

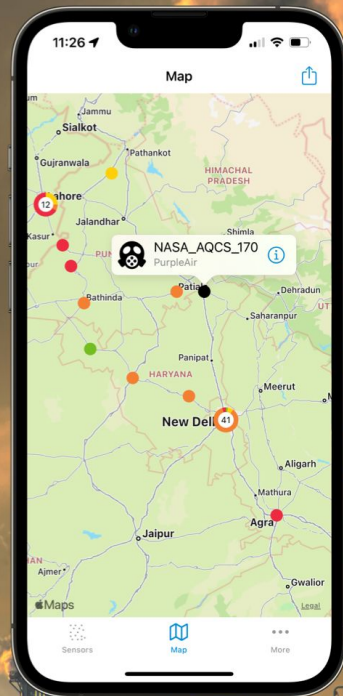
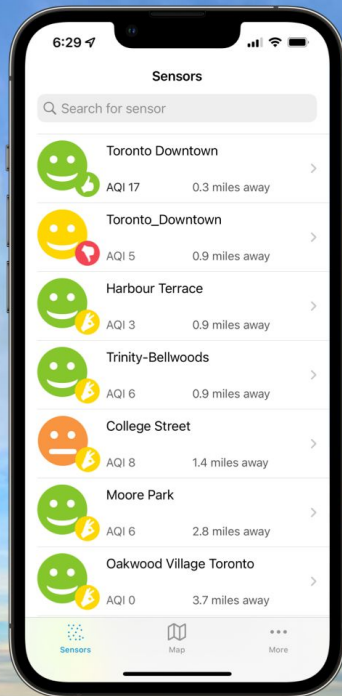
TorCHI

INTERACTIONS @SCALE FOR MONITORING AIR

Thu April 28, 2022
7:00 PM ET

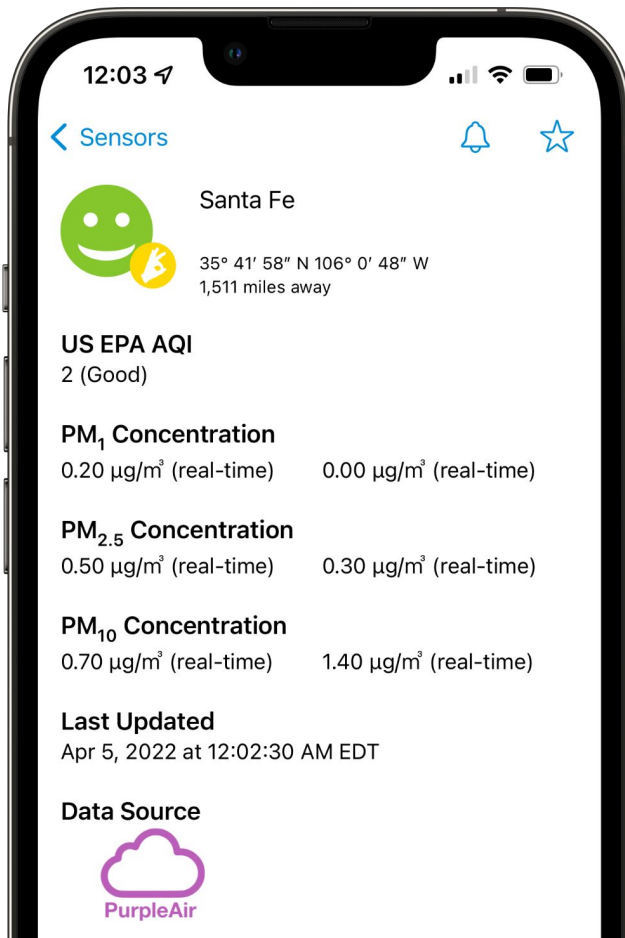
Guest speaker:
Karen Donoghue

TorCHI is the Toronto chapter of ACM's SIGHI, the Special Interest Group on Computer-Human Interaction



Agenda

- Air Quality Monitoring
- Case study: Local Haze
- Q & A: Submit questions into the chat

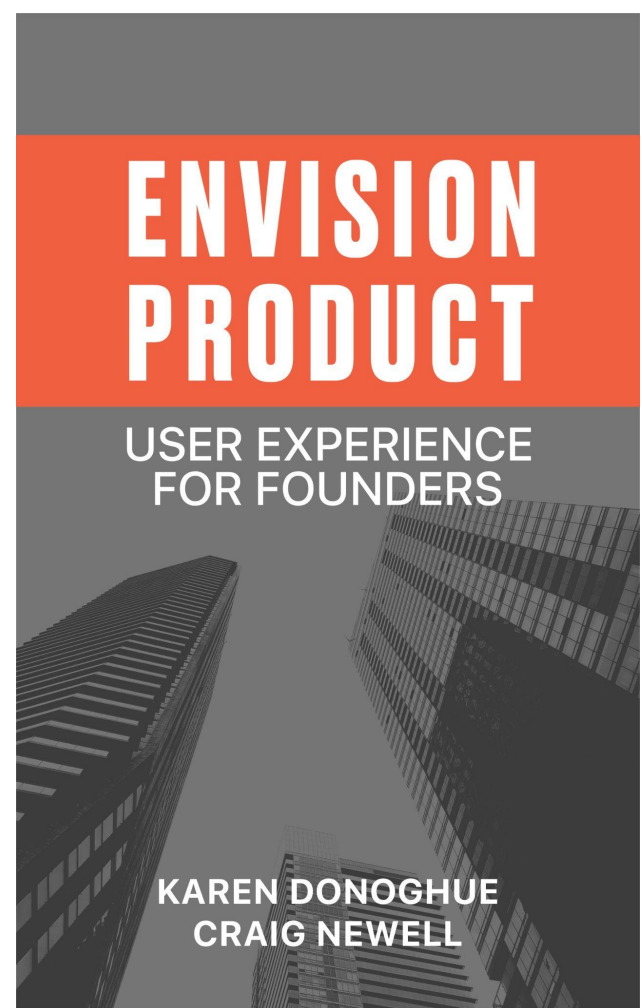


Questions covered

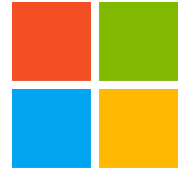
- What does it mean to monitor air quality at scale?
- What are some of the HCI design challenges to enable citizen scientists to monitor air quality?
- What other impacts does scale have in designing data-intensive air quality monitoring experiences for consumers?

Hello, I'm Karen!

- HCI practitioner and developer of the **Local Haze** app
- Founder of global UX design practice **HumanLogic**
- Long career in technology, software development, platform design for connected devices
- Recently published a book on early-stage UX design
- MIT Media Lab alum (MS)



Companies I have helped



Microsoft



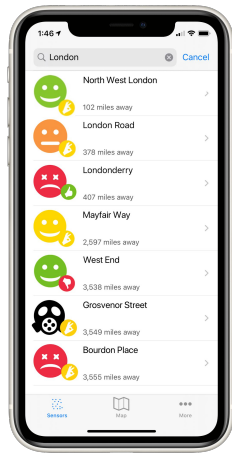
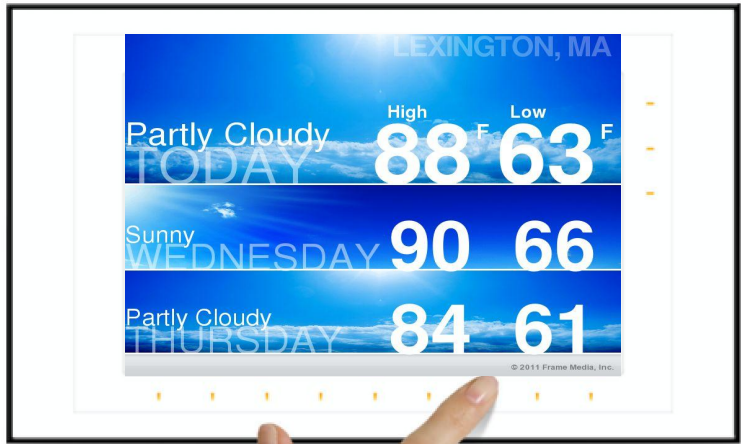
MOTOROLA



SecurityScorecard



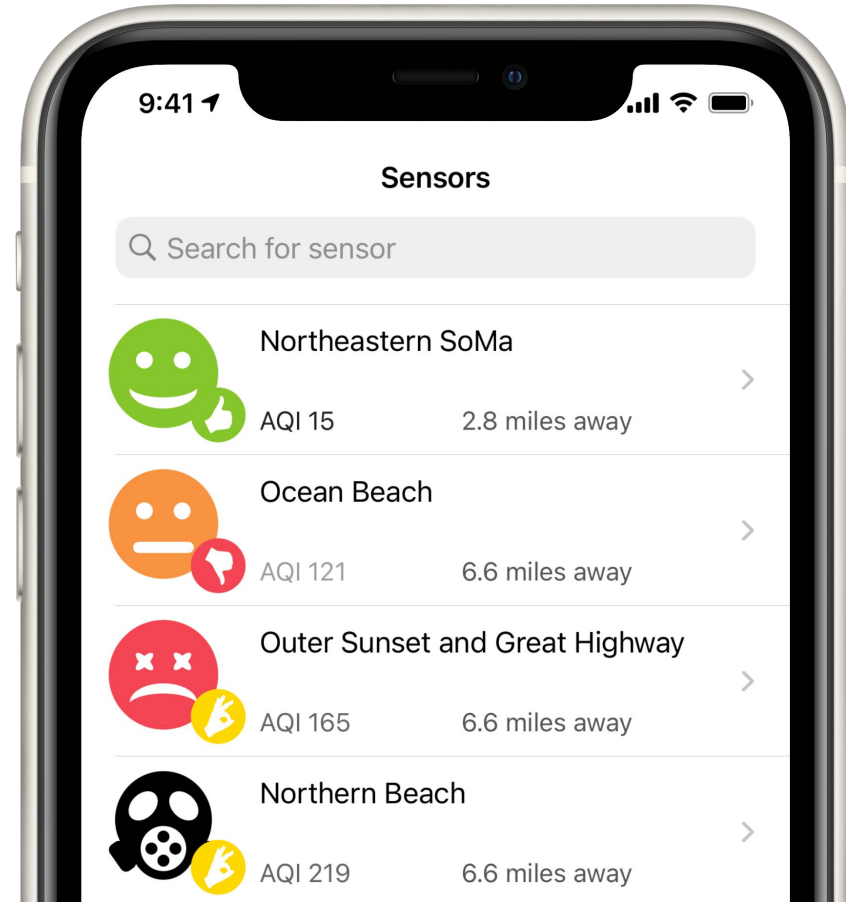
HUMANLOGIC



Local Haze



Consumers can easily understand their local air quality “on the go”



Local Haze crowdsources air quality sensor readings worldwide and rates sensor accuracy



WHY

Why is this important?

The Washington Post

HEALTH

Urban air pollution affects 2.5 billion people worldwide, study says

By Linda Searing

February 6, 2022 at 9:00 a.m. EST

The Guardian

Air pollution linked to more severe mental illness – study

Fri 27 Aug 2021 12.26 BST

Exclusive: research finds small rise in exposure to air pollution leads to higher risk of needing treatment



REUTERS®

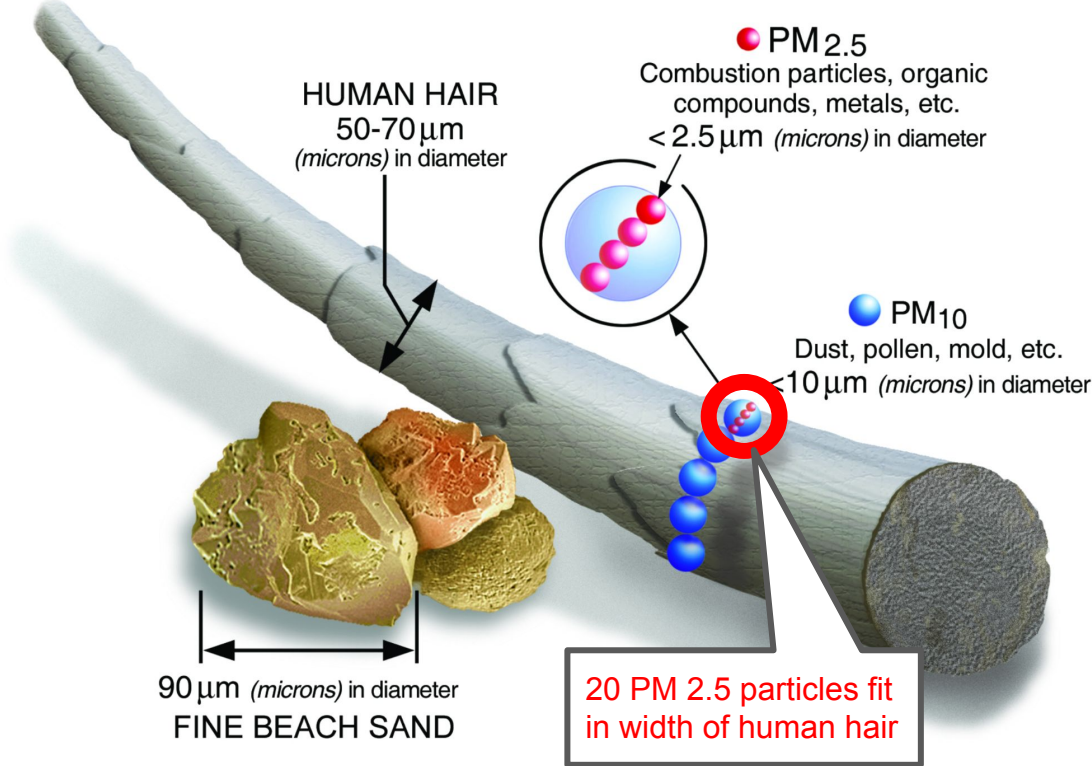
New Delhi to shut schools, construction sites as pollution worsens

November 13, 2021

By Suchitra Mohanty and Swati Bhat

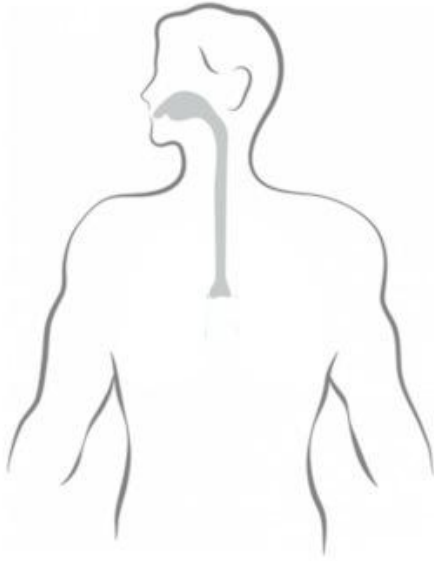


Particulate Matter < 2.5 micrometers in diameter poses a risk to health



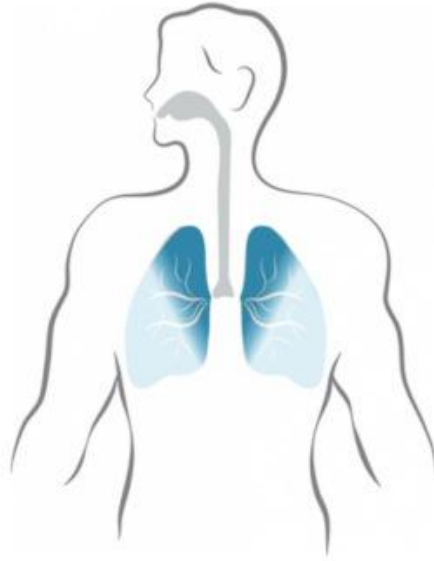
Source: EPA

PM10
 $\leq 10 \mu\text{m}$



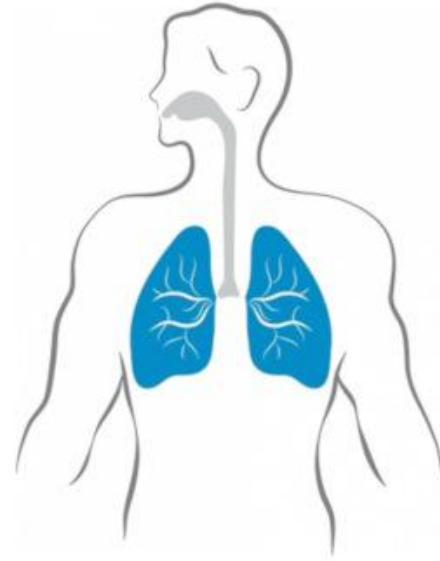
Coarse particles
Upper respiratory tract

PM2.5
 $\leq 2.5 \mu\text{m}$



Fine particles
Lower respiratory tract

PM1
 $\leq 1.0 \mu\text{m}$



Very fine particles
Alveolus (tiny air sacs)

Source: © Encyclopédie de l'Environnement

Air Quality Index (AQI)

Every country has a health impact index for Particulate Matter (e.g. US EPA AQI is shown below)

| Daily AQI Color | Levels of Concern | Values of Index | Description of Air Quality |
|-----------------|--------------------------------|-----------------|---|
| Green | Good | 0 to 50 | Air quality is satisfactory, and air pollution poses little or no risk. |
| Yellow | Moderate | 51 to 100 | Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution. |
| Orange | Unhealthy for Sensitive Groups | 101 to 150 | Members of sensitive groups may experience health effects. The general public is less likely to be affected. |
| Red | Unhealthy | 151 to 200 | Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects. |
| Purple | Very Unhealthy | 201 to 300 | Health alert: The risk of health effects is increased for everyone. |
| Maroon | Hazardous | 301 and higher | Health warning of emergency conditions: everyone is more likely to be affected. |

HOW

How is air quality measured?

Many alternatives to measure Particulate Matter (PM)

- **(\$\$\$) Gravimetric**
 - Batch process to weigh filter before and after air blown in
- **(\$\$\$) Beta-ray absorption (BAM)**
 - Nuclear radiation absorption
- **(\$\$) Tapered element oscillating microbalance (TEOM)**
 - A continuous system of weighing particles
- **(\$) Laser Particle Counting**
 - Fire a laser through the air and count the interruptions
- **(\$) Light scattering**
 - Measure visual haze at a small scale

Classic air quality monitoring = big and expensive



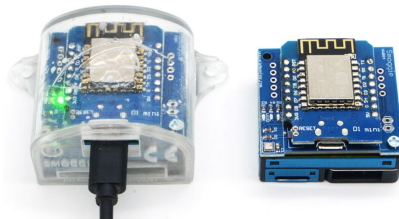
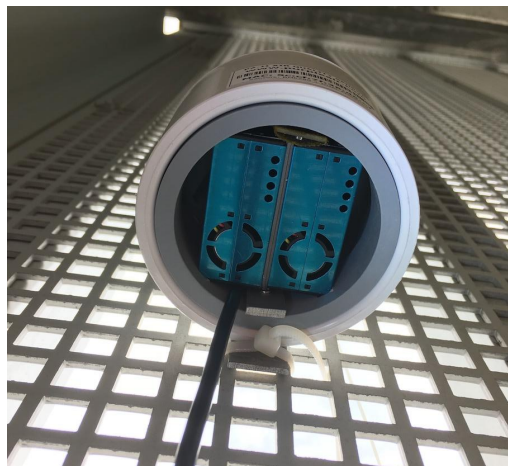
Classic air quality monitoring

Expensive to buy and operate

- Regular maintenance
- Regular calibration



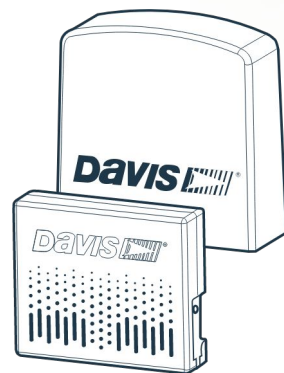
The rise of low cost PM sensors



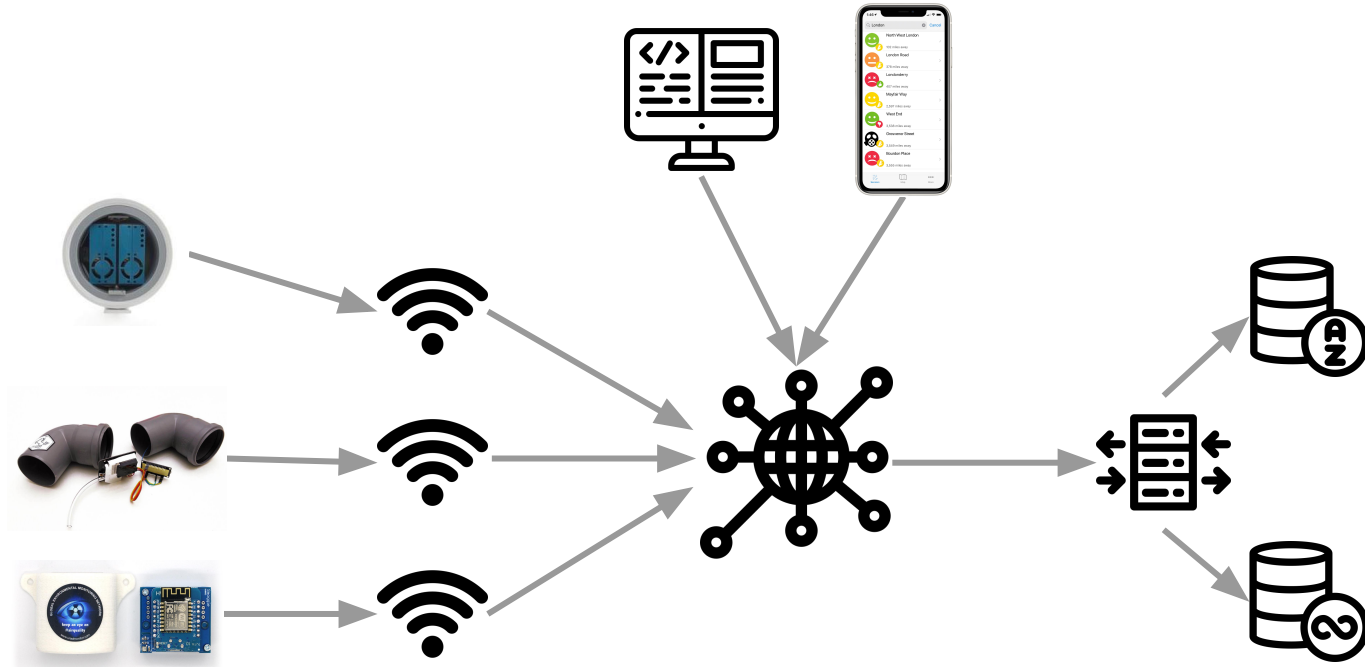
SENSOR.COMMUNITY



- Laser PM Sensor
- Microcontroller
- Case



Basic Data Gathering IoT System



Basic IoT system has devices connected across a network, a database and application server. Data is sent to the cloud.



PurpleAir



SENSOR.COMMUNITY



Data Sources



15638 sites 

SENSOR.COMMUNITY

12841 sites 



1308 sites 



48 sites 



480 sites 

Total Active Sensors

30,315 sites

**LOW COST
SENSORS**

Data Sources



15638 sites 

SENSOR.COMMUNITY

12841 sites 



1308 sites 



48 sites 



480 sites 

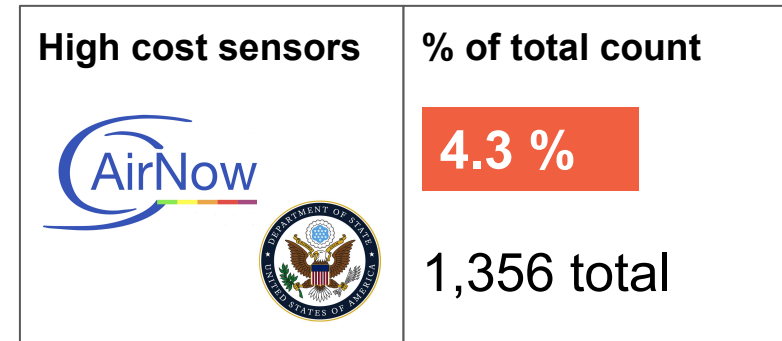
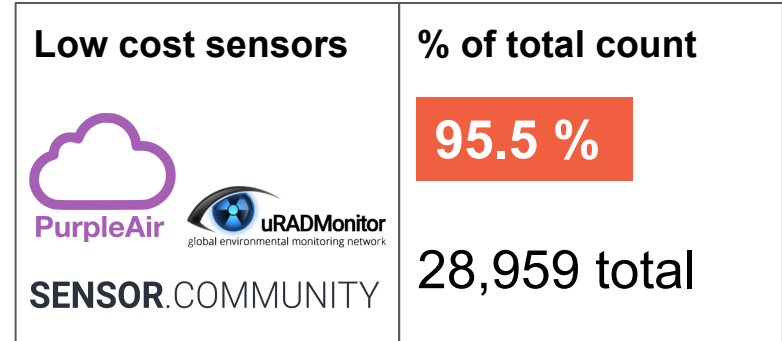
Total Active Sensors

30,315 sites

**EXPENSIVE
SENSORS**

UX Challenge: Wide range of data quality

- Large disparity in the volume and quality of data
- Lots of low quality data vs. a very small amount of high quality data
- UX presentation challenge to communicate the quality of the data, not just the value



WHO

Who is the user of your product?

Targeting consumers that are also citizen scientists

CRAIG / Persona role: Air quality enthusiast

HUMANLOGIC



Job title:
Engineer

Gender, age, location
M, 44, Boston, MA USA

Preferred channels
Email, SMS, web, mobile

Example quote

“I want to be able to see, understand and analyze my local air quality sensor data.”

Key characteristics
Very technical

Favorite brands



| | | |
|--|--|--|
| Frustrations & pain points Concerned about local air quality Can't find DIY AQ sensor to buy Family member with asthma | Motivations & key influences Interested in the rise of low-cost sensors and their ability to quantify air quality Reads EPA scientific reports on air quality | Goals & needs Wants to understand about AQ data and the ability to have confidence in sensor readings Will build own hardware as required |
| Questions How can I trust that the AQ sensor readings are accurate? How many sensors are there and where are they located? | Applications used in work & life iPhone X and iPad Pro MacBook Pro JIRA | Feature requests iOS app to monitor local air quality Simple way to understand the reliability of the data, not just the readings |



Job title:
Engineer

Example quote

Key characteristics
Very technical

Gender:
M, 44

Preferences:
Email,

"I want to be able to see,

Frustrations & pain points

Concerned about local air quality

Can't find DIY sensor to buy

Family member with asthma

Frustrations & pain points

Concerned about

Can't find DIY AQ

Family member w

Questions

How can I trust the
sensor readings a

How many sensors are there and
where are they located?

MacBook Pro

JIRA

Simple way to understand the
reliability of the data, not just the
readings

nds



nd about AQ

to have
sor readings

ware as

local air quality

UX Design challenges

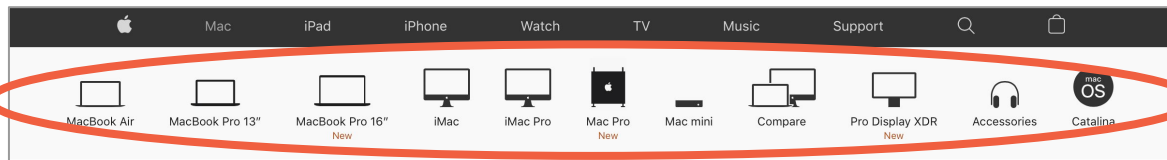
- Presentation - how does the data get presented?
 - Scientist may be expecting an excel sheet vs. citizen “non scientist” user expects an “at-a-glance” dashboard
 - Consumer-quality experience expected due to underlying platform
- Interaction model
 - Mapping the data into a high-quality user experience
 - Interaction model and performance have to be appropriate

PRIMER

Interaction design toolkit

What user experiences work best for dealing with lots of things?

Displaying a few items



Calling all pros.

Our most powerful pro lineup ever — MacBook Pro, Mac Pro, and Pro Display XDR. Ready for your best work ever.



16-inch model

MacBook Pro

The best for the brightest.

Buy

[Learn more >](#)

Lists of many items

Customer Service - Available 24/7 at (800) 927-7671 Perk Alert! Military families, Teachers, and Students get 10% off! Learn More

Zappos
POWERED BY AMERICAN EXPRESS

slippers SEARCH MY CART

Women Men Kids Departments Brands Sale Sign In / Register

Slippers

1656 items found

Sort By Relevance

Do these items match what you were searching for? YES NO

Login to see saved sizes SIGN IN

Gender

- Women (970)
- Men (548)
- Girls (181)
- Boys (98)

Product Type

- Shoes (1614)
- Clothing (35)
- Bags (7)

Brand

Search Brand

- 3.1 Phillip Lim (1)
- Acorn (142)
- Acorn Kids (27)
- adidas (4)
- adidas Originals Kids (1)
- Arcteryx (2)















Price

- \$50.00 and Under (789)
- \$100.00 and Under (1438)
- \$200.00 and Under (1638)
- \$200.00 and Over

Color

Search Color

- Black (338)
- Brown (271)
- Gray (233)
- Pink (139)
- Blue (114)
- Tan (74)
- Multi (72)

| | | | | |
|---|---|---|---|---|
|  56 Old Friend Cloth Lined Moccasin \$69.95 ★★★★★ |  84 Old Friend Loafer Moccasin \$79.95 ★★★★★ |  594 Old Friend Scuff \$69.95 ★★★★★ |  42 Old Friend Romeo \$89.95 ★★★★★ |  45 Old Friend Scuff \$79.95 ★★★★★ |
| Customers Who Searched This Also Bought | | | | |
|  7331 UGG Ansley \$99.95 |  1043 Deer Stags Nordic Slipper \$27.99 MSRP: \$55.00 |  1404 BOBS from SKECHERS Keepsakes - Ice Angel \$28.00 MSRP: \$40.00 |  5837 UGG Ansley \$99.95 | |
|  55 Old Friend Bootee \$89.95 ★★★★★ |  140 Old Friend Bootee Ladies \$99.95 ★★★★★ |  30 Old Friend Beau \$39.99 MSRP: \$69.00 ★★★★★ |  25 Old Friend Ragnar \$59.95 ★★★★★ |  66 Old Friend Ladies Scuff \$49.95 MSRP: \$69.95 ★★★★★ |

1656 items



Scrolling

Pagination

\$60.00
★★★★★



♥ 192

Minnetonka
Pile Lined Romeo Slipper
\$49.95
★★★★★

\$28.09 MSRP: \$55.00
★★★★☆



♥ 67

Deer Stags
Nordic Slipper
\$28.09 MSRP: \$55.00
★★★★☆

\$76.95
★★★★★



♥ 149

Minnetonka
Cally Slipper
\$44.95
★★★★★

\$46.95
★★★★★



♥ 163

Deer Stags
Nordic Slipper
\$27.99 MSRP: \$55.00
★★★★★

\$78.95
★★★★★



♥ 139

Spenco
Supreme Slipper
\$76.95
★★★★★



♥ 47

FitFlop
Furry Slipper
\$59.90 MSRP: \$80.00
★★★★★



♥ 46

Deer Stags
Spun Slipper
\$34.99 MSRP: \$60.00
★★★★★



♥ 118

Deer Stags
Nordic Slipper
\$27.99 MSRP: \$55.00
★★★★★



♥ 65

FitFlop
Furry Slipper
\$59.89 MSRP: \$80.00
★★★★★



♥ 112

Minnetonka
Pile Lined Romeo Slipper
\$49.95
★★★★★

1 2 3 4 ... 17 Next Page



Finite scrolling

17 pages

Infinite scrolling

localhaze
3/8 Tweets

Tweets Tweets & replies Media Likes

localhaze @localhaze · 2/2/20

2018 carbon dioxide emissions, tonnes per capita

World, combined: 36.57 billion tonnes
World, per capita: 4.82 tonnes

▼ Emissions down since 2008
▲ Emissions up since 2008

Data: Global Carbon Project (2019), World Bank
Picture: Ville Seppälä www.villeseppala.fi

localhaze @localhaze · 1/29/20

Research study has found that childhood exposure to traffic-related air pollution is linked with structural changes in the brain

Traffic air pollution may be linked to structural brain changes
apple.news

You Retweeted

R Subramanian @subu_caps · 1/18/20

Folks working with low-cost sensors for air quality research/monitoring in Africa: we (@kofiamegah @JimmyGasore @PauliJllo @vfmcneill @albertpresto @etjernst @d_westy, Tim Brown, and moi) are organizing a workshop at the new @cmu_africa campus on March 9-10, 2020. 1/3

4 26 53

Show this thread

Who to follow

Infinite scrolling



Clustering

Hide Filters

Sort By

Category

- Slim (84)
- Classic (80)
- Tall (49)
- Untucked (48)

Silhouette

Fabric

Length

Occasion

Fit

Size

Color

Pattern

Trending

Brand

Re-Imagined

- Sustainable (90)
- Organic (95)

SLIM



Slim short-sleeve Baird McNutt Irish linen shirt
CAD 125.00
 also in: Classic, Tall



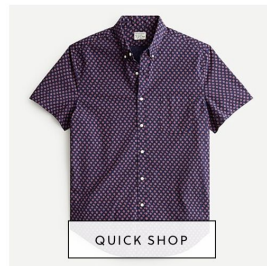
Slim short-sleeve slub cotton shirt in wave print
CAD 94.00
 also in: Classic, Slim Untucked, Tall



Slim short-sleeve stretch Secret Wash shirt in springtime floral organic cotton
CAD 94.00
 also in: Classic, Tall

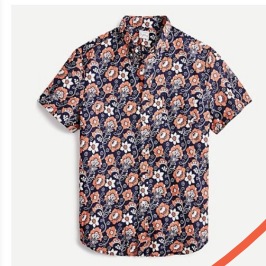


Slim short-sleeve shirt in Liberty® floral print
CAD 144.00

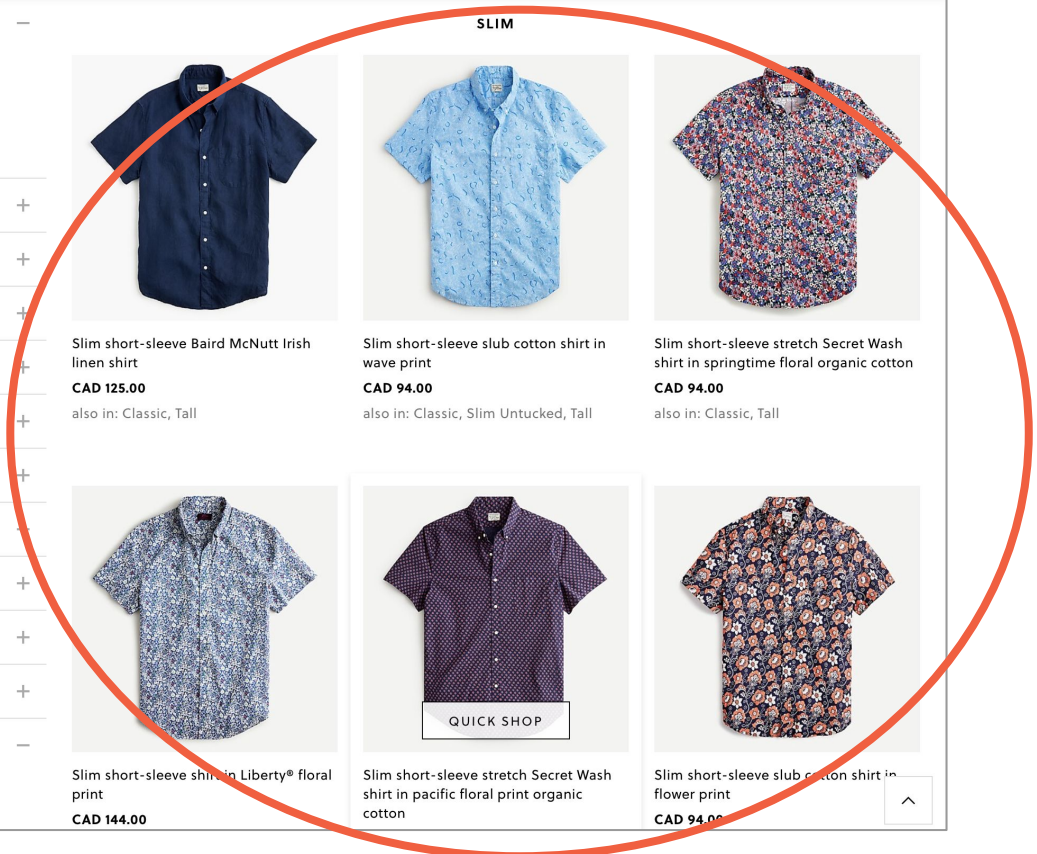


Slim short-sleeve stretch Secret Wash shirt in pacific floral print organic cotton

QUICK SHOP



Slim short-sleeve slub cotton shirt in flower print
CAD 94.00



SHOP ALL WOMEN'S CLOTHING

Hide Filters

Sort By

1

of 12

View 120

Category

- Blazers (15)
- Brands We Love (11)
- Coats & Jackets (17)
- Denim (69)
- Dresses & Jumpsuits (68)
- Home (1)
- Maternity (48)

+ Show 11 More

Size

Color

Pattern

Trending

Brand

Re-Imagined

- Sustainable (132)
- Fair Trade (20)
- Organic (11)



Long-sleeve drapery scalloped top in polka dot
CAD 116.00



Ruffled pleated polka-dot dress
CAD 230.50 CAD 202.50 (12% Off)

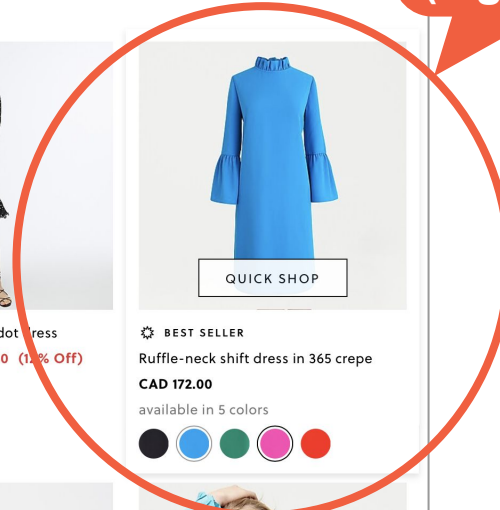


QUICK SHOP

BEST SELLER
Ruffle-neck shift dress in 365 crepe
CAD 172.00
available in 5 colors



Summary as a cluster of entities (e.g. dresses)



Keyword search



taxes|

 [Do Your Taxes for Free](#)

 [Get Your Refund Status](#)

 [Get Your Tax Record](#)

 [View Your Account](#)

 [Make a Payment](#)

 [Renew Your PTIN](#)

 [Get Answers to Your Tax Questions](#)

 [Apply for an Employer ID Number \(EIN\)](#)

Forms and Instructions

[1040 and Schedules 1-3](#)
Individual Tax Return

[Other 1040 Schedules](#)
Information About the Other Schedules Filed With Form 1040

[Form W-4](#)
Employee's Withholding Certificate

[Search Forms & Instructions](#)

What happens when search fails to return a manageable number of results?

Help the user to search more precisely

Faceted search

These are the category tags - or "facets" - of the search results

The screenshot shows an eBay search results page for the query 'unicycle'. The page includes a search bar at the top with the eBay logo and a 'Shop by category' dropdown. Below the search bar, there are filters for 'Categories' (Sporting Goods, Cycling, etc.), 'Price' (Under \$40.00, \$40.00 to \$85.00, Over \$85.00), and 'Condition' (New, Used, Not Specified). The main content area displays four product listings, each with an image, title, price, and shipping information. The listings are: 1) '20" Wheel Unicycle Cycling Exercise 1.75" Tire Adjustable Height Chrome Blue' for \$63.96; 2) '20" Unicycle Wheel Free Stand Chrome Uni-bicycle Cycling Exercise Blue' for \$63.96; 3) 'ACTION BI0049 24" CHROME UNICYCLE FORK' for \$32.11; and 4) 'ACTION BI0048 20" PRO BLACK UNICYCLE FORK' for \$35.14. A red oval highlights the filter sections on the left side of the page.

FILTERS <<

New filter

Find filters

My Open Issues

Reported by Me

Recently Viewed

All Issues

FAVORITE FILTERS

6.2-OD5 Docs

Enterprise issues ass...

JIRA documentation t...

m7 Ecosystem

Open JRADEV issue...

Search

Save as

Share

Export

Tools

Sample Scrum ... Epic, Story In Progress, To... Assignee: All Contains text More Advanced

Creator: Current User

1-4 of 4

Columns

| T | Key | Summary | Assignee | Reporter | P | Status | Created | Updated |
|---|--------|----------------|------------|------------|---|--------|-----------|-----------|
| | SSP-38 | Estimates epic | Unassigned | Andrew Lui | ↓ | TO DO | 03/Sep/14 | 23/Oct/14 |
| | SSP-37 | Filters epic | Unassigned | Andrew Lui | ↓ | TO DO | 03/Sep/14 | 03/Sep/14 |
| | SSP-36 | Ranking epic | Unassigned | Andrew Lui | ↓ | TO DO | 03/Sep/14 | 03/Sep/14 |
| | SSP-35 | A test story | Andrew Lui | Andrew Lui | ↓ | TO DO | 05/Jun/14 | 03/Sep/14 |

1-4 of 4



>>

Search

Save as

✓ project = "Pomodoro Web Client" AND updatedDate < 30d

AND

OR

ORDER BY

[Syntax Help](#)

Assignee

Reporter

Jay Sonman

Paige N. Spector



PWC-98

As a user I would like to capture a screenshot so that

Unassigned

System Administrator

**If the user can't search precisely enough,
then try to organize the results**


Progressive disclosure

Google unicycles

www.jugglegear.com › unicycle ▾
Unicycles complete - Jugglegear.com
Quality unicycles for sale in Canada. We stock a large range of quality trials, freestyle, giraffe, mountain and road unicycles.

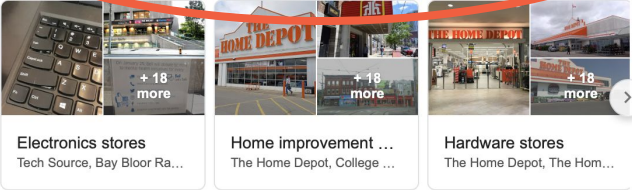
Images for unicycles

electric trials street circus cool racing >



→ More images for unicycles Report images

Discover more places



Electronics stores
Tech Source, Bay Bloor Ra...

Home improvement ...
The Home Depot, College ...

Hardware stores
The Home Depot, The Hom...

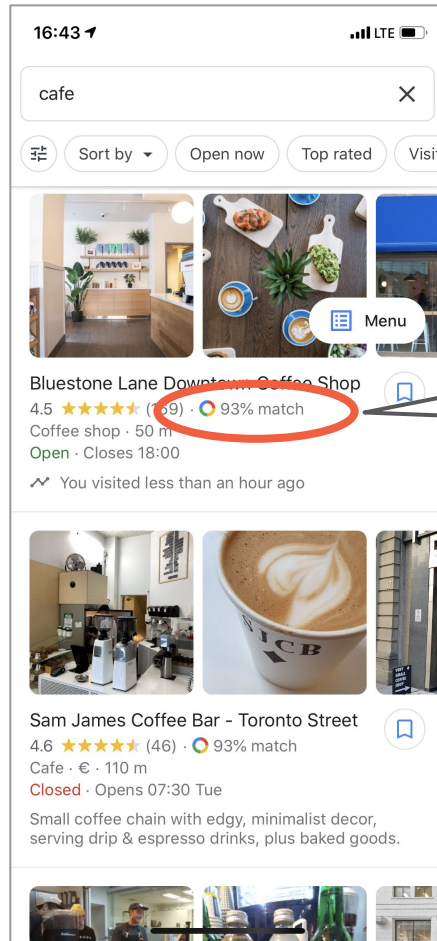
Searches related to unicycles

| | |
|-------------------|--------------------|
| electric unicycle | unicycle history |
| muni unicycle | unicycle victoria |
| unicycle toronto | unicycle vancouver |
| beginner unicycle | braun unicycle |

Go oooooo oogle >
1 2 3 4 5 6 7 8 9 10 Next

Progressive
disclosure of
search results

Sorting by relevance



Dynamic relevance calculation used to order based on user behavior

Introducing echo loop

Smart ring with Alexa



Browse history influences sort order of results



Hi, Karen

Customer since 2009

Recommendations for you



Your Orders



Home & Kitchen

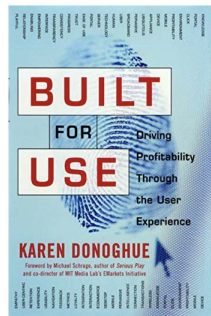


Health & Household



Books

Recently viewed



Today

[Edit your browsing history](#)



Sweaters



Pants



Bags



Shoes

[Try Prime Wardrobe](#)

DESIGN

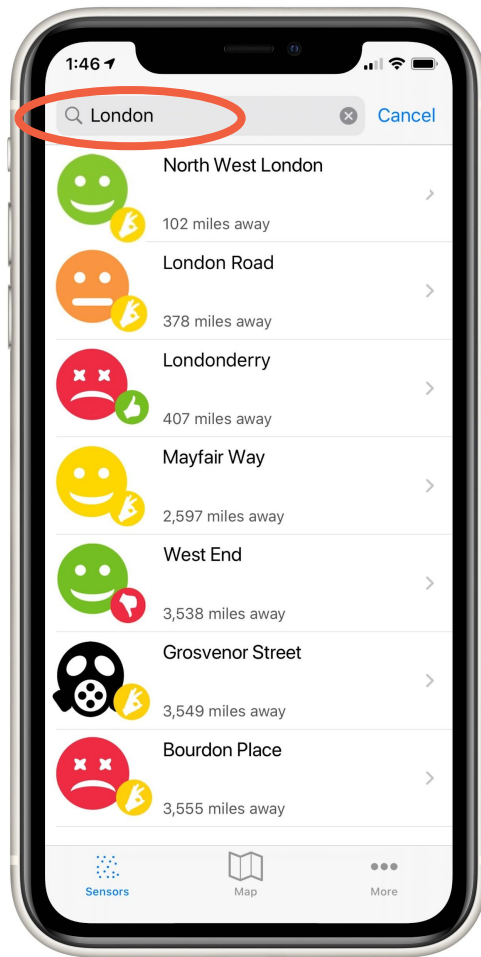
iOS application

**We now have a toolkit of
interactions for dealing with
objects at scale**

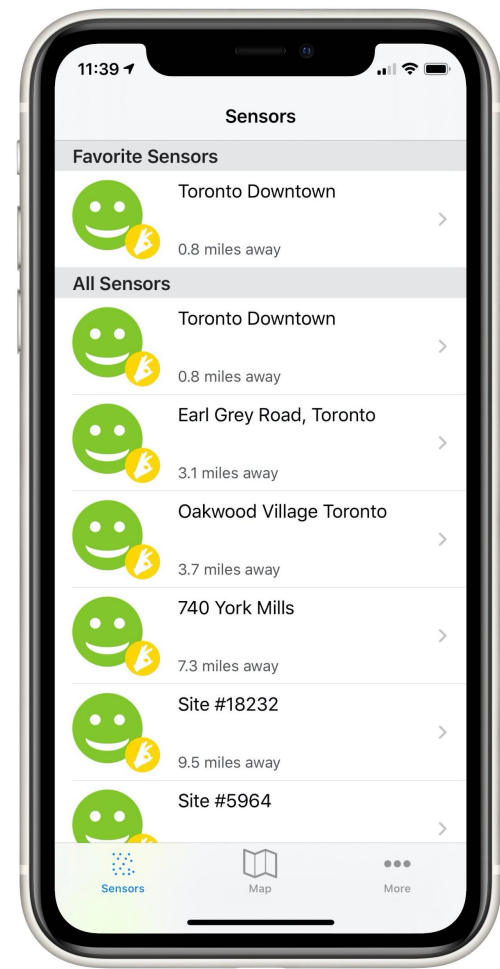
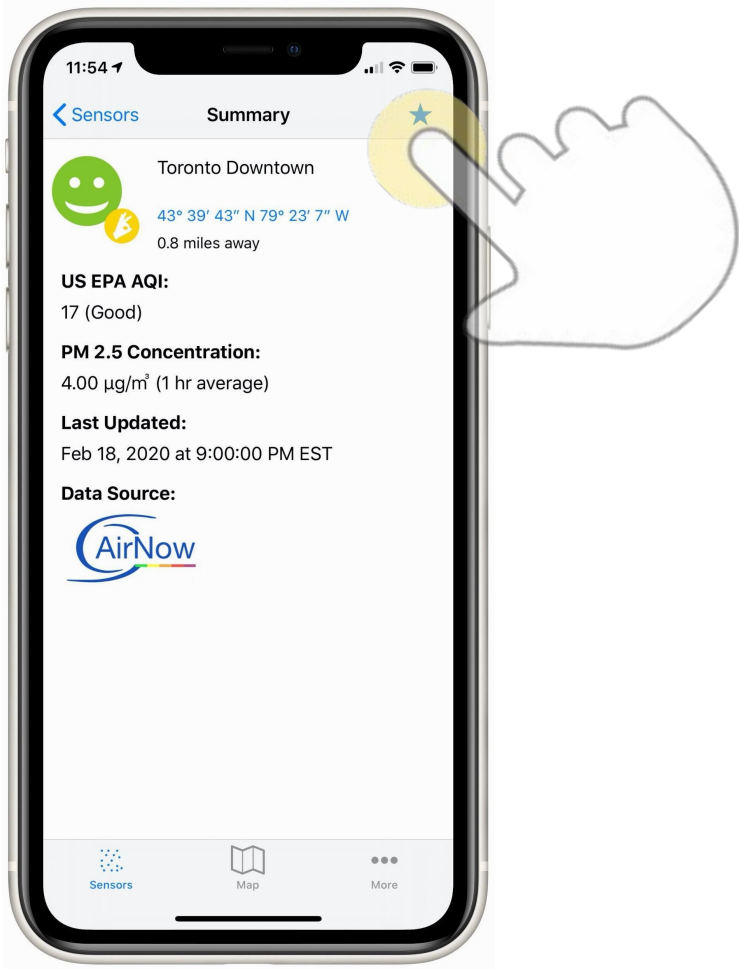
**“At scale”: many, thousands,
hundreds of thousands, millions,
tens of millions...**

Infinite scrolling list

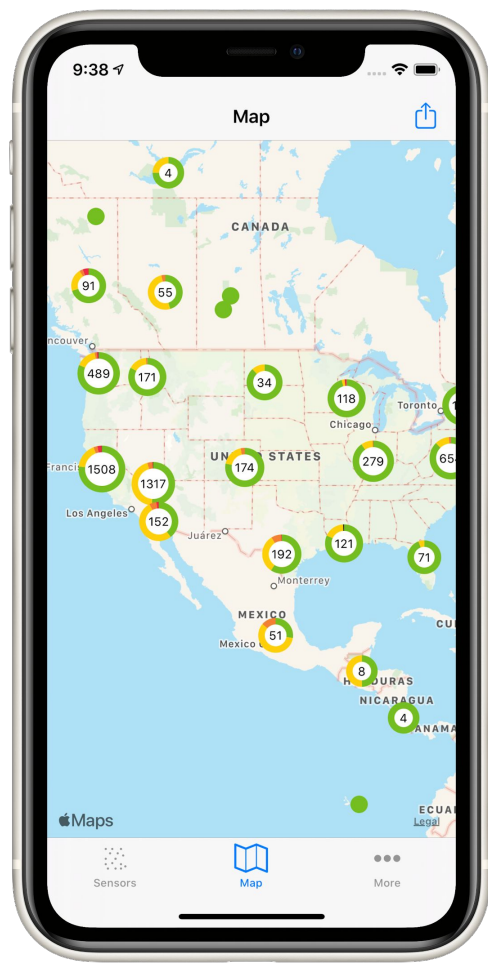
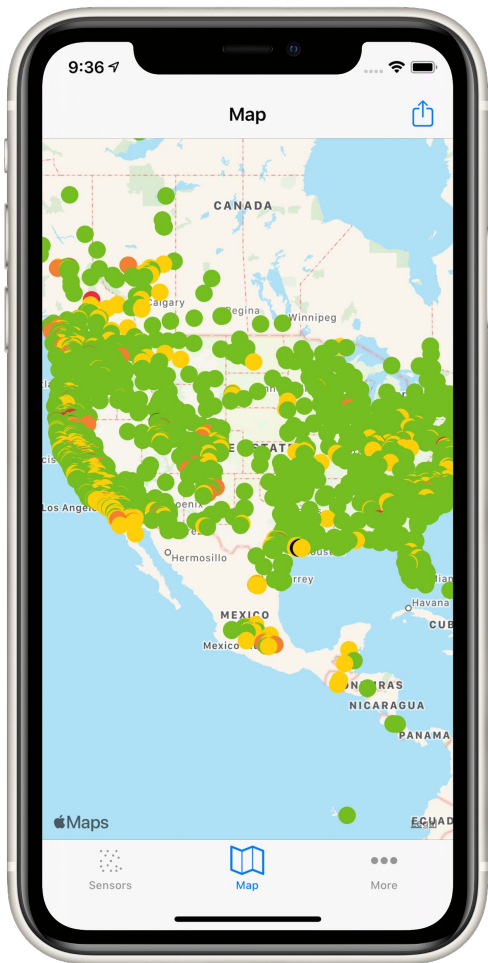
**To help manage infinite scrolling lists,
we added filtering**



After filtering, we added relevancy

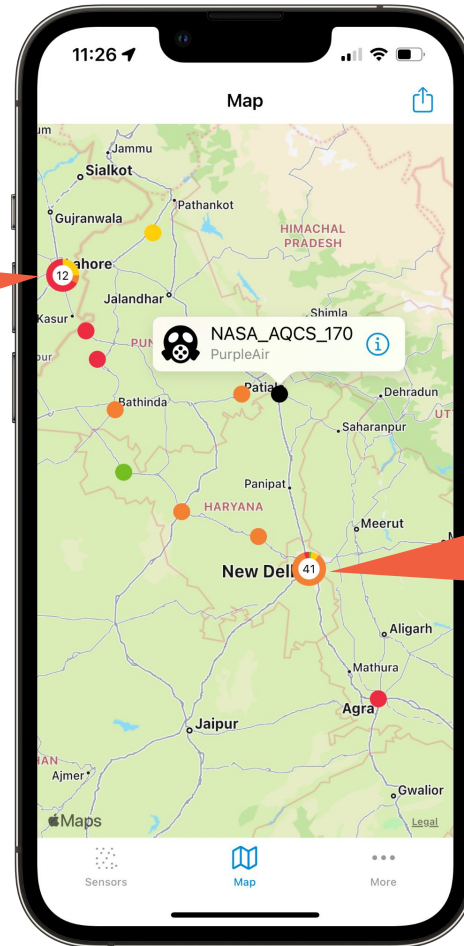


We added a map view to help users understand the geography of sensors

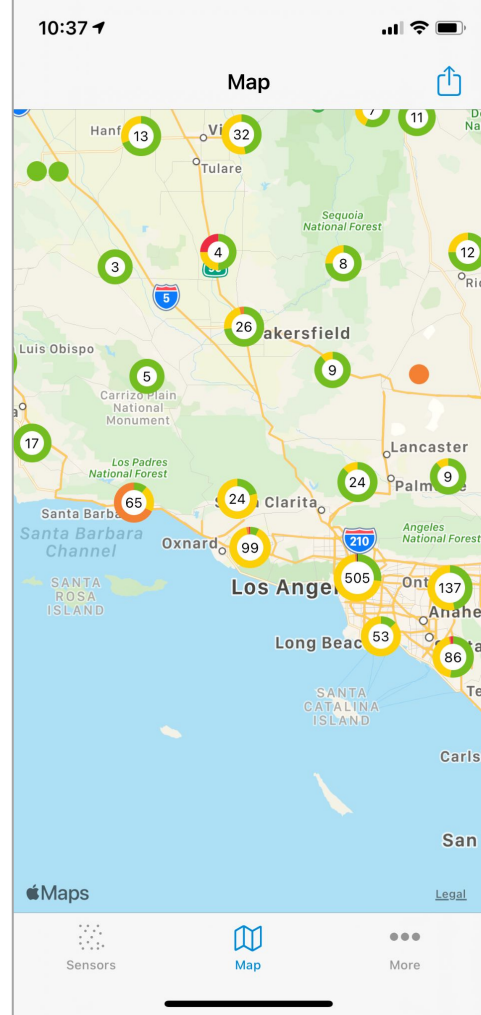
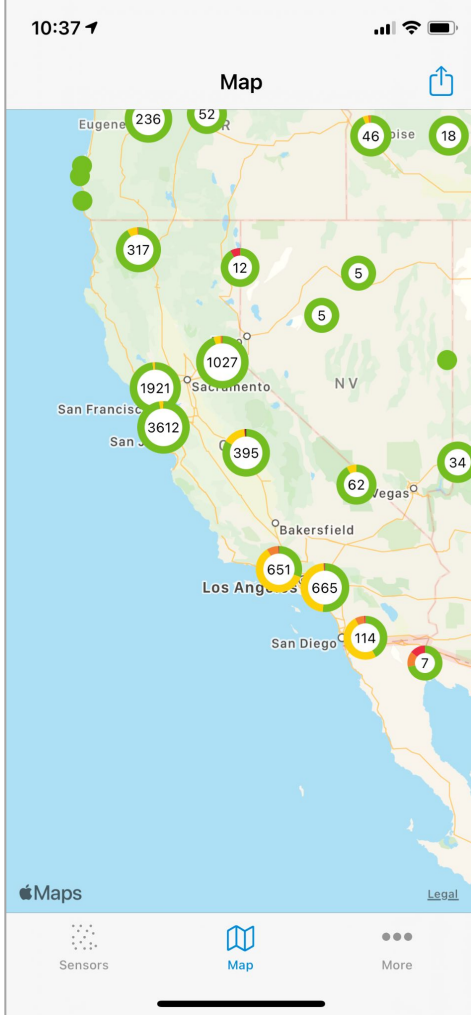
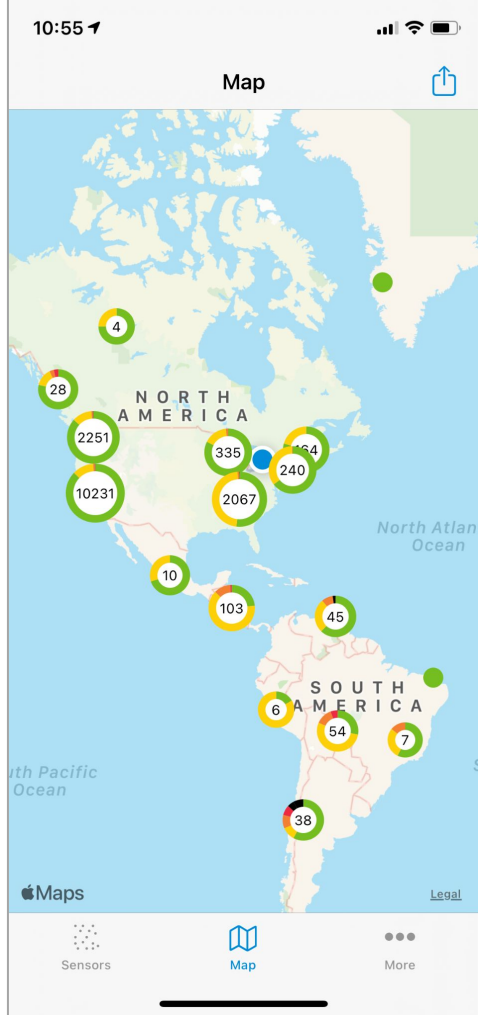


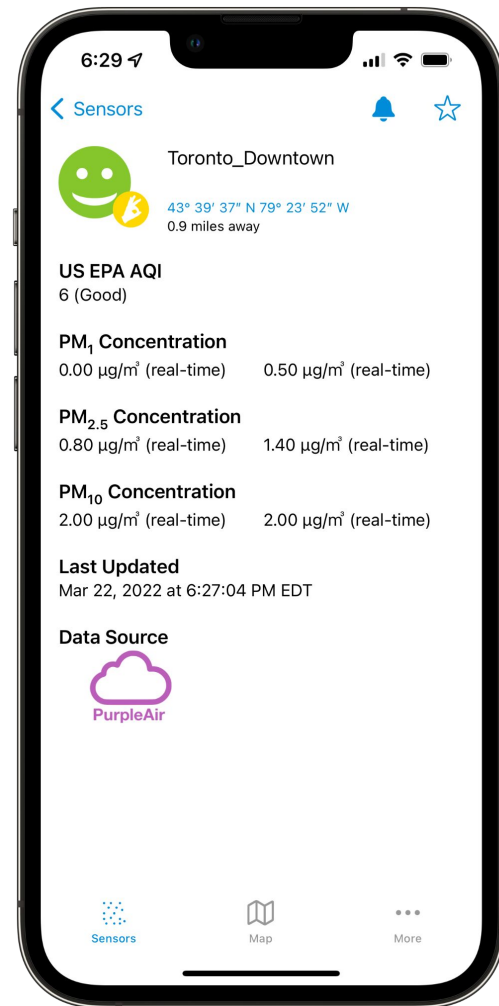
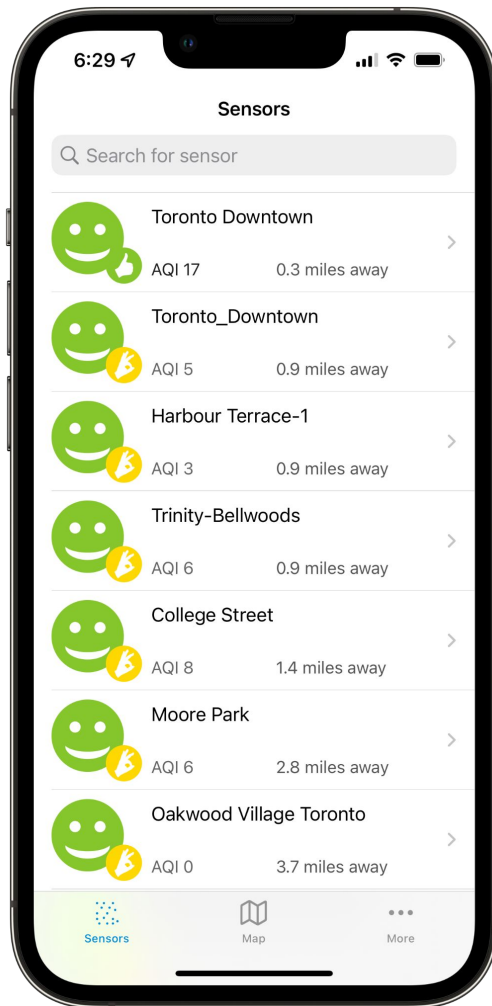
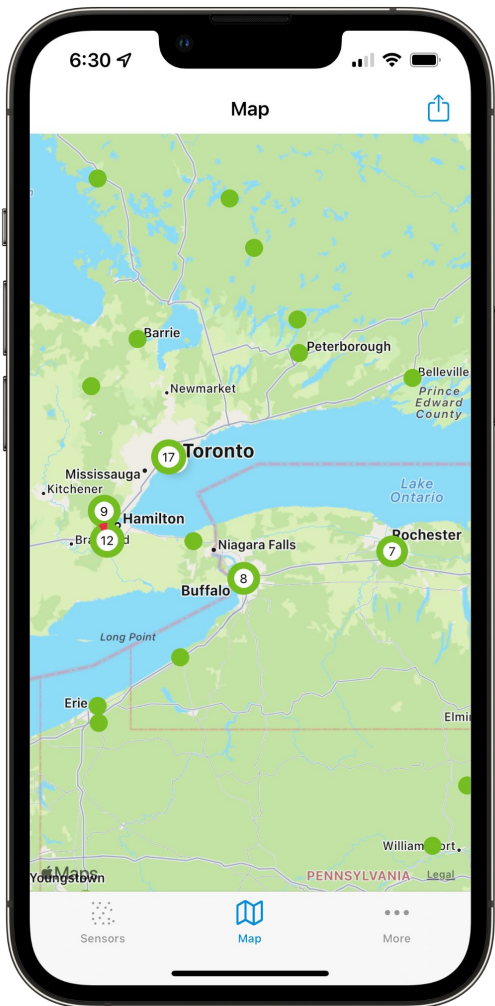
Presentation UX

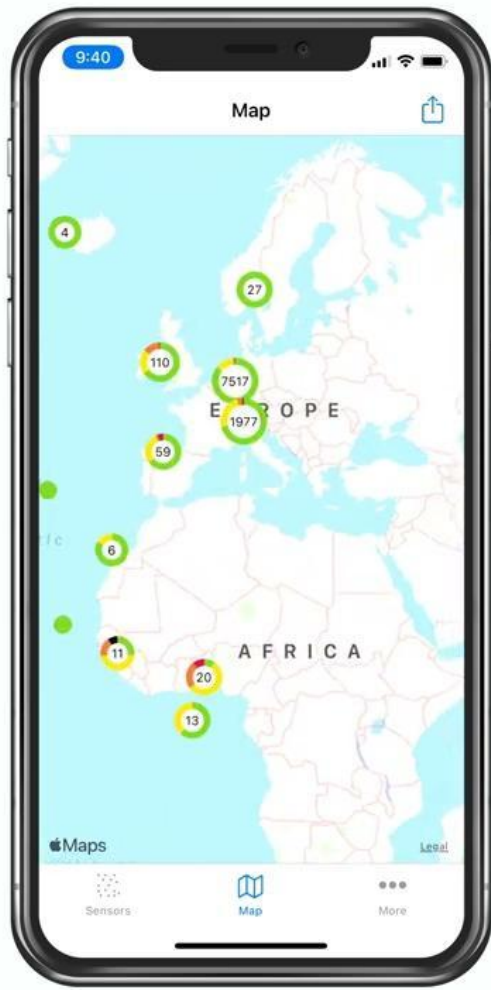
12 sensors
at this level
of map scale



41 sensors
at this level
of map scale







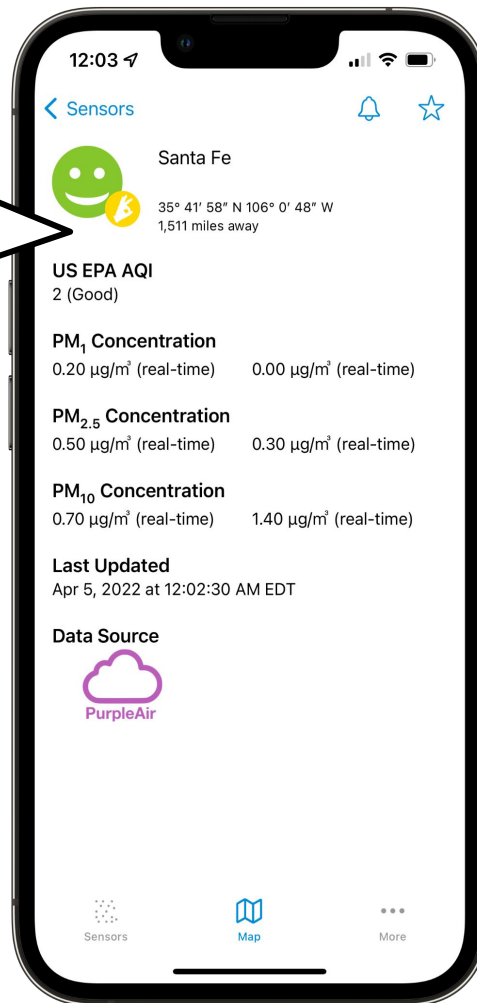
SCALE






Scale in time




**Users want to be notified about changes
to air quality at a specific location**

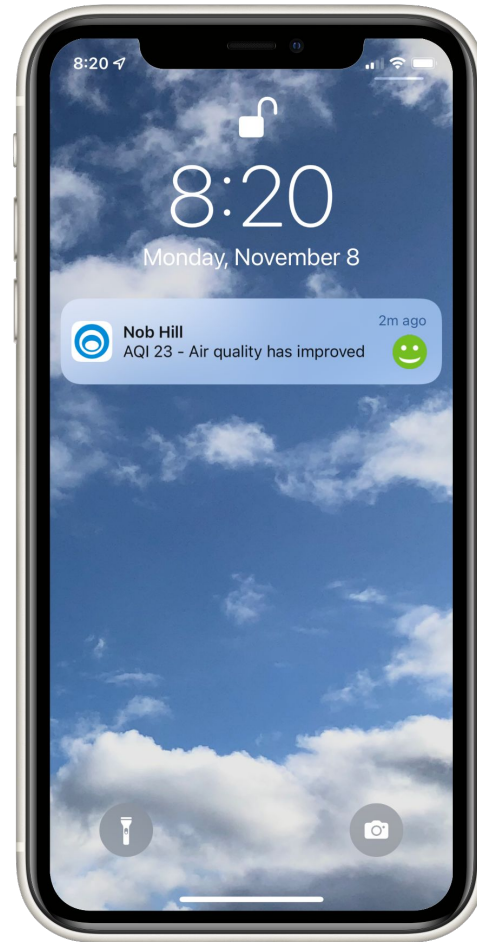
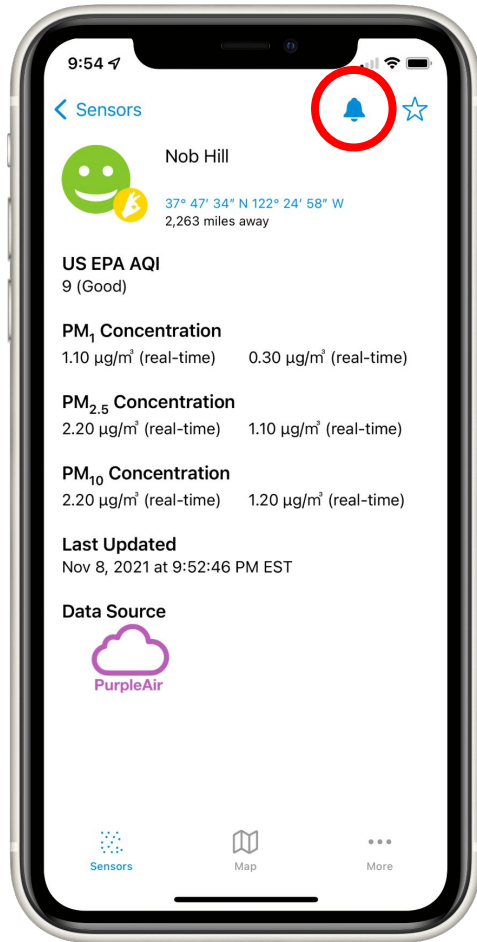
PurpleAir sensors report an AQI index value (US EPA) every two minutes.

Other sensors report AQI different periodic intervals.



| Local Haze sensor reading | Description |
|---|--------------------------------|
|  | Good |
|  | Moderate |
|  | Unhealthy for sensitive groups |
|  | Unhealthy |
|  | Hazardous |

| Local Haze confidence | Description |
|--|-----------------|
|  | High confidence |
|  | OK confidence |
|  | Low confidence |



Challenge with notification cadence

- App reads PurpleAir sensor data which updates every two minutes
- AQI reading near the boundary of the index range causes oscillation back and forth across the boundary
- This oscillation caused too many/too frequent notifications for sensor readings on boundary between two index values



User feedback on the feature

- Worked with ten users on a beta release
- They complained that notifications were occurring too frequently
- Developed algorithms to smooth out notification cadence by filtering appropriately
- An ongoing process of continual refinement

Design challenges

- What is the correct way to notify for a specific sensor?
- How to filter too frequent notifications?
- Should notifications remain persistent or should they be ephemeral? (i.e. fade away)



LESSONS

Lessons learned for UX for monitoring air

Understand the user's needs and journey

Example journey map for Local Haze app for iPhone with monetization

Channel: mobile device End-to-End Subscription UX (Persona: Air Quality Enthusiast)



Social

Click on referral link

Search

Click on result

App Store

Install application

Launch

First launch of application

Onboard

Welcome Experience

Browse

Browse AQ sensors list

Drilldown

View sensor data details

Favorite

Tag favorite sensors

Purchase

Maintain subscription

Share

Global AQ sensor maps



Example metrics

of Referrals

of Installations
% of Onboarding completed

of Favorite sensors tagged

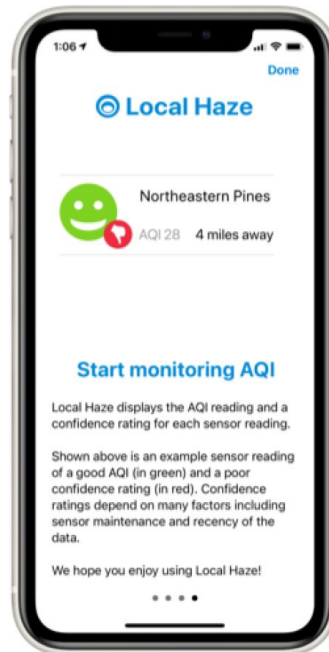
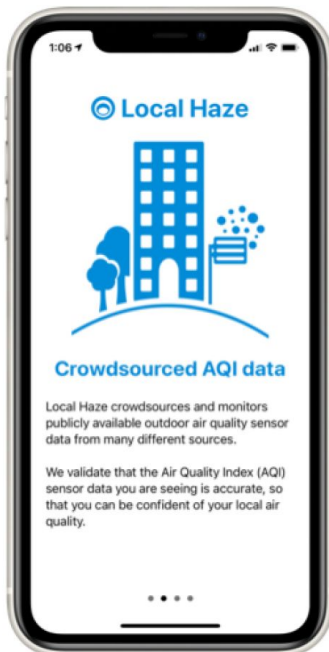
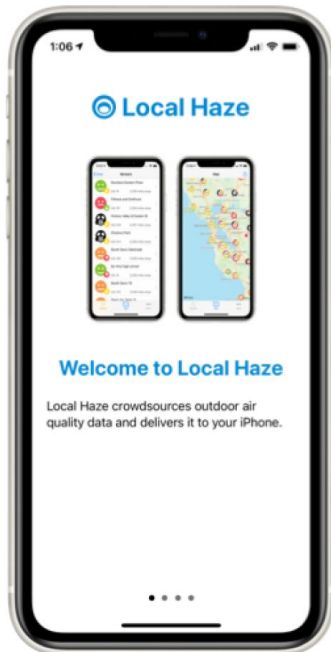
of purchases (Subscription metrics, AAR etc)

of maps shared

HUMANLOGIC
humanlogic.com

Updated onboarding flow for Local Haze app

New panel explaining confidence rating









HUMANLOGIC
humanlogic.com

Ease of use as a core attribute

Branding applied to user experience elements in the Local Haze app

PRODUCT UI ELEMENTS: AIR QUALITY INDEX (AQI) RATINGS

| | | | | | |
|--|---|---|---|---|--|
|  |  |  |  |  |  |
| Good | Moderate | Unhealthy for sensitive groups | Unhealthy | Hazardous | Error state |

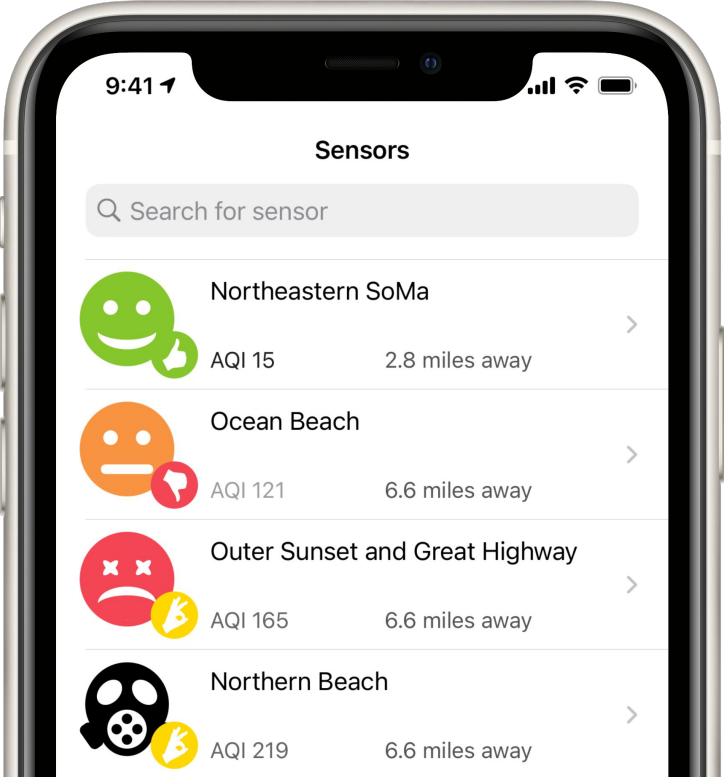
CONFIDENCE RATINGS ON AQI READINGS

| | | |
|--|---|---|
|  |  |  |
| High Confidence | OK Confidence | Low Confidence |

CONFIDENCE BADGE ON AQI RATING

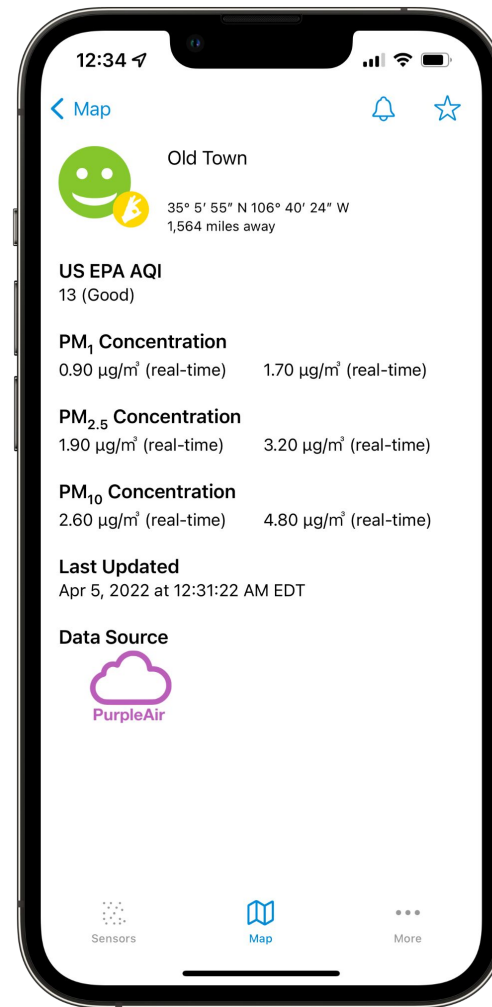
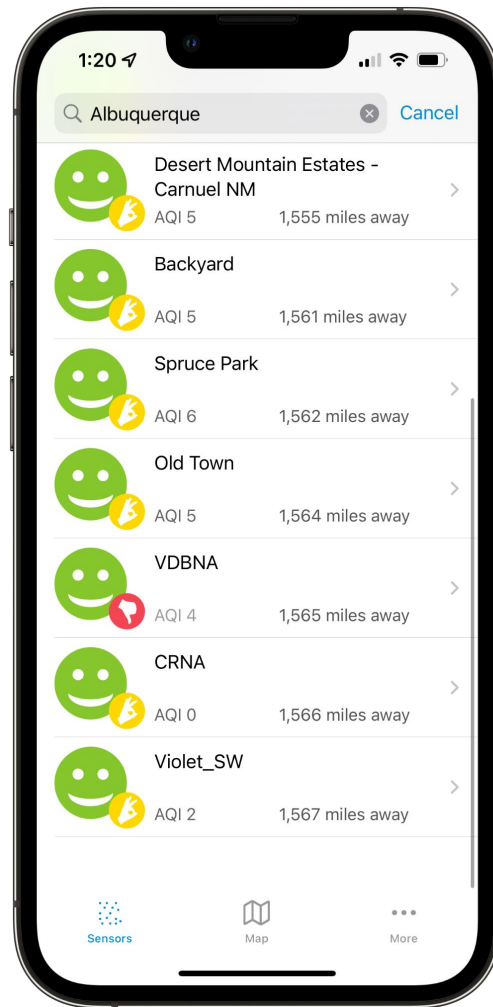
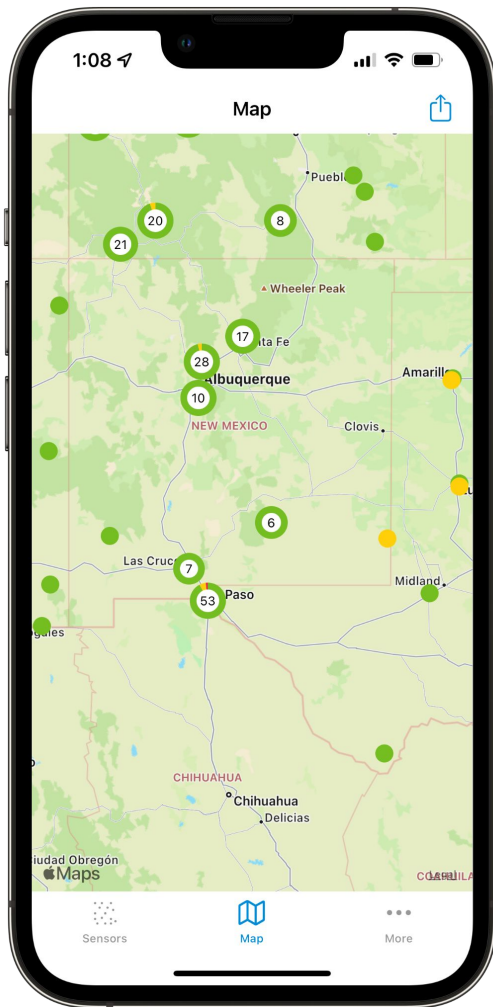


Moderate AQI with High Confidence



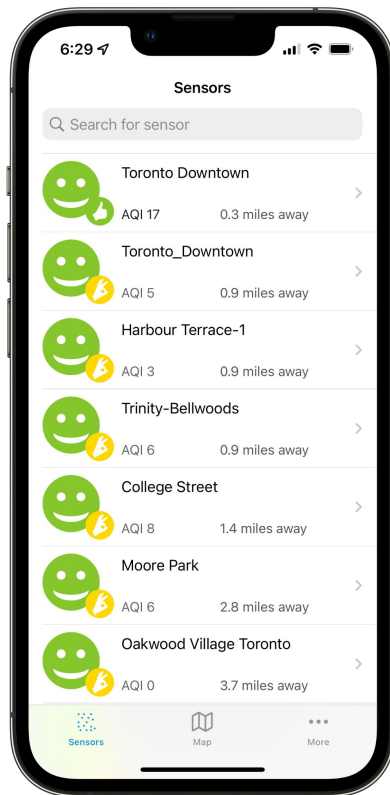
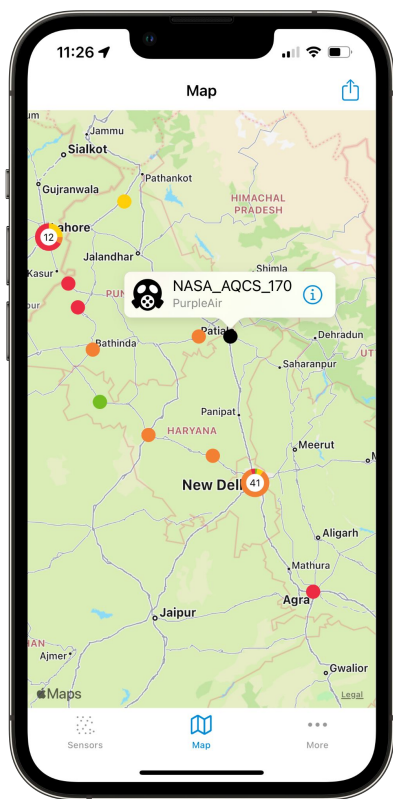
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**Match the interaction model to the
user's needs**



Solve for applicable scale

Solve for scale: entities, geography, data quality, time

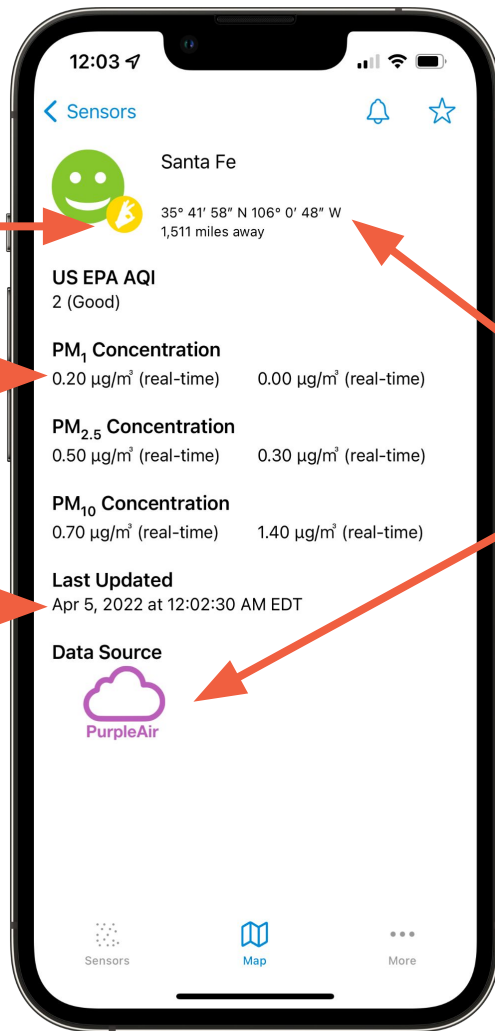


**Understand what attributes of the data
impact perception of “trustworthiness”**

Confidence

Precision

Recency



Transparency



Ratings and Reviews as of April 2022

4.6

out of 5



26 Ratings

- Over 30,000 sensors across six continents
- Increases in downloads due to events like wildfires

What Local Haze users are saying:

"I downloaded Local Haze last week while in Lake Tahoe where the fires are happening. The app really helped me to understand the quality of the air while I was there."

Nick M.

 **Local Haze**



TorCHI

INTERACTIONS @SCALE FOR MONITORING AIR

Thank you!

Any questions?

