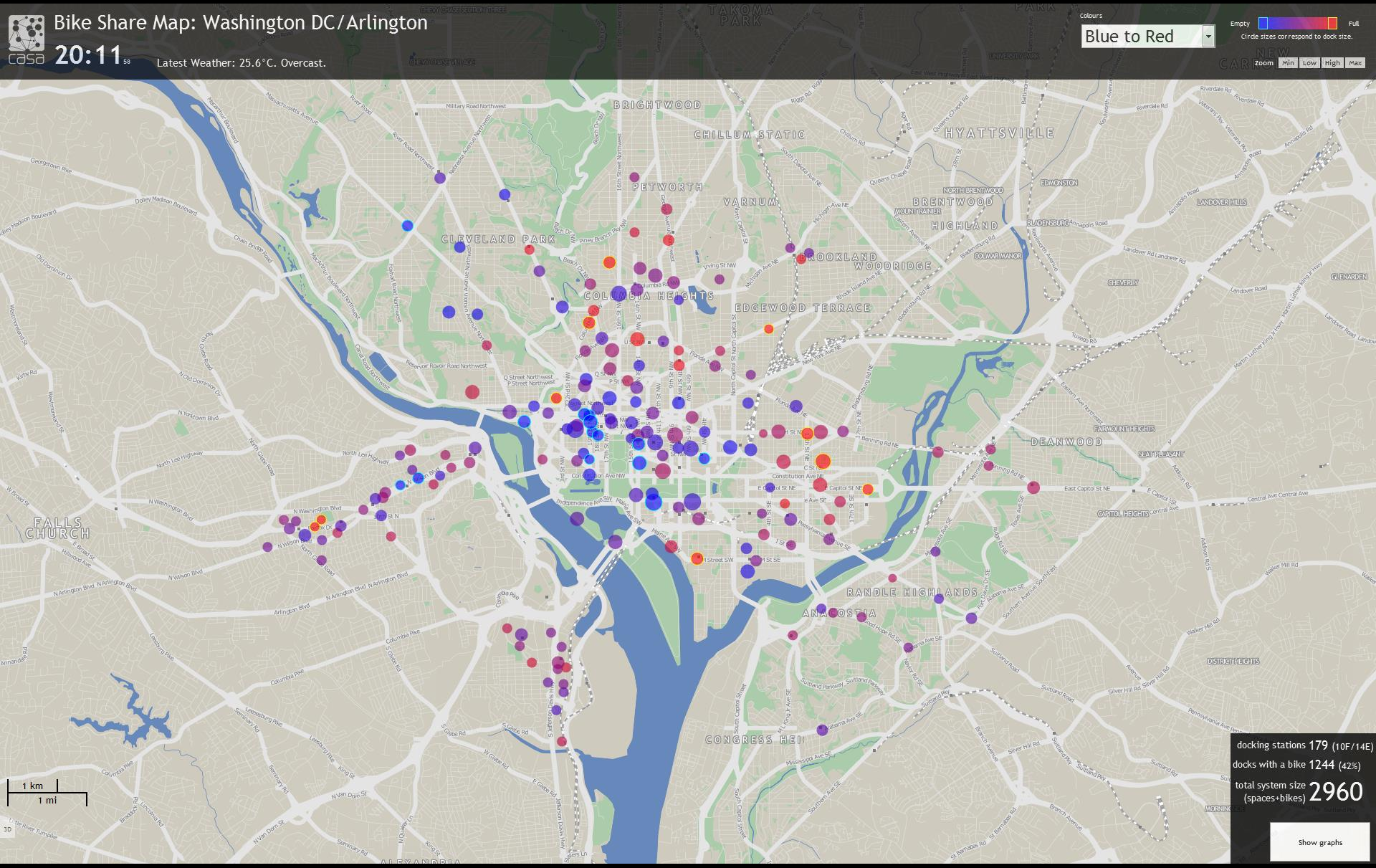

Percentage of Trips that are Repeat Trips
After approximately 1 month of observation, the number of repeat trips reaches 50%
% of Trips that are Repeat Trips
100%
80%
60%
40%
20%
0%
1
6
11
16
21
26
31
36
41
46
51
Day of Observation


Avg Cumulative Distribution of Trips in Routes
100%
80%
60%
40%
20%
0%
Percentage of Trips
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
Route (Ordered By Most Frequently Traveled)
No Repeat Trips

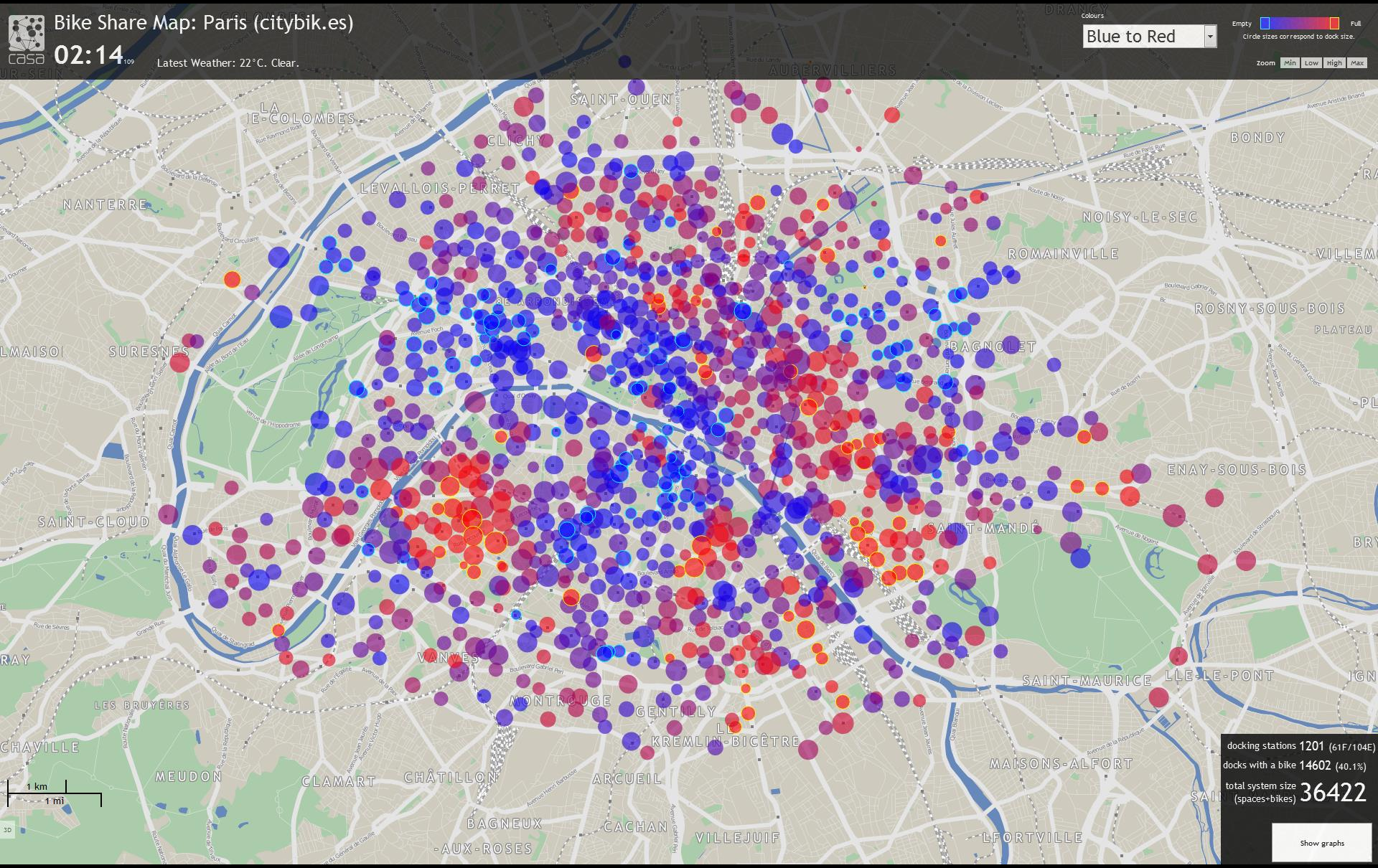

Avg Cumulative Distribution of Trips in Routes
100%
80%
60%
40%
20%
0%
Percentage of Trips
The top ten most frequently traveled routes account for 50% of a driver's trips
The most frequently traveled route accounts for 12% of a driver's trips
Average
No Repeat Trips
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
Route (Ordered By Most Frequently Traveled)

sensing and predicting the movement of a city via shared bicycling

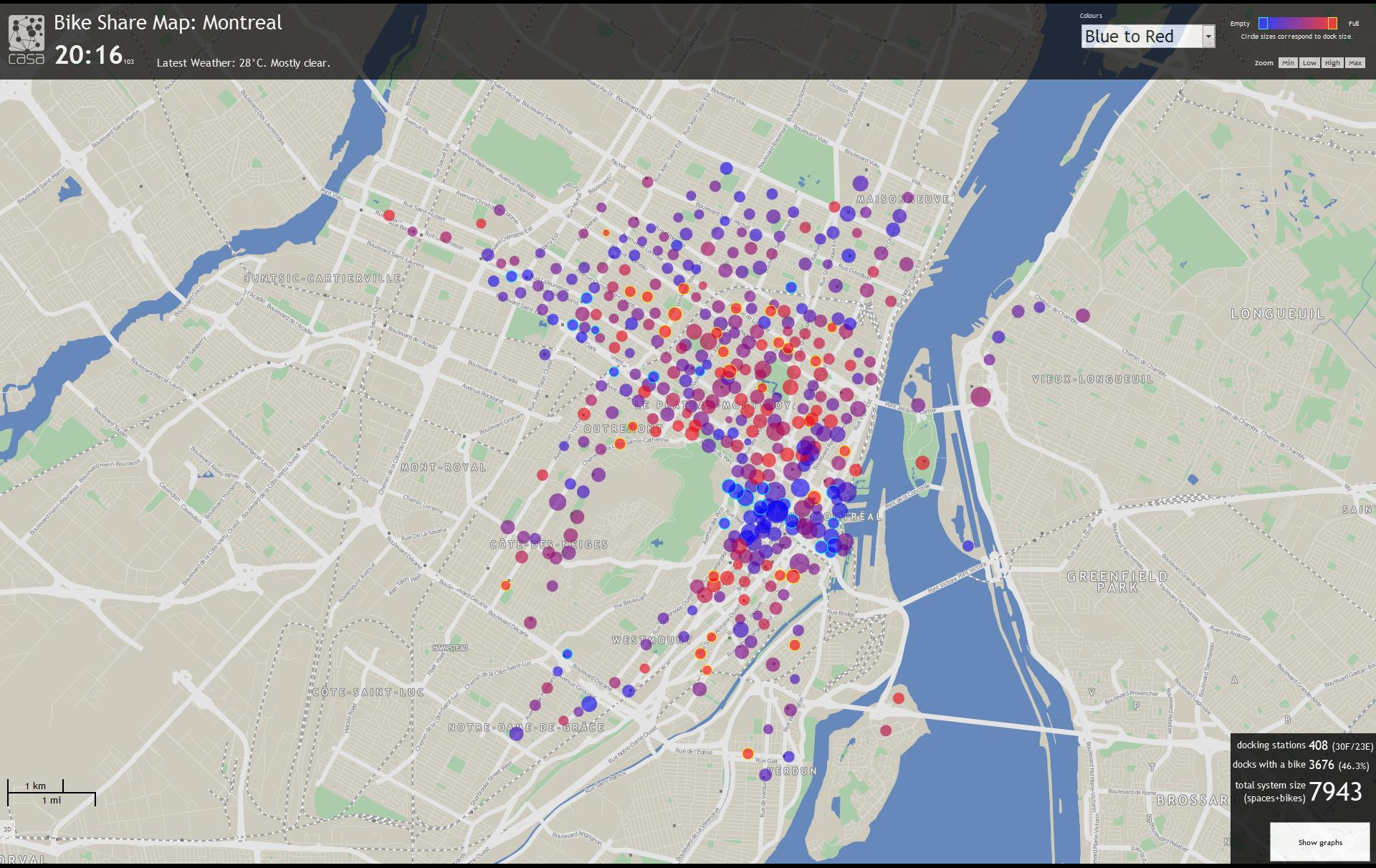
[Froehlich et al., UrbanSense2008; IJCAI2009]



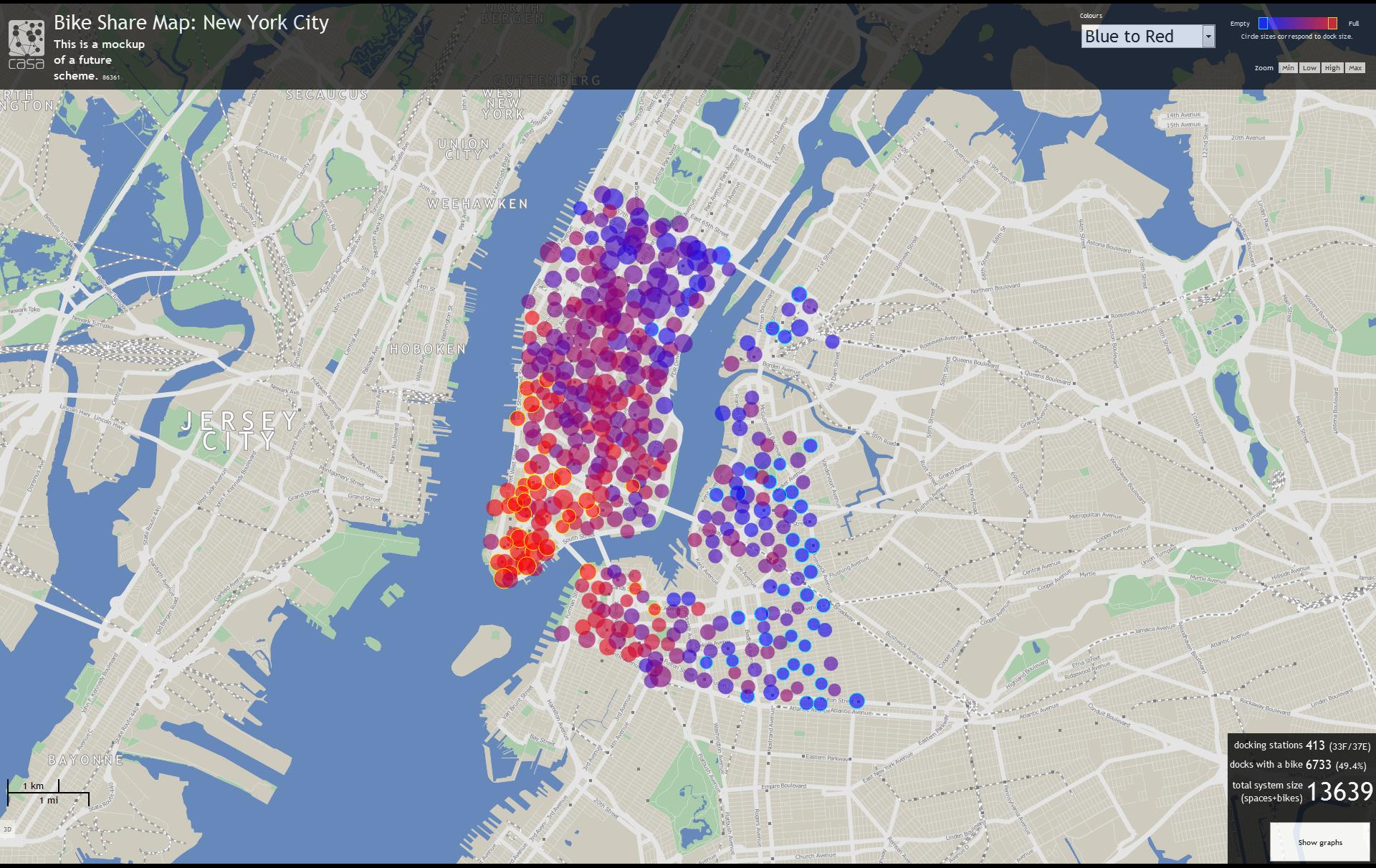
[Oliver O'Brien, http://bikes.oobrien.com/washingtondc/]



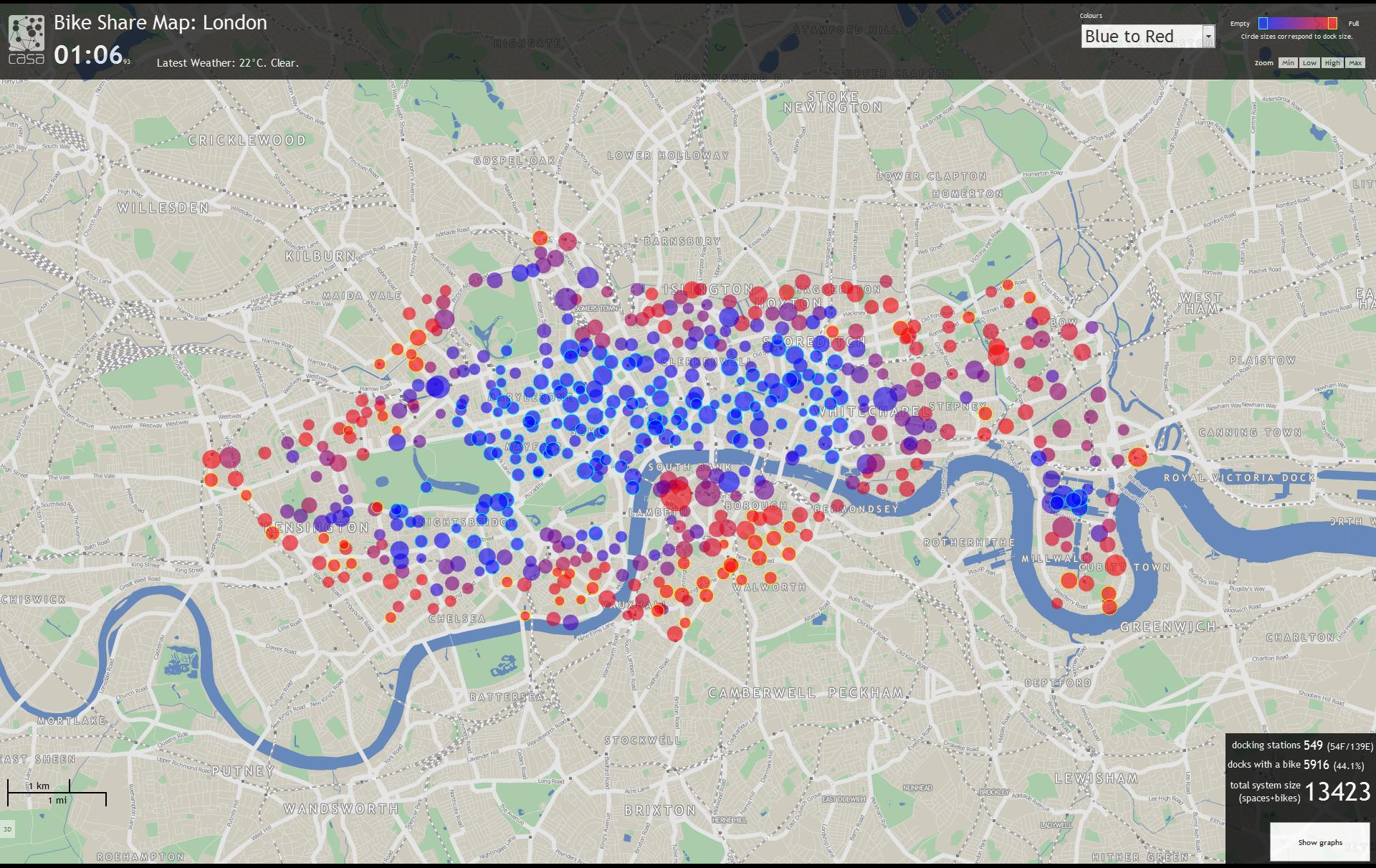
[Oliver O'Brien, http://bikes.oobrien.com/paris]



[Oliver O'Brien, http://bikes.oobrien.com/montreal]

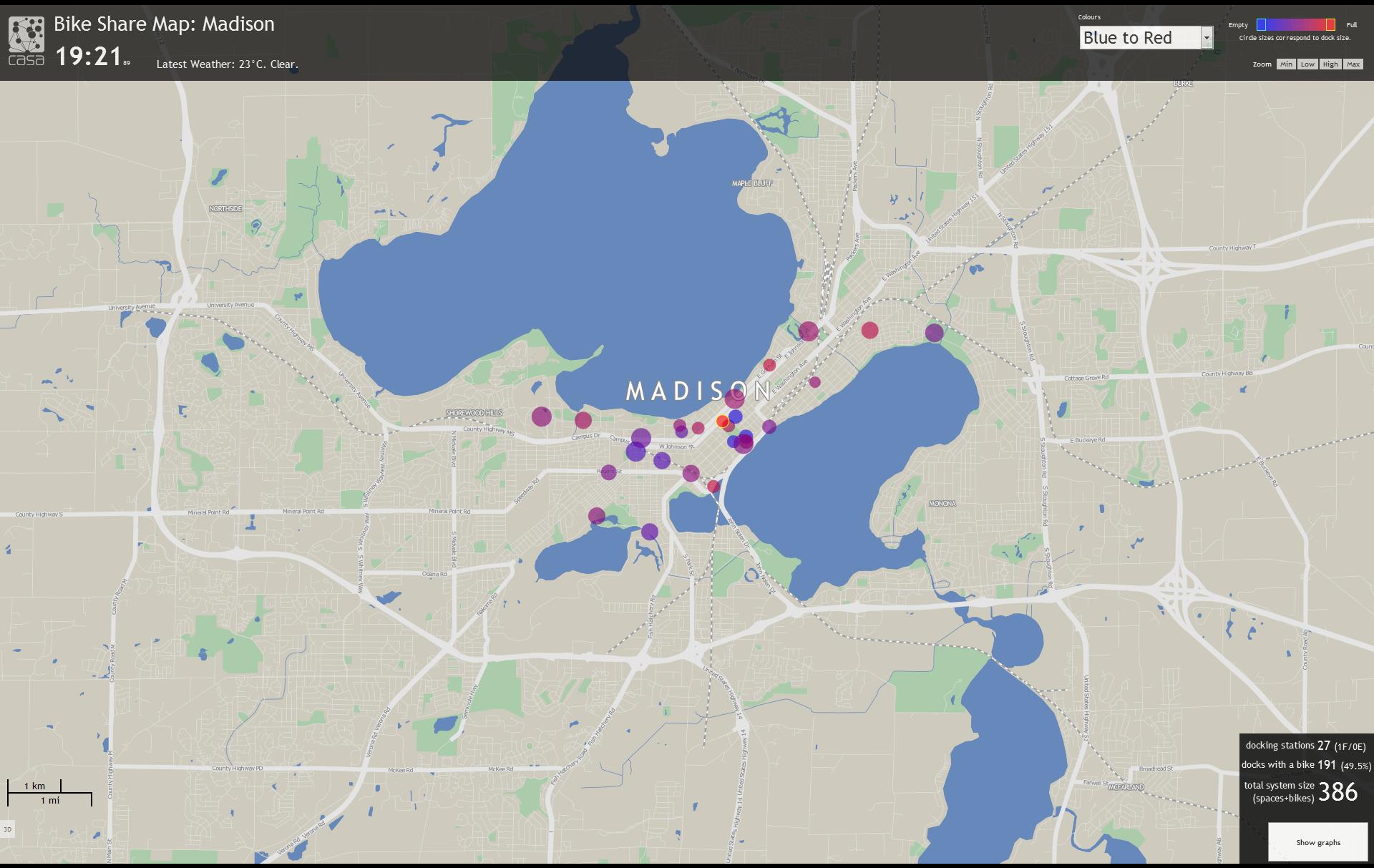


[Oliver O'Brien, http://bikes.oobrien.com/newyork/]

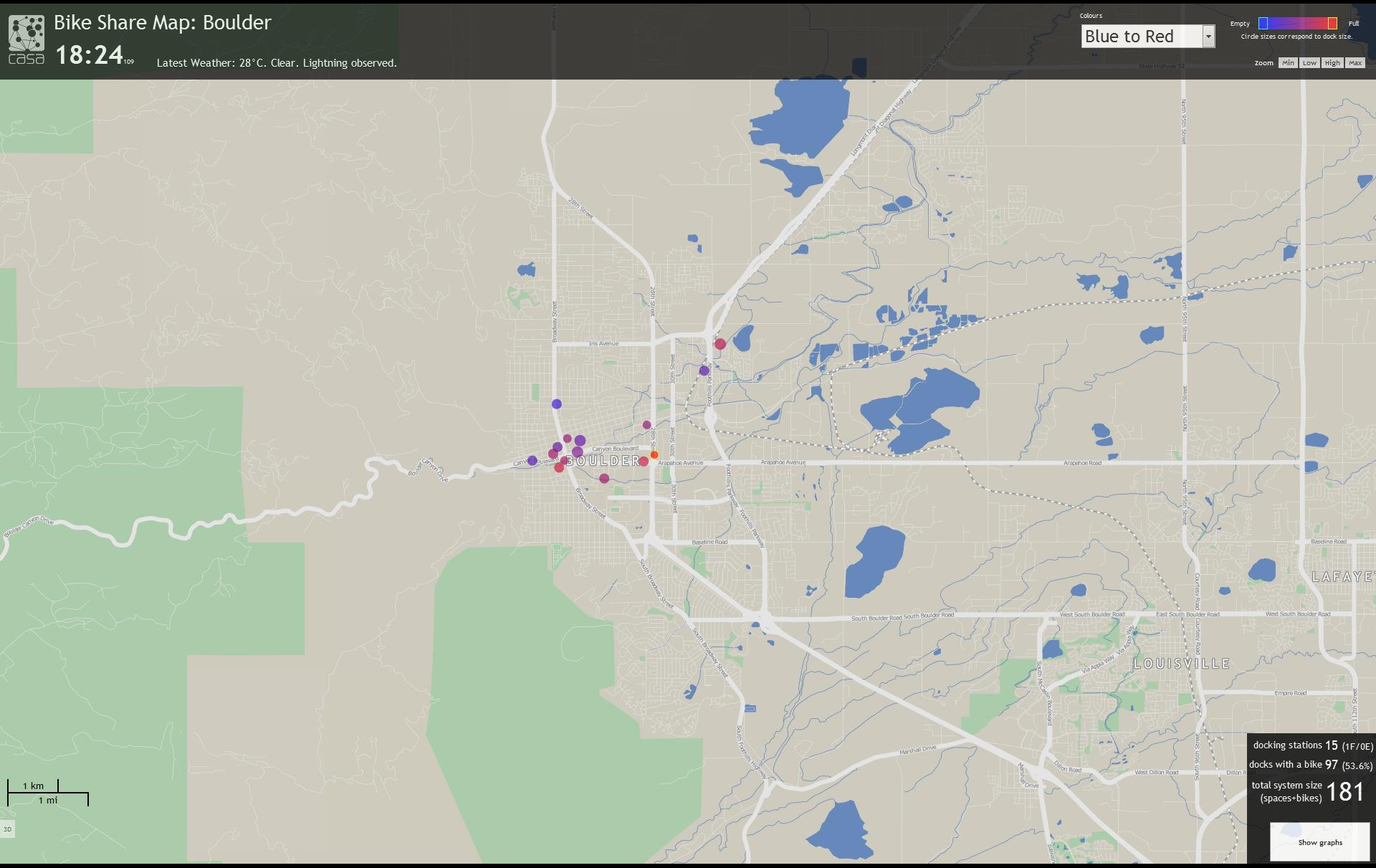


[Oliver O'Brien, http://bikes.oobrien.com/london]


LONDON
2012



[Oliver O'Brien, http://bikes.oobrien.com/madison]



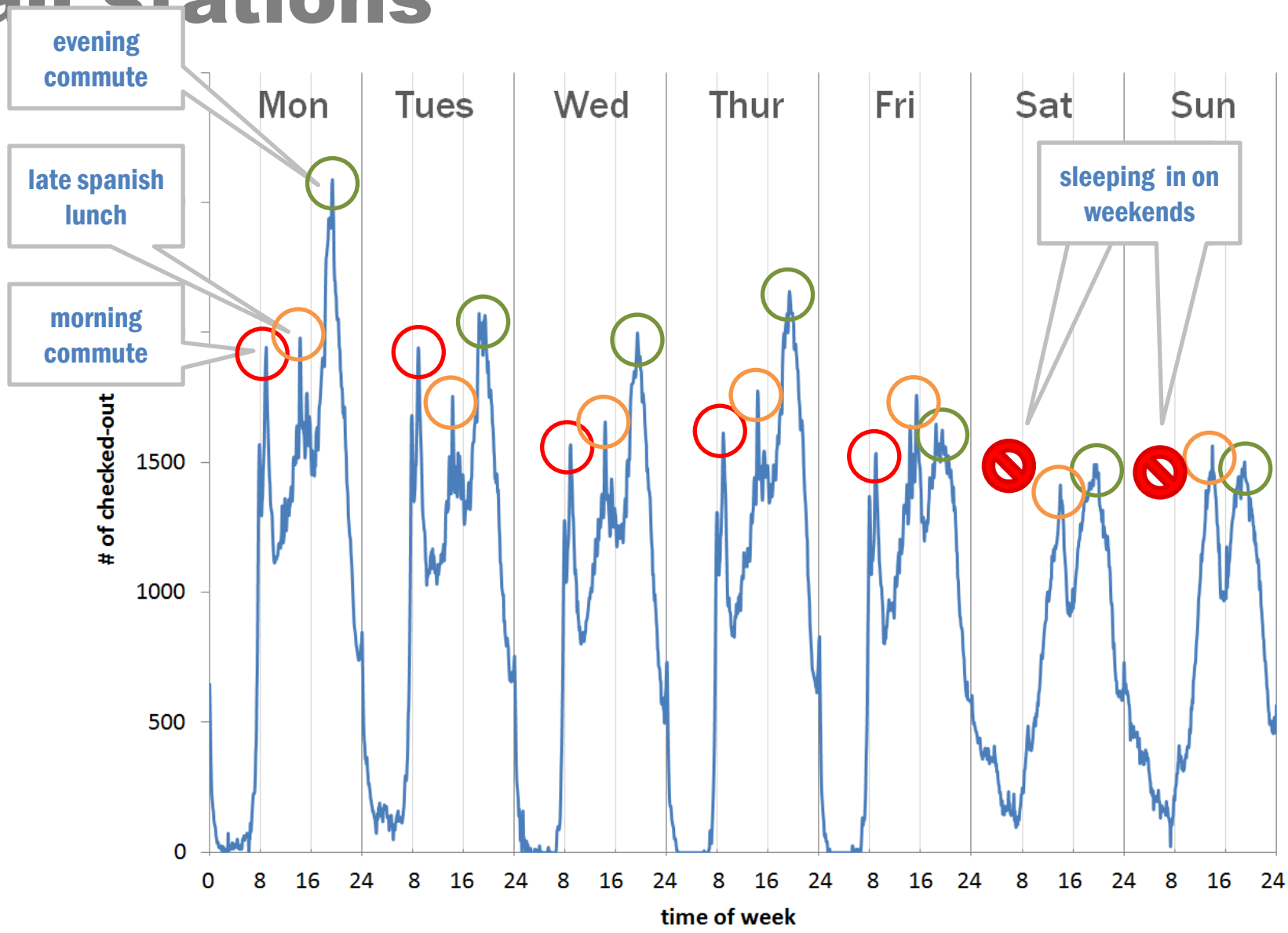
[Oliver O'Brien, http://bikes.oobrien.com/boulder]

bicing

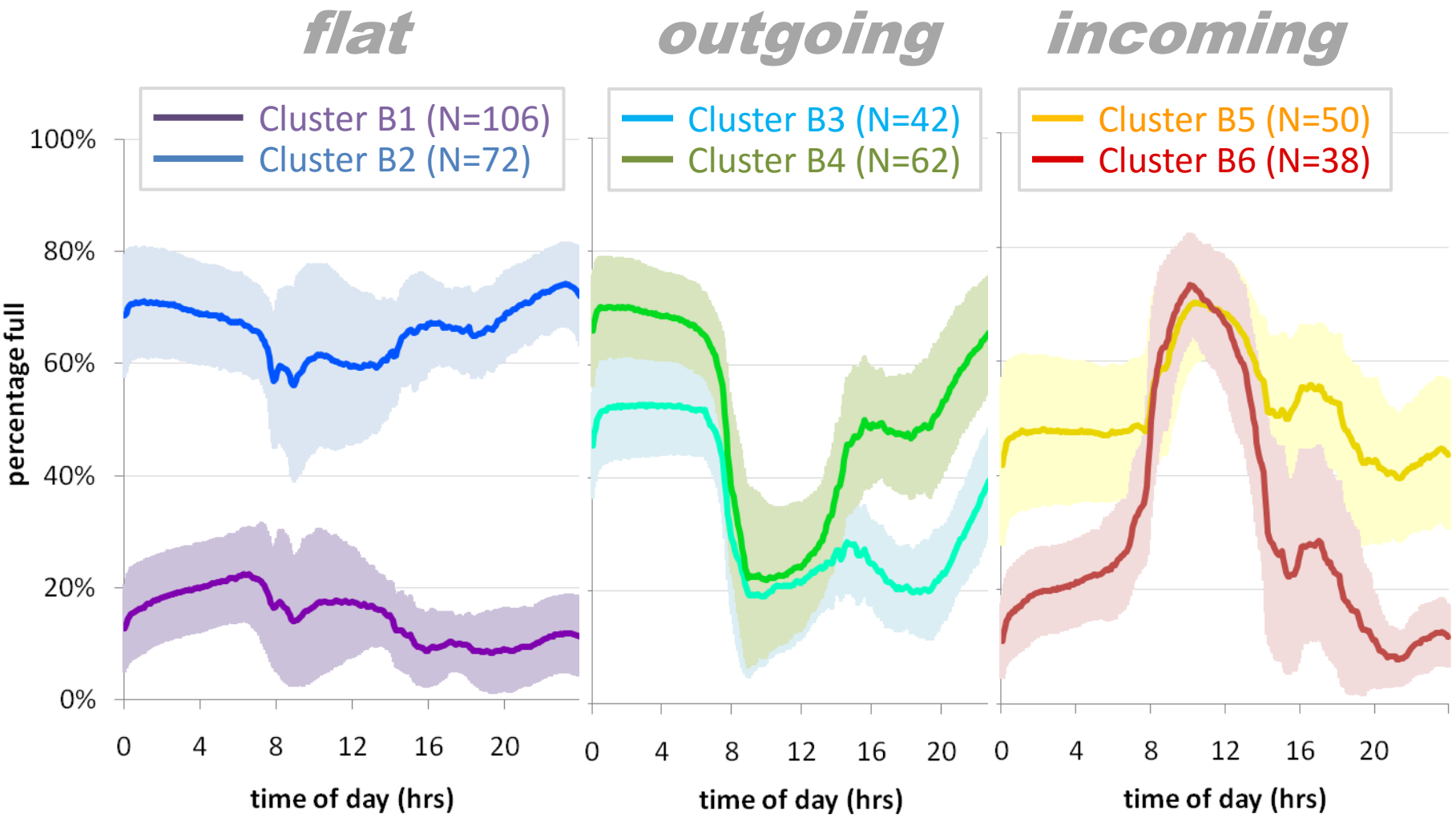
barcelona, spain

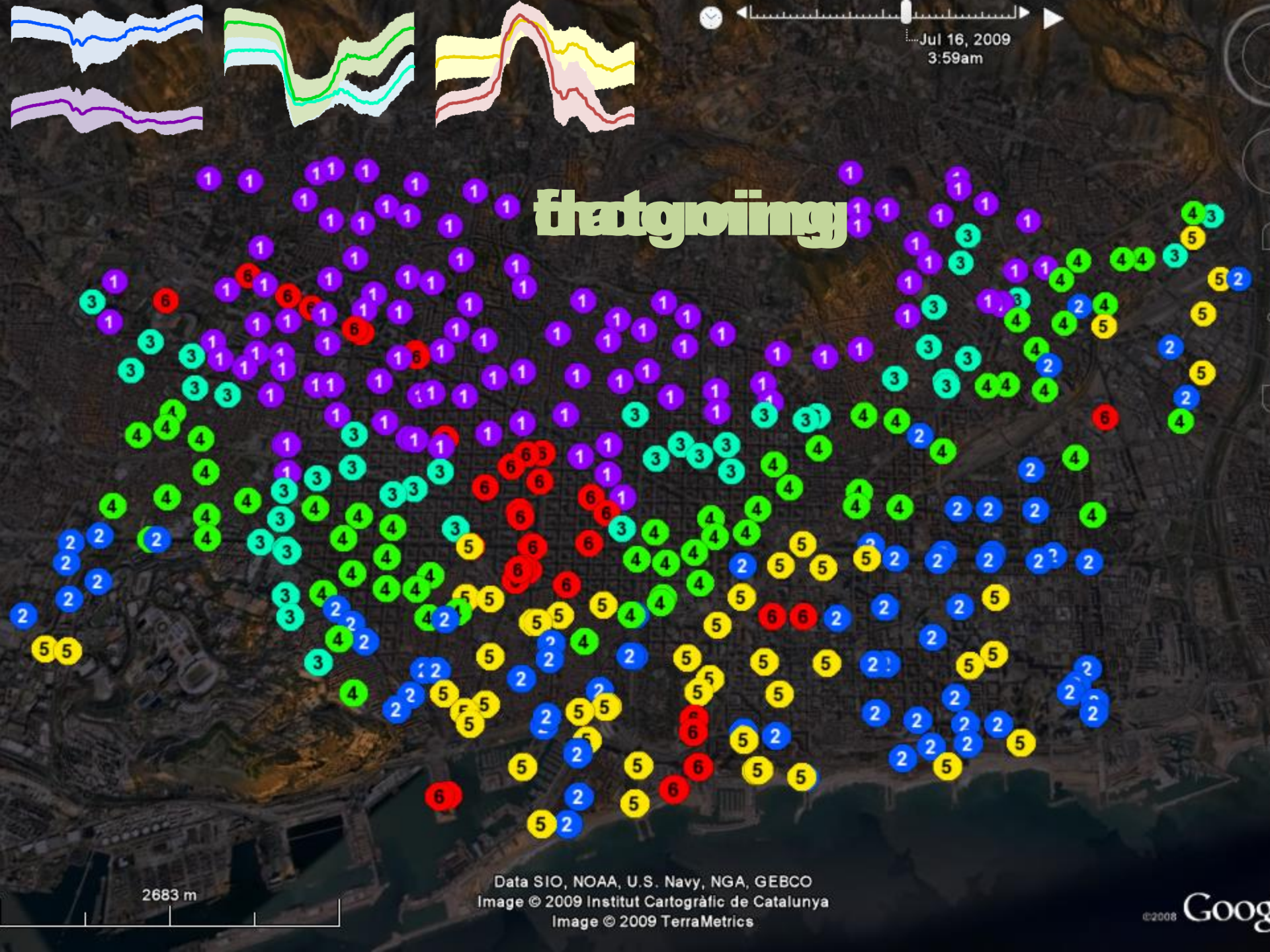
Summer 2008:
- 373 stations
- 6,000 bicycles
- 150,000 subscribers

num checked-out bicycles across all stations

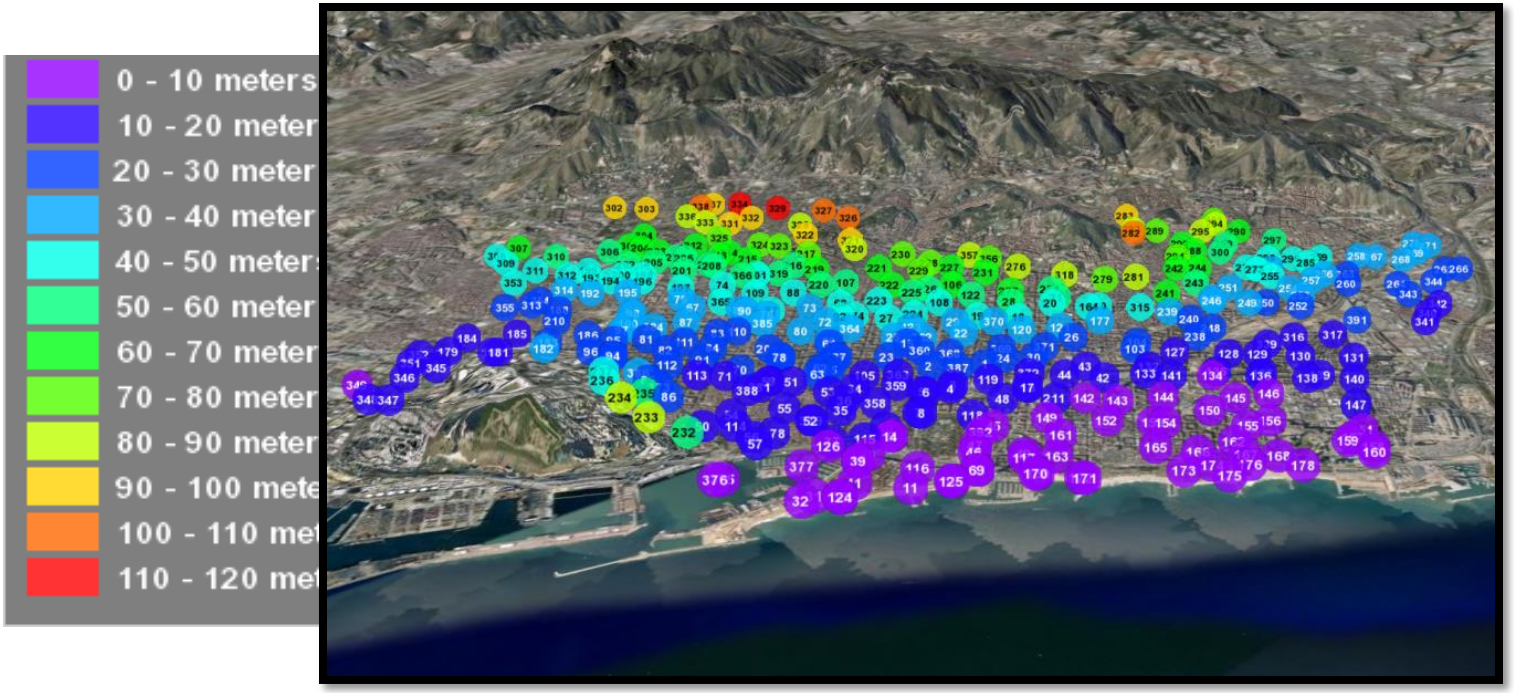


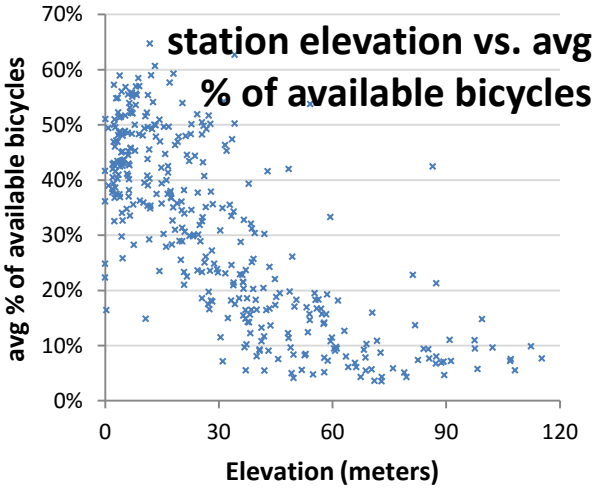
available bicycle clusters

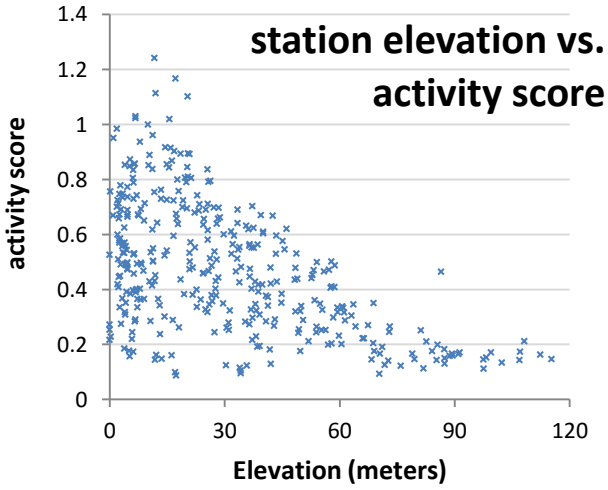



Jul 16, 2009
3:59am
2683 m
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 Institut Cartogràfic de Catalunya
Image © 2009 TerraMetrics
©2008 Google

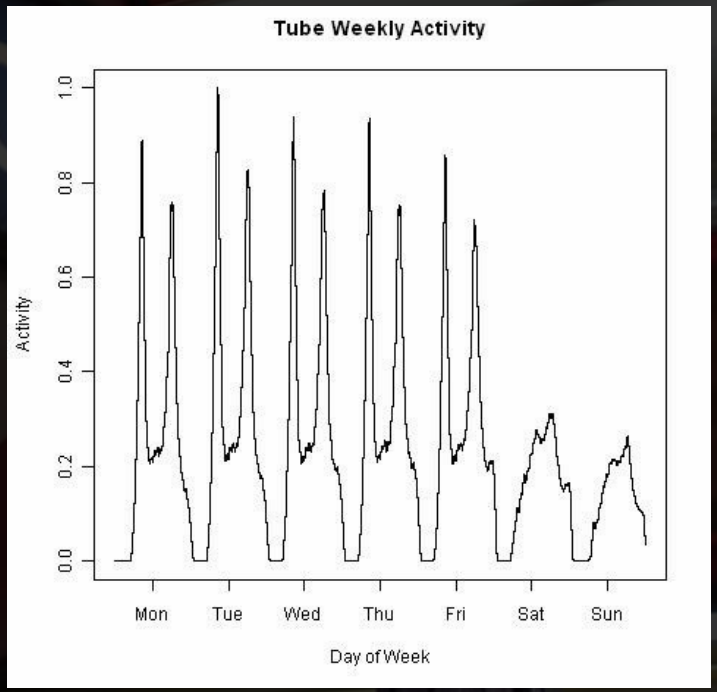
biases of human behavior



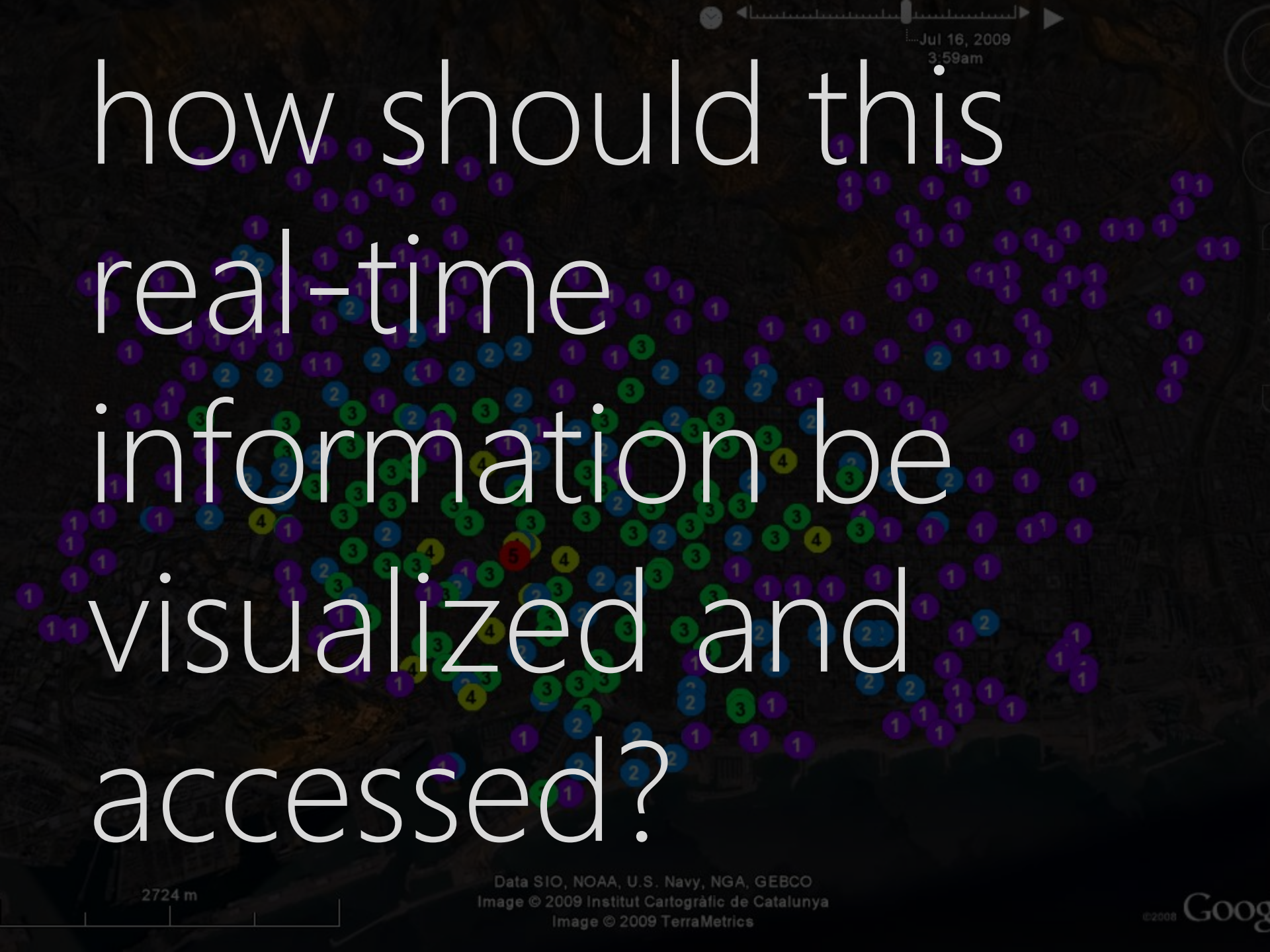




what can we learn if we combine data from other sources?



[Lathia, Froehlich & Capra, ICDM2010]

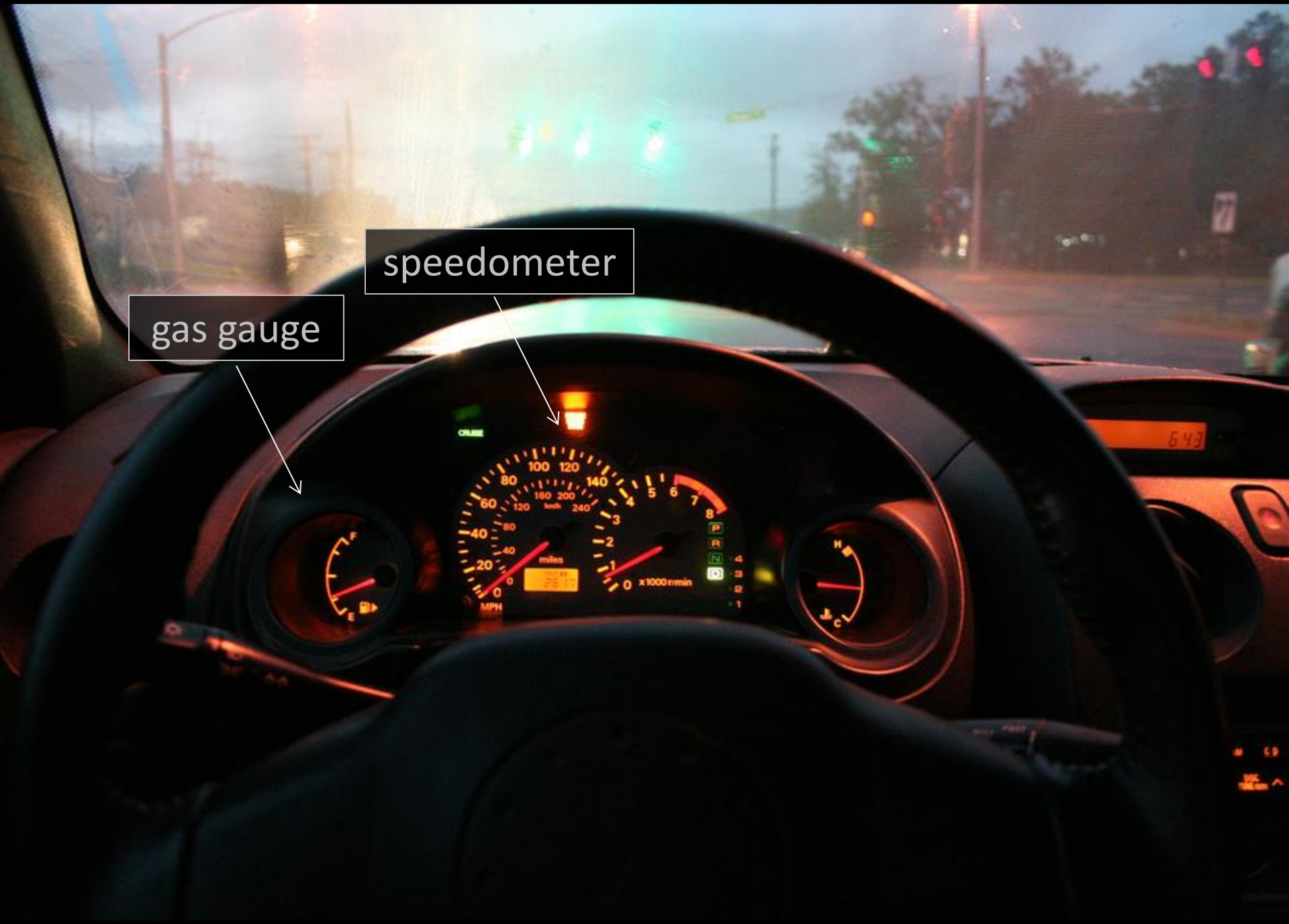


how should this real-time information be visualized and accessed?

can we use this data to automatically detect events in the city?

In Closing


Generation 1
commodore
commodore
1541


speedometer
gas gauge


CRUISE
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become a better
you
sensing
feedback

BEHAVIOR, ENERGY & CLIMATE CHANGE CONFERENCE

A conference focused on understanding the behavior and decision-making of individuals and organizations and on using that knowledge to accelerate our transition to an energy-efficient and low-carbon economy.

ciee California Institute for Energy and Environment

Precourt Energy Efficiency Center STANFORD UNIVERSITY

ACEEE American Council for an Energy-Efficient Economy

BECC 2012 | November 12 - November 14, 2012 | Sacramento, CA

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ACTIONS

- Conference Registration
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- Submit Abstract
- Watch BECC Talks
- Scholarship
- LinkedIn Group

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Save the date! The conference regularly sells out so be sure to register now for BECC 2012: **Monday, November 12 - Wednesday, November 14, 2012 at the Hyatt Regency Hotel in Sacramento, CA.** There will also be pre-conference workshops and a kick-off dessert and networking reception on Sunday, November 11th.

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Applying Iterative Design to the Eco-Feedback Design Process

BECC 2012 will build on the overwhelming success of previous BECC conferences, at which 700 participants discussed innovative policy and program strategies, shared important research findings, and engaged in building dynamic new networks and collaborations.

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RT @nwalliance: RT @aolenergy: Smart Meters Make Customers Smarter: t.co/eztAE6oD (Great infographic in the article.)
Time ago 118 Days via Twitter

Great article on community-based social marketing #CBSM

http://beccconference.org/

research publications

smartcities

Sensing and Predicting the Pulse of the City through Shared Bicycling
Jon Froehlich, Joachim Neumann, Nuria Oliver, *Proceedings of IJCAI2010*

Measuring the Pulse of the City through Shared Bicycle Programs
Jon Froehlich, Joachim Neumann, Nuria Oliver, *Proceedings of UrbanSense 2008*

Mining Public Transport Usage for Personalised Intelligent Transport Systems
Neal Lathia, Jon Froehlich, Licia Capra, *Proceedings of ICDM 2010*

ubigreen

UbiGreen: Investigating a Mobile Tool for Tracking and Supporting Green Transportation Habits
Jon Froehlich, Tawanna Dillahunt, Predrag Klasnja, Jennifer Mankoff, Sunny Consolvo, Beverly Harrison, James A. Landay, *Proceedings of CHI 2009*

hydrosense

HydroSense: Infrastructure-Mediated Single-Point Sensing of Whole-Home Water Activity
Jon Froehlich, Eric Larson, Tim Campbell, Conor Haggerty, James Fogarty, Shwetak N. Patel, *Proceedings of Ubicomp 2009*

Disaggregated Water Sensing From a Single, Pressure-Based Sensor: An Extended Analysis of HydroSense Using Staged Experiments
Eric Larson, Jon Froehlich, Tim Campbell, Conor Haggerty, Les Atlas, James Fogarty, Shwetak N. Patel, *Journal of Pervasive and Mobile Computing (PMC) 2010*

A Longitudinal Study of Pressure Sensing to Infer Real-World Water Usage Events in the Home
Jon Froehlich, Eric Larson, Elliot Saba, Tim Campbell, Les Atlas, James Fogarty, Shwetak Patel, *Proceedings of Pervasive 2011*

reflect$_2$O

The Design and Evaluation of Prototype Eco-Feedback Displays for Fixture-Level Water Usage Data
Jon Froehlich, Leah Findlater, Marilyn Ostergren, Solai Ramanathan, Josh Peterson, Inness Wragg, Eric Larson, Fabia Fu, Mazhengmin Bai, Shwetak Patel, James Landay, *Proceedings of CHI 2012*

Sensing and Feedback of Everyday Activities to Promote Environmental Behaviors
Jon Froehlich, *University of Washington Doctoral Dissertation 2011*

Thank You!

@jonfroehlich

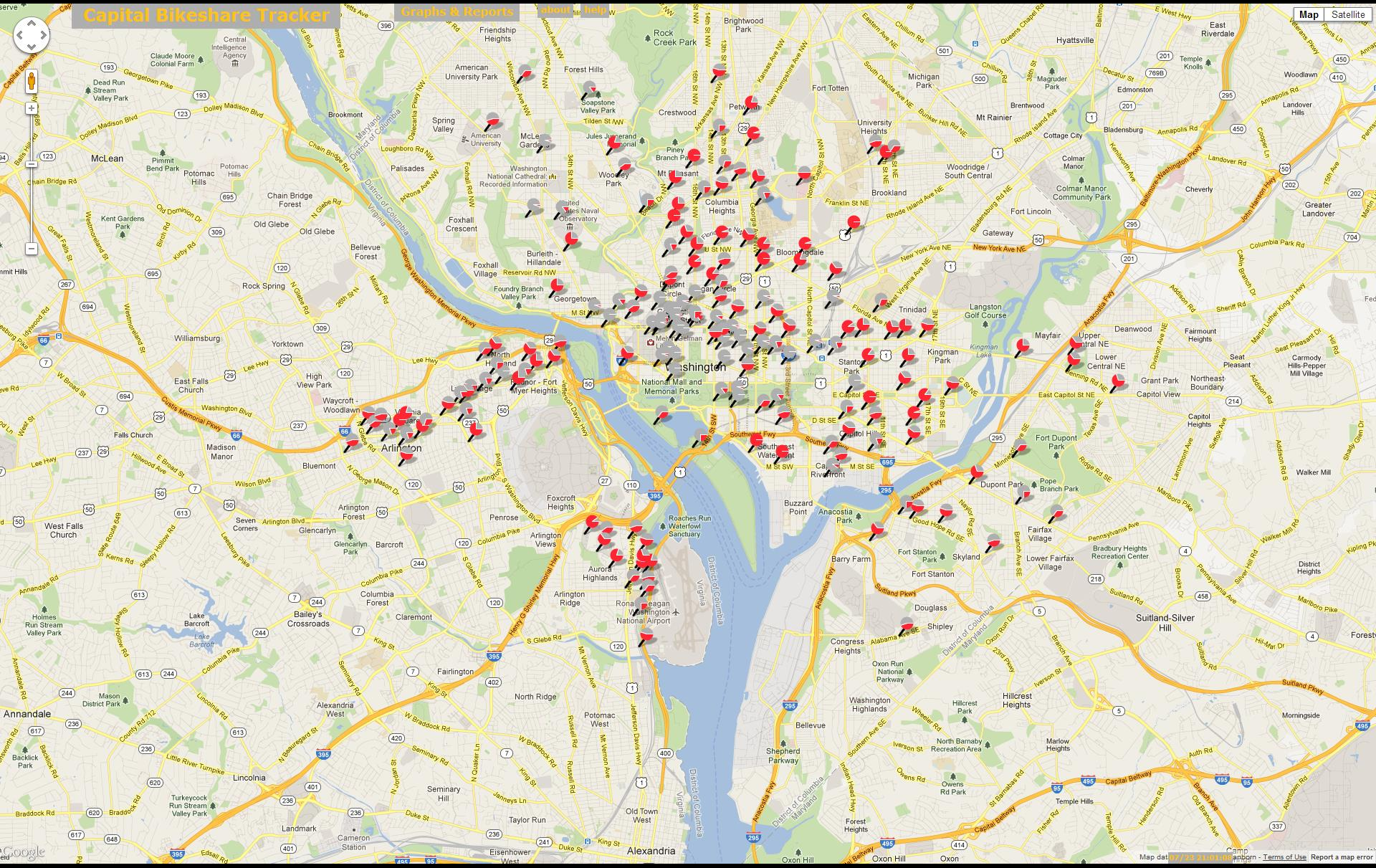
Human Computer Interaction Laboratory

University of Maryland

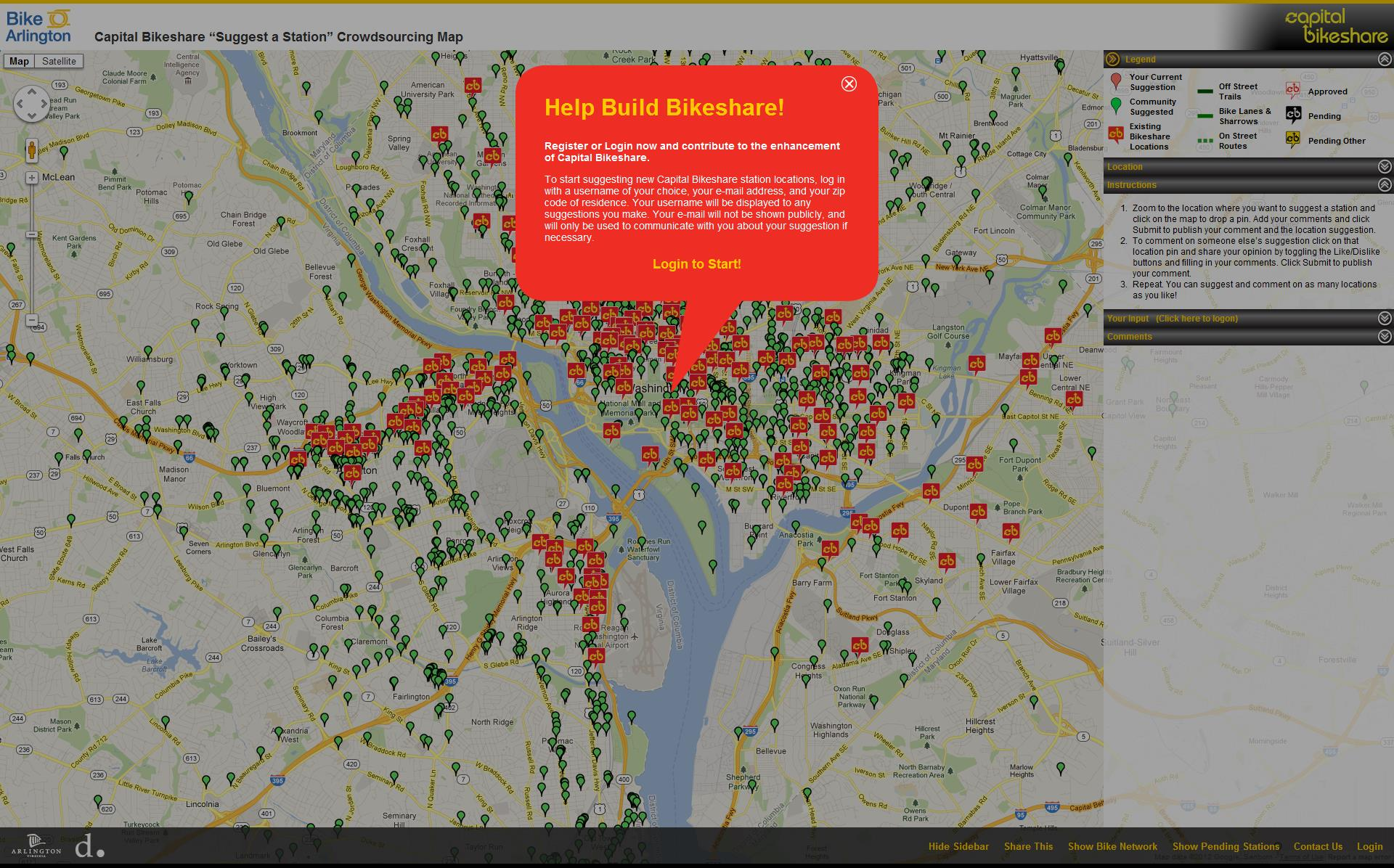
- Benefits of bikeshare:

- The Washington, D.C. region's Capital Bikeshare (CaBi) service released the third-party analysis of its 2011 member survey yesterday and it has some impressive results. Analysis shows that members save an average of $891 per year and collectively reduce their driving miles by 5 million annually.

- Other highlights include:
- 83% of respondents said they were more likely to patronize a business that was CaBi-accessible
- 82% of respondents reported increased bike use since joining Capital Bikeshare and 70% said CaBi was an important reason for this
- CaBi was a major or main factor for 56% who reduced car use



[Daniel Gohlke, http://bikes.oobrien.com/barcelona]


Bike Arlington
Capital Bikeshare "Suggest a Station" Crowdsourcing Map
capital bikeshare
Map
Satellite
Help Build Bikeshare!
Register or Login now and contribute to the enhancement of Capital Bikeshare.
To start suggesting new Capital Bikeshare station locations, log in with a username of your choice, your e-mail address, and your zip code of residence. Your username will be displayed to any suggestions you make. Your e-mail will not be shown publicly, and will only be used to communicate with you about your suggestion if necessary.
Login to Start!
Legend
Your Current Suggestion
Community Suggested
Existing Bikeshare Locations
Off Street Trails
Bike Lanes & Sharrows
On Street Routes
Approved
Pending
Pending Other
Location
Instructions
1. Zoom to the location where you want to suggest a station and click on the map to drop a pin. Add your comments and click Submit to publish your comment and the location suggestion.
2. To comment on someone else's suggestion click on that location pin and share your opinion by toggling the Like/Dislike buttons and filling in your comments. Click Submit to publish your comment.
3. Repeat. You can suggest and comment on as many locations as you like!
Your Input (Click here to logon)
Comments
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Show Bike Network
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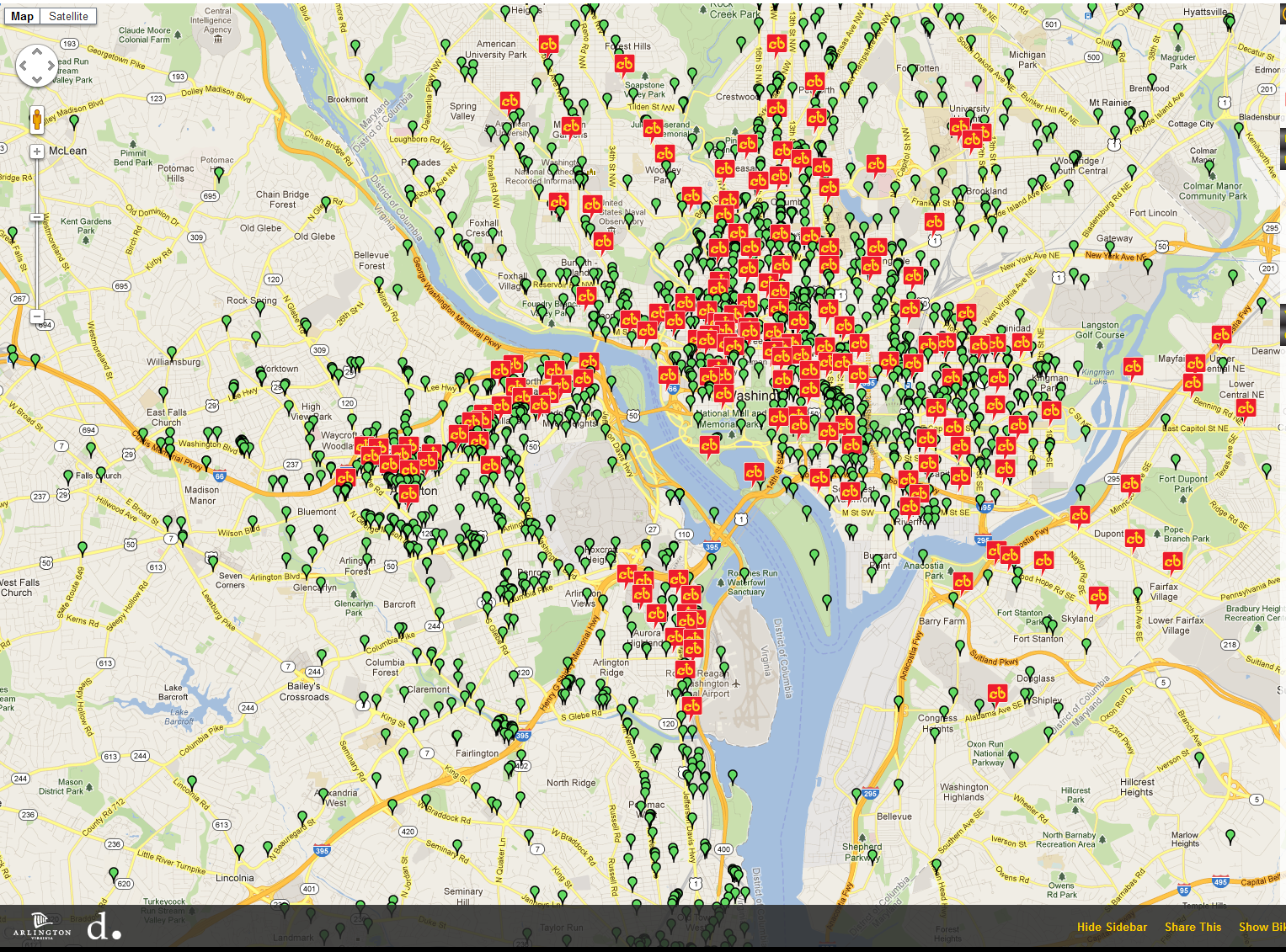
Bike Arlington

Capital Bikeshare "Suggest a Station" Crowdsourcing Map

capital bikeshare



ARLINGTON VIRGINIA d.

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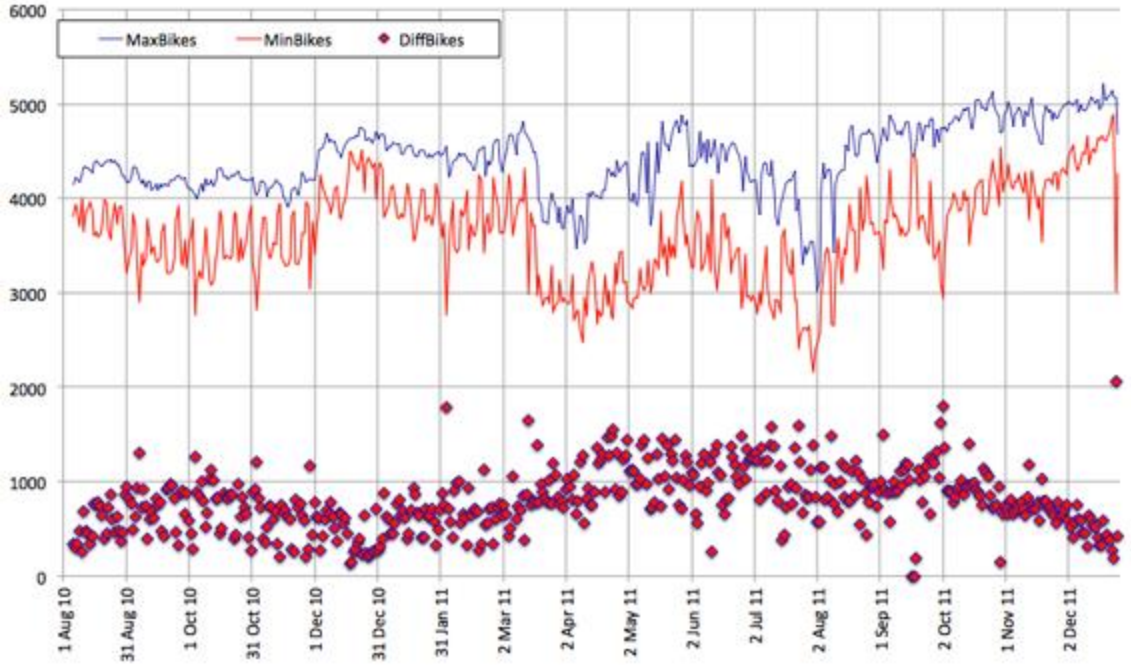
MaxBikes
MinBikes
DiffBikes
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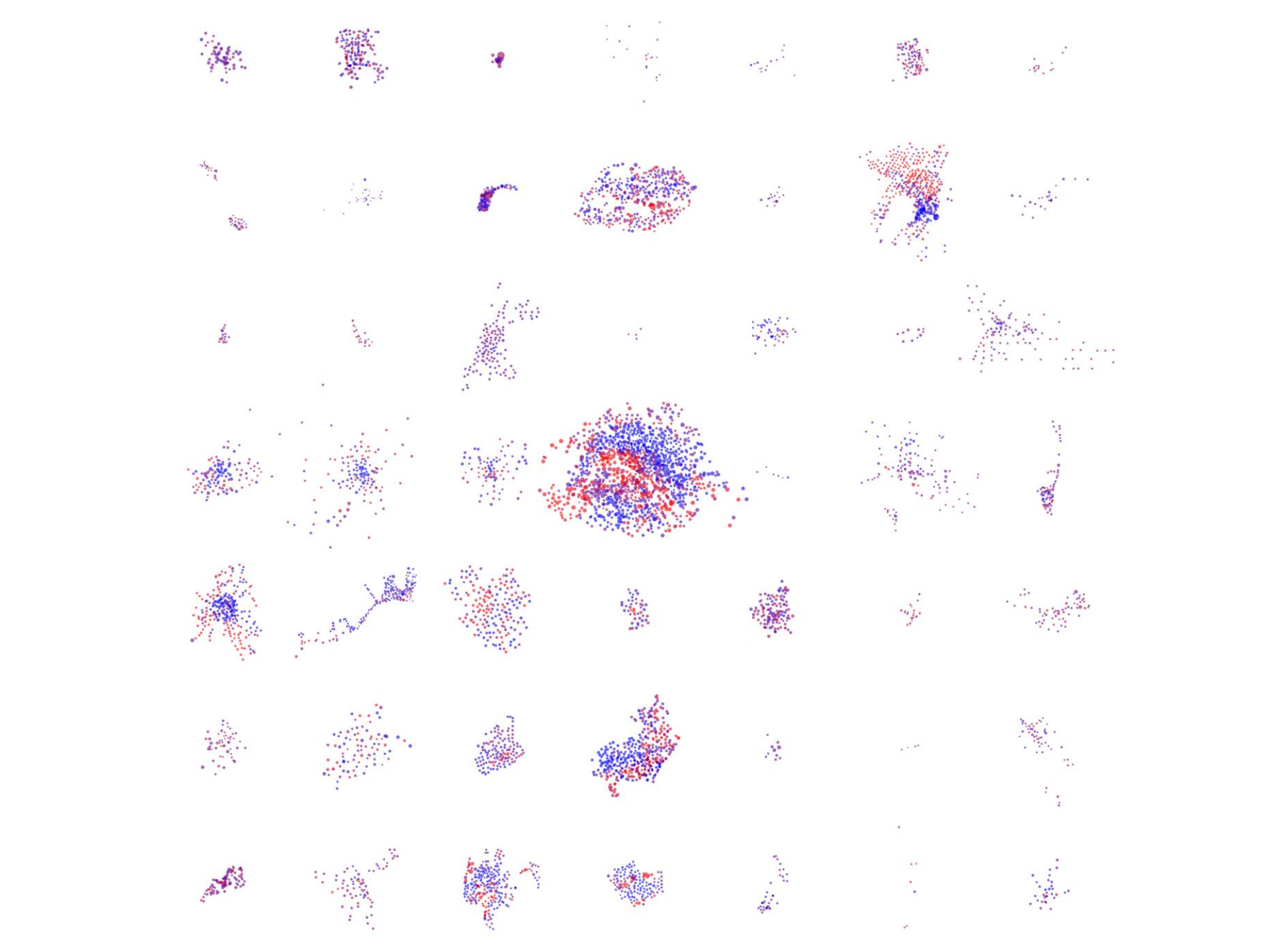
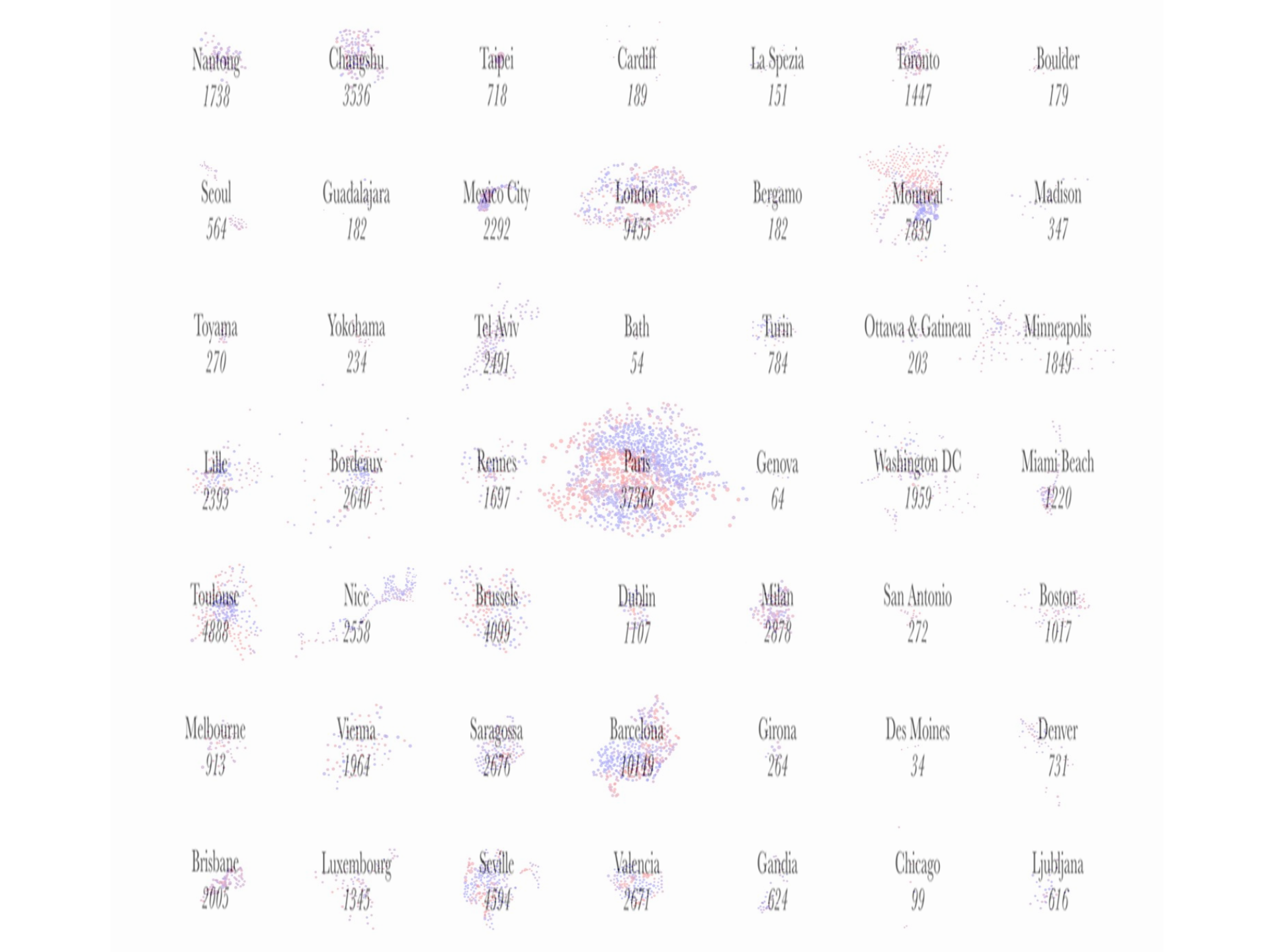
2 Dec 11

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Toronto
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Boulder
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Seoul
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Guadalajara
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Mexico City
2292
London
9455
Bergamo
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Montreal
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Madison
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Toyama
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Yokohama
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Bath
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Turin
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Genova
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Washington DC
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Miami Beach
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1888
Nice
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Luxembourg
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