SMART CITIES + ACTIVE CITIZENS

PROJECT BY

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INTRODUCTION

This report describes my Master's project, in which I explored how runners might use sensor networks and open data in smart cities to better plan their running routes. This involved researching existing projects and theory of smart cities, user-centered design and ethnographic research with runners, and the design, development, and testing of an interactive prototype.

The purpose of this project was to explore what could be, and in doing so discover what would be helpful for runners and what would be required of smart cities to make it possible. Specific goals of the project were 1) to explore specific use cases of data generated by and for the smart city, 2) bring together different approaches to the smart city, and 3) discover how runners might benefit from smart city data.

BACKGROUND

1. SMART CITIES

A “smart city” can mean many different things, depending on who you ask. Anydefinition or example might include improving government efficiency [ibm rio],enhancing public services [big belly], providing communication [Better Reykjavik, madame mayor], revising transportation methods [Smartquesina, cycle atlanta], promoting education [shelton actually existing], developing data dashboards [city dashboard], or something else entirely. To help explain the context and focus of this project, I will briefly discuss three non-exclusive approaches: IBM, Anthony Townsend, and Atlanta.

In an executive report, IBM describes how “(Cities) can improve their current service delivery capabilities (as well as lay the foundation for new and expanded services) by making their core systems – transport, public safety, government services, education and health – “smarter.” This can be achieved through the application of advanced information technology, analytics and systems thinking to improve how a city works and how it stimulates a thriving, knowledge-driven economy [].” Note the emphasis on “core systems”; the focus here is on using technology to improve government operations.

Alternatively, Anthony Townsend defines smart cities “as places where information technology is combined with infrastructure, architecture, everyday objects, and even our bodies to address social, economic, and environmental problems [].” This view is broader than what IBM presents; it is not specific to government operations and is problem-centric.

SmartATL, the focus of the City of Atlanta’s smart city efforts, describes their strategy like this: “In utilizing a data-centric model, we are able to use descriptive, prescriptive, and predictive capabilities to radically improve city operational efficiency, service delivery, and transparency [].” Through SmartATL, a number of projects are in progress. One of these is an effort to “deploy over 100 connected devices/sensors on North Avenue to baseline mobility, public safety, and sustainability KPIs (Key Performance Indicators)[].” Beyond this general statement, there are no specific use cases for the data generated by these sensors. Most thinking is centered around how the government might use the data, and little around how residents might interact with the data. This led to the identification of the first goal, exploring specific use cases of data generated by and for the smart city.

While SmartATL aligns more with IBM’s approach to smart cities, by focusing on improving “city operational efficiency” which is essentially “making core systems smart”, these three approaches are not in

opposition to each other. Rather, they target different elements of a smart city. Using Townsend's definition, particularly the emphasis on everyday objects and problems, I endeavored to explore how data generated from SmartATL's North Avenue sensors might be used by residents in an everyday capacity to solve a set of problems. This emphasizes the second goal of the project, to bring together different approaches to the smart city. While I primarily use Townsend's approach, I also used SmartATL's government-centric sensor deployment as a foundation.

2. RUNNERS

I selected runners as a specific group of residents in Atlanta for three reasons. First, they are active and healthy. This lifestyle promotes a "healthy" city, which is generally understood as a desired quality for a livable city. Second, runners move through the city as a pedestrian. This is a means of transportation, and is indirectly a way of informally evaluating pedestrian-friendly infrastructure. Third, many runners already use data, particularly when they track their mileage, pace, heart rate, etc through watches and smart phones. Data is information technology, which is something shared by any approach to smart cities.

As many runners are already familiar with data, they are familiar with the technology that exists for them. This general application domain includes watches by Garmin and Fitbit, smartphone apps, and web-based tools. In summary, the existing digital tools for runners can be divided into two categories: one that facilitates personal data collection and another that facilitates route planning. Within personal data collection, there are tools facilitate tracking general health and journaling.

However in my review, I focused on data collection tools that runners use while running, because this is situated directly in their environment. There are a variety of Garmin watch models - all track data like mileage, time run, and pace. Certain versions include heart rate. At this point, all models allow for exploring generated data on Garmin Connect - the online platform where runners have an account to view their data history and trends. Fitbit and Apple Watch are newer competitors. Fitbit technology is primarily based around counting steps, only recently have Fitbit models included GPS. Apple Watch struggled with the running population when first launched as it required the user to carry their phone for full capabilities. Apple Watch Series 2 now has GPS which makes it more of a competitor. The other main tool is a smartphone application, most of which also track mileage, time run, and pace. Apps include Mapmyrun, owned by Under Armour, Strava, RunKeeper, Endomondo, and Nike+. A competitive analysis is included in **APPENDIX ?**

USER RESEARCH // PHASE I

1. OBSERVATIONS

Prior to any other user research, I spent one fall morning walking on the Atlanta Beltline to observe runners. This provided a chance to see the users in their environment, allowing an opportunity to generate questions and gain an overall understanding. A few moments were notable.

First, I saw two runners not using the provided sidewalk - one near a construction site and another on a dirt path next to the concrete Beltline. Based on personal experience, and later confirmed in interviews, runners care about the surfaces they run on. Particularly if they are high-mileage runners, concrete creates the hardest impact and potentially leads to injuries. Dirt, and even asphalt, are softer and thus easier on the body.

Second, I saw people running together in a group, which raises questions around how groups are formed and how they coordinate their runs together.

Third, I saw runners using Camelbaks, or backpacks with water, as well as belts with water bottles, which highlights the need for runners to have access to water.

Fourth, I noted runners with watches and other runners with phones strapped to their arms.

Fifth, I noted runners with and without headphones.

Sixth, I noted how runners move around other users of the Beltline, such as walkers, cyclists, people with strollers, etc.

DESIGN // PHASE I

To facilitate and enhance my planned interviews with runners, I did some initial design work beforehand, including a mockup in Balsamiq, a fictional scenario, and sketching. The main motivation behind this work was to help my interviewees understand the concept of smart cities. Naturally, this led to some bias, which I will address later.

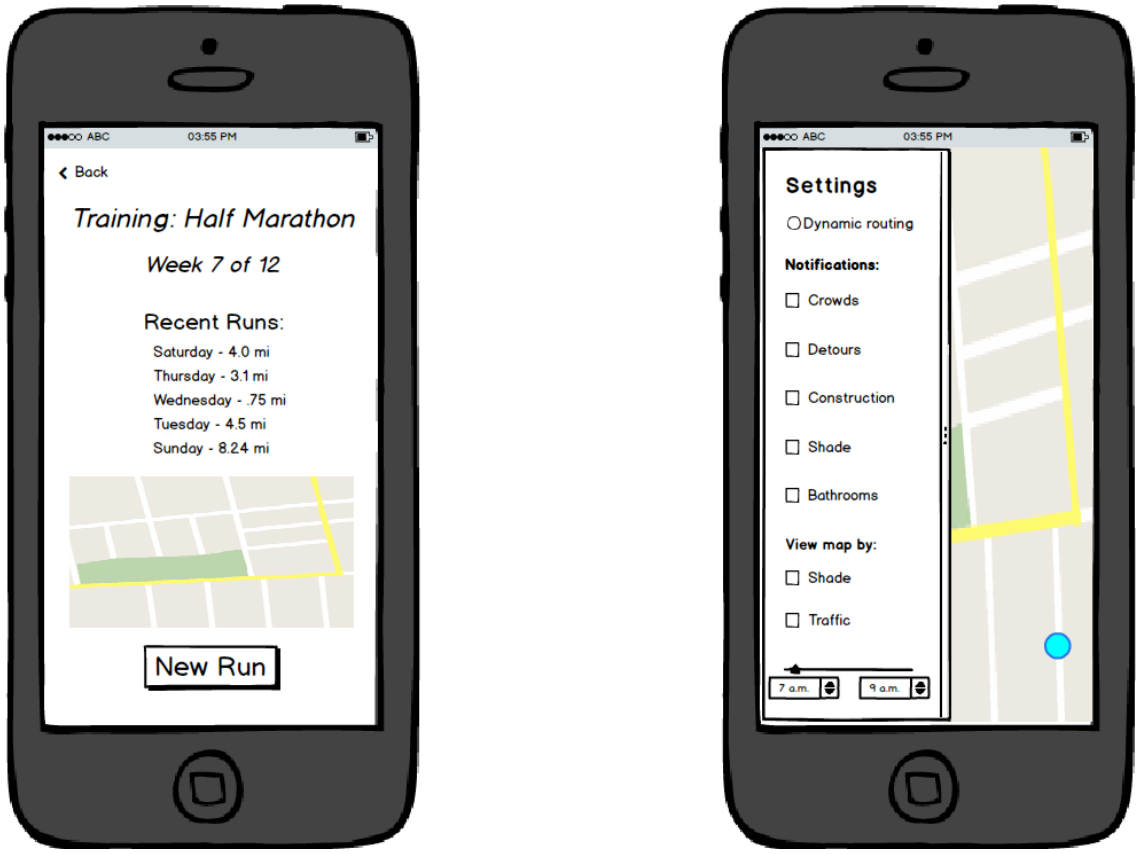

FIG. 1: Balsamiq Mockup

The mockup in Balsamiq draws general inspiration from existing digital tools for runners, but does not include any specific features. The screen on the right shows how a runner might turn on notifications to learn about city data that might be relevant to them.

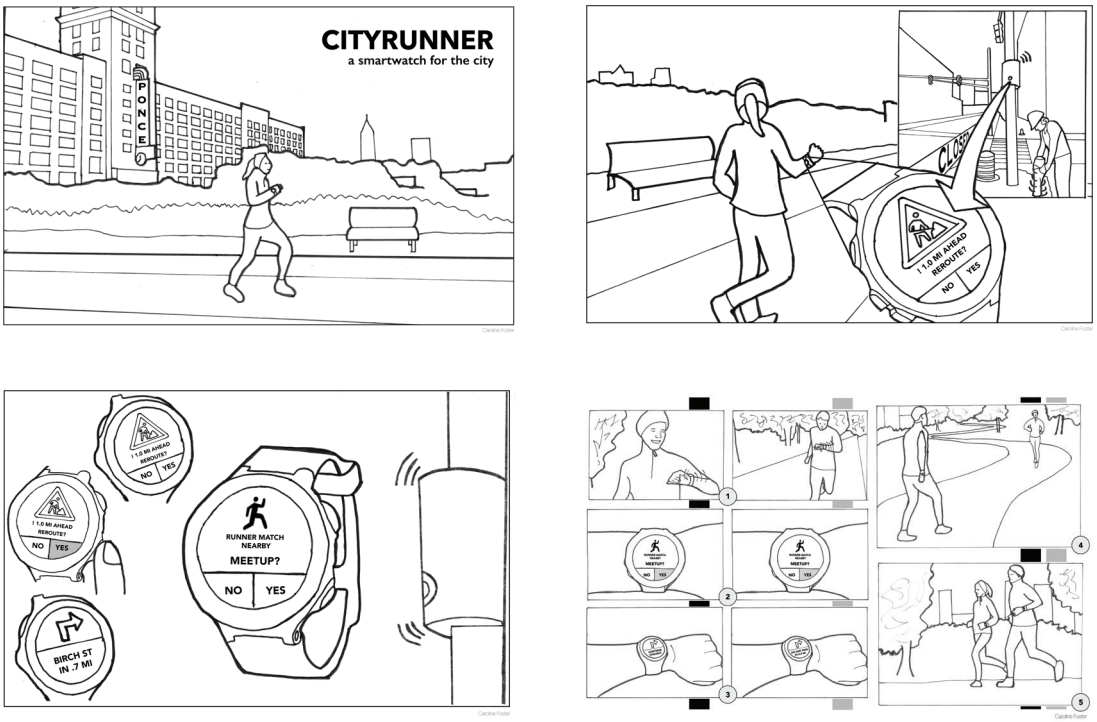

FIG. 2: Concept Sketches

These sketches illustrate various ideas. The top right sketch shows one including a runner receiving a notification about construction that is blocking her normal route one mile ahead. The bottom right illustrates a social concept of facilitating runner meetups. This one I abandoned fairly quickly, as it does not integrate any use of city-related data.

Finally, I wrote a one-page fictional scenario which I presented to runners in the interviews. The goal of doing this was to facilitate the runner's creativity and imagination on what could be. The scenario can be found in **APPENDIX A**.

USER RESEARCH // PHASE 2

1. INTERVIEWS

Referring back to the specific goals of the project, particularly the goal to discover how runners might benefit from smart city data, I decided to conduct semi-structured interviews. I could not assume the user population of runners would understand the idea of smart cities, so having an in-person conversation would be most effective in terms of providing clarity. I entered this project with a direction, but I also wanted to leave the research process somewhat open-ended to hear everything runners had to say.

To facilitate these interviews, I created a printable guide. This can be found in **APPENDIX ?** Before speaking with the primary set of participants, I interviewed two Georgia Tech HCI students and one professor, all of whom are runners, to refine the guide.

To find participants, I reached out to the Atlanta Track Club. ATC is "a member-based organization centered around running that delivers world-class events, training programs and community outreach activities to the Metro Atlanta Area." The interviews were done over four separate days over a few weeks, for a total of 17 participants. The first day was done at ATC's headquarters, where I spoke with two elite runners and three staff members, who are also runners. The remaining days I interviewed runners participating in ATC's half and full marathon training programs. The timing lined up well, with the runners training for the Publix Marathon on March 19. All interviewees live in Atlanta or the metro area, and those taking part in the training program pay a fee to participate. This decision was based on convenience of accessibility to a large group of runners with structured meeting times, as well as the fact that all participants would have experience running in the city.

I spoke with the runners in the training program at their organized runs at ATC's headquarters, and Candler Park. Participants were selected as I approached the runners when they completed their run. Some were done one-on-one, others in pairs, and one set in a group of three. This was convenient to both myself as a researcher and the participants, who often liked to stay after their run to stretch and chat. It also provided the benefit of runners being able to think about their most recent run, and generally be in their "running" mindset.

The structure of the interview involved first getting to know the participant's experience with Atlanta (How long have they lived in the city?), then getting to know them as a runner (How long have you

been running? What's your weekly mileage?), understanding their experience with technology as a runner (Do you track data? Own any wearables?), and finally asking about their experience running in Atlanta. Before this last section, I presented the initial design artifacts I created - including the fictional scenario and mockup. This was to help them understand the concept of smart cities and how it might relate to them as a runner. In the last section, I asked them to think about and describe where they run, what their frustrations are, etc. I also specifically asked about categories of data that might be generated from the SmartATL sensor deployment, such as the number of pedestrians, humidity, and brightness. This naturally led them to think about these specific things, but it also successfully helped them generate new ideas or mention other data points that I didn't explicitly mention.

2. RESULTS

For each of the interviews I completed, I took notes on my printed interview guide. This, plus an audio recording in some cases, comprised the raw qualitative results of the interviews. To analyze them, I inputed the runner's demographics into an one collective Excel sheet. Each runner received their own row, and multiple columns were dedicated to categories of "Runner Information", "Runner's relationship with technology", "Runner's use of data", and "Interested in". "Interested in" includes 19 columns which contain things or data points runners expressed they care about - and each row for the runner includes a 1 or 0 indicating they specifically did or did not express interest in, respectively. THIS SHEET CAN BE FOUND IN APPENDIX ?

Using the analysis described above, I noted three main points to aid design. First, types of runners, second, things runners care about during their run or along their route, and third, an apathy or disdain towards technology. Finally, I generated five design requirements from the qualitative data, described in the following section.

From the results, I identified four types of runners: Beginner, Casual, Competitive, and Elite. They vary based on how many miles they run a week, what their training priority is, whether they run with a phone, Garmin watch, or nothing, and who with. Based on these needs, I decided to focus on everyone except for Elite runners as their needs are extremely different from non-professional runners.

Runners expressed interest in either knowing or improving things related to safety (in general), safety (at intersections), traffic, sidewalks, crowds*, construction*, stopping at intersections, temperature*, air quality*, surfaces, shade*, events*, bathrooms and/or water, and crime states. The * means I specifically mentioned it during the interview, and thus the participants might have mentioned it more than they

would have if unprompted. In summary, runners care about their safety (generally, at intersections), anything that obstructs their route (crowds, construction, stoplights, events), and their comfort (temperature, air quality, surfaces, shade, bathrooms, water).

It's also important to call to attention how many runners verbally expressed apathy or disdain towards technology. One runner said "I don't pre-plan my routes based on what's going on, I kind of just go on my run." At least 4 other runners said something similar, including phrases like "We're not high tech" and "I don't know if I want something (technology) barking at me." However, all of these runners also owned a wearable and tracked their data. This suggests that while the participants don't want an overdose of technology, they might be open to a certain amount if it calls their attention to obstructions on their typical route or allows them to stop less at traffic intersections.

3. DESIGN REQUIREMENTS

1. Should not be dependent on runners using WATCH OR PHONE during run.

17 of the 17 runners own smartphones. 11 carry their phone with them during their run. 12 runners use a GPS watch when they are running. This means some runners who use a watch also carry their phone. The 6 who said they do not run with their phone are highly opposed to running with it - citing it as an inconvenience to carry and/or having zero desire to interact with it during their run. For these reasons, the design should not require use of a phone during the run or the use of a watch, since not everyone wants to carry their phone and not everyone uses a watch.

2. Should require MINIMAL INTERACTION w/ tech during run.

6 runners expressed they do not want to be "bothered" by technology during their run. Therefore, they probably want to interact with it as little as possible.

3. Should enable runners to MAKE DECISIONS to improve personal safety.

Based on what the participants said they care about, they should be able to make decisions to feel safer during their run.

4. Should enable runners to PICK ROUTES with minimal obstructions.

Based on what the participants said they care about, they should be able to pick routes with minimal obstructions and be aware of obstructions when they are blocking their typical route.

5. Should enable runners to PLAN for comfort.

Based on what the participants said they care about, they should be able to plan their runs around bathroom and water availability.

4. DESIGN DECISION

Based on these findings and the user requirements, I decided to create a route planning tool for pre-run use. This allows for the majority of technology use to occur before the run, and potentially allows runners to make plans based around the challenges they face running in the city.

5. COMPETITIVE ANALYSIS, V2

As previously discussed, I explored existing digital tools for runners. I first focused on the category of tools facilitating data collection, the watches and smartphone apps. However, upon deciding to create a route planning tool for runners to use pre-run, I added to the competitive analysis existing digital tools that facilitate route planning (see appendix). I looked at Mapmyrun, Route Loops, Strava - including their Global Heatmap and beta Route Builder, USATF, and Mapometer. For each, I noted their features and capabilities, what the user can input or control, and subjective positives and negatives about the interface.

For example, Mapmyrun provides a feature to randomly generate a route and Strava provides a feature to see where other people have run. Based on interviews, product reviews, and personal opinion, I noted that Strava's approach is preferred since it shows where people actually run. On the other hand, Mapmyrun's random routes generated paths through less desirable areas in Atlanta. The use of "desirable" is entirely subjective and is based on the general safety of the area and the road type.

DESIGN // PHASE 2 + PROTOTYPING

1. EXPLORATION + LOW-FI PROTOTYPE

After exploring the existing market, I decided to build my design on top of existing solutions for three reasons. First, a few of the tools I examined, particularly Mapmyrun and Strava, already have a relatively decent interface. This judgement is purely mine and not based on any specific user research, however, based on the significant user base and the breadth of the companies behind them, I feel confident in this decision. Second, it does not add significantly to the amount of technology in the runner's lives. Third, by using an existing interface following a familiar format, runners can easily learn the new features rather than having to learn an entirely new system.

After deciding to add robust features to an existing platform, I chose to specifically expand Strava's tool. I chose Strava for three reasons. First, it provides the cleanest interface in terms of minimal detail and is the most modern. Second, runners are more unfamiliar with this platform than Mapmyrun, for example, and thus they will hopefully be less constrained by their reality. Runners are less familiar with this platform because Strava's first user base was cyclists, and they've recently expanded to include runners. Third, Strava is working on providing governments with data generated by its users to aid cities in planning, so it fits within the project's smart city space.

My prototype went through two major iterations, with many smaller modifications throughout the process. The first iteration was using paper and index cards. I printed out Strava's existing interface, and built new panels on top of it with index cards.

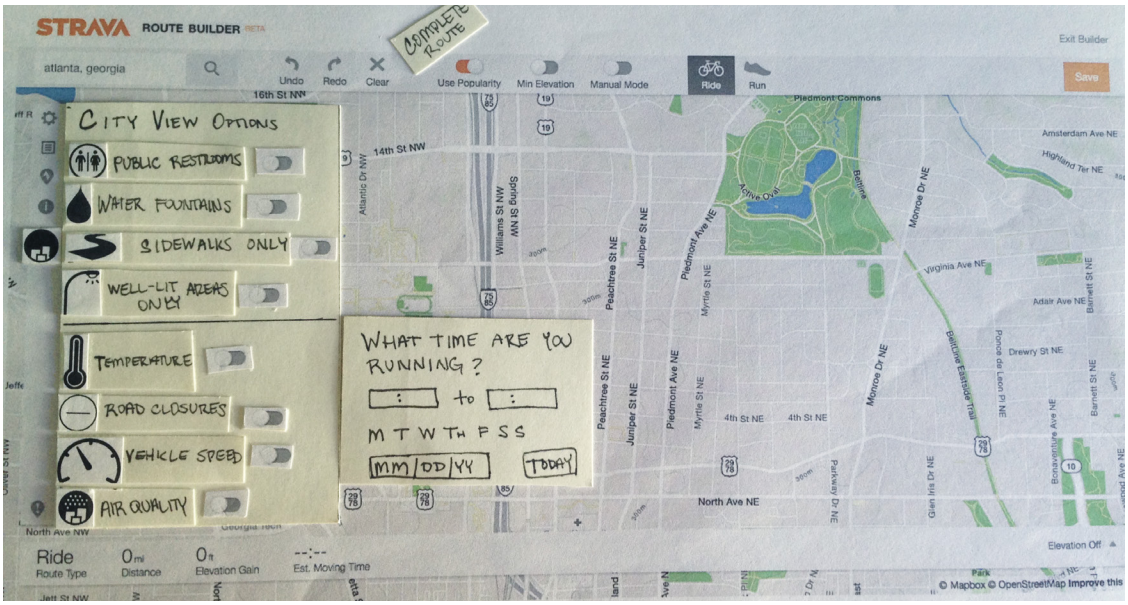

FIG. 3: Paper Prototype

The main panel “City View Options” included toggles of city features that are important to runners. The data on these features can be separated into three categories. First, data that can be generated by the existing sensor box in its current form (temperature, well-lit areas), second, data that might be generated by a sensor box with additional sensors (air quality, vehicle speed, road closures), and third, data that will likely exist in a database and not be generated by a sensor box (public restrooms, water fountains, sidewalks). Initially, I determined only 4 data points would be dependent on time (temperature, road closures, vehicle speed, and air quality).

I tested the initial prototype with my advisor, Carl DiSalvo, and classmates. This was done through the users “turning on” the toggles by “tapping” them and then myself placing the relevant map icons on the printed interface. Based on feedback, everything might be time dependent. For example, water fountains might be shut off in the winter or public restrooms only open during a park’s open hours.

2. FINAL PROTOTYPE

Following the paper prototype, I implemented an interactive prototype using a combination of Sketch and Axure. This allowed for a mid-fidelity prototype which was appropriate for the first round of user testing. It did not take an excessive amount of time, as developing a fully-functioning code-based interface would have, and kept it simple for future modifications. It also provided just enough fidelity for users to believe it was a real interface.

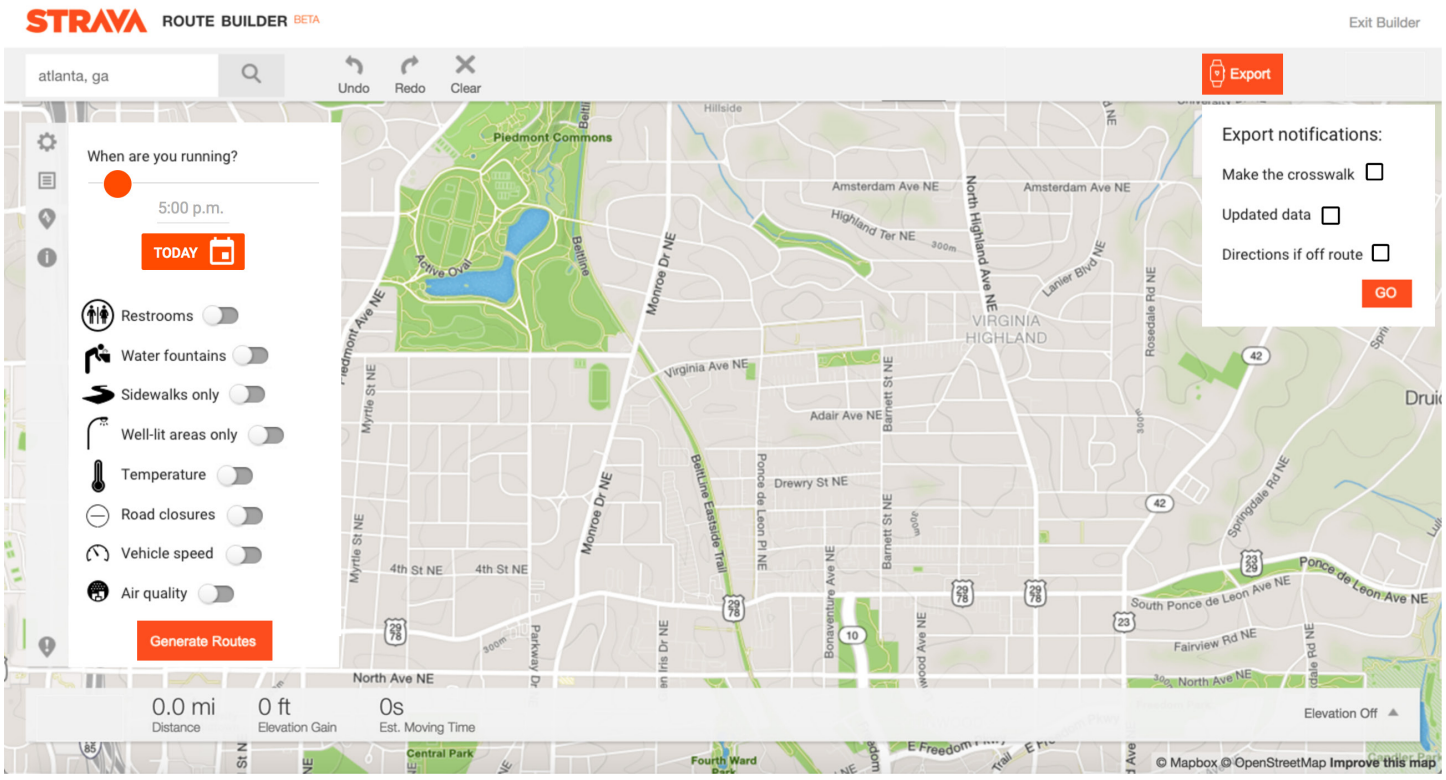

FIG. 4: Initial State

In addition to the “City View Options” I first included in the paper prototype, I added two significant features. One is the “Export to Watch” feature, with three notifications the runner can choose from. Here, “watch” is inclusive of a matching mobile app if the runner chooses to use a smartphone instead. If the runner selects any of these and clicks the button, then the selections along with the created route are sent to the watch. “Make the crosswalk”, if activated, would send the runner notifications to increase or decrease their pace when they are a certain distance from the intersection in order to cross the street before the walk signal turns off. “Updated data”, if activated, would provide the runner with any changed data points along their upcoming route. “Directions if off route”, if activated, would provide directions to get back on their chosen route if the GPS detects they are not following it.

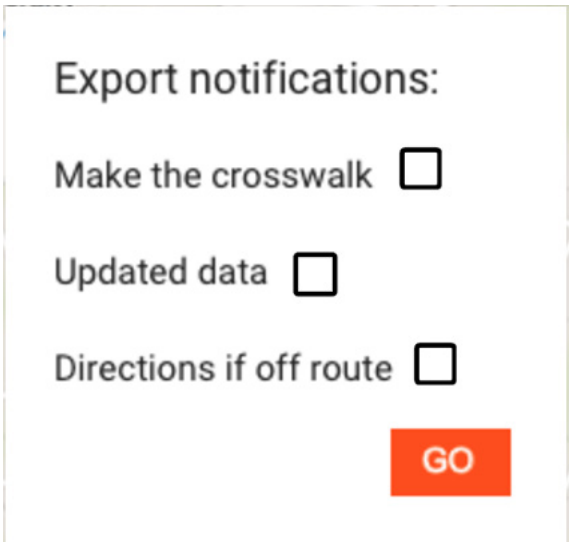

FIG. 5: EXPORT NOTIFICATIONS

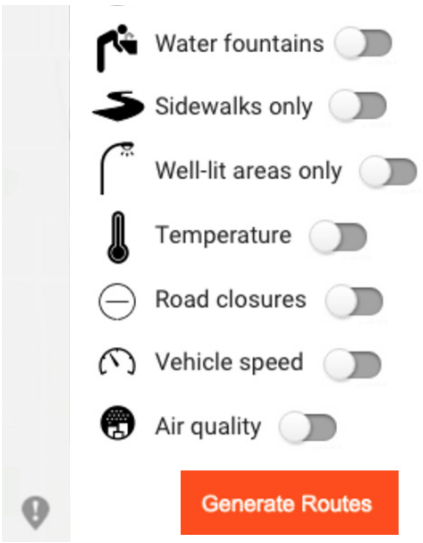

FIG. 6: GENERATE ROUTES

The second feature I added is the “Generate Routes” button which takes into consideration user preferences and desired mileage to create a route for them. This is an alternative to the method of plotting and connecting points to create a custom route.

I used Sketch to create the visual assets, including additional buttons, and highlights for well-lit areas and sidewalks only. These were all designed on top of a screenshot of Strava’s existing interface. I used Axure to add animation, interaction, and states based on the conditions. Because the main goal was to test the features centered around city data, I did not recreate any of the functionality that already exists in route planning tools, like clicking on the map to build a custom route or viewing the route’s elevation profile. This would also have been redundant since it already exists and many runners are familiar with the tools and how they work.

Additional screenshots of the interface can be found in APPENDIX ?

USER EVALUATION

I tested my prototype with 5 runners in ATC's half or full-marathon training program. No one I tested with was one of the 17 previously interviewed. The testing took place at ATC's final Saturday training before the half or full-marathon race, at Philippides near Piedmont Park. I recruited the 5 participants by approaching them after they completed their run, as they were stretching or chatting with fellow runners, or they approached me. Since the runners likely did not have their personal laptops with them, I brought mine with the prototype which was used for testing.

The testing involved a few initial questions, similar to the needs-gathering interviews, to understand them as a runner and their relationship with technology. These questions can be found in APPENDIX ? I then gave them tasks to complete with the prototype, and asked follow-up and clarification questions (see appendix for script/questionnaire guide).

The testing was more qualitative than quantitative for a few reasons. This is primarily because I was not concerned about quantitative metrics like the time it takes to complete a task. At this point in the design phase, I was more focused on how runners understood the integration of city data into the existing platform, which is harder to measure quantitatively. Therefore, I created tasks divided into two sections. First, I had the participants turn on the toggles in the city panel, use the time slider, and finally use the "export to watch" button. Second, I described a short scenario for which, if completed successfully, would lead them to turn on some toggles and click the "generate routes" button.

RESULTS

For analysis, I created an Excel document with the questions and answers from the participants. The columns include participants' answers in direct quotations, and my observations as a researcher including general comments and what the participant did for the task. The Excel document can be found in APPENDIX ?

One participant had not used mapping tools for his run and was unfamiliar with how to operate a Macbook, so his answers varied greatly from the others and were primarily focused on Strava's initial interface or the Macbook interface.

For the tasks, I noted general observations rather than specific time or ability, again because it was not the main focus. All five participants completed the task of toggling the data features without asking any questions and without noticeable delay. One participant didn't notice the "Generate Routes" button when given the scenario-based task, until I pointed it out.

I also noted how participants understood the phrasing of the three export notifications (see FIG. 5). 2 understood make the crosswalk, 1 understood updated data, and 4 understood directions if off route. I asked the users to pick between having routes generated for them or making their own route by plotting points. 3 explicitly preferred the former.

Two of the follow-up questions I asked participants were to pick the top 3 data points they would use the most, and to state anything they felt was missing. For the first question, 5 participants included sidewalks, 4 restrooms, 2 water fountains, 2 well-lit areas, and 1 vehicle speed. For the second question, 2 mentioned elevation, 2 the number of major roads to cross, 2 the sidewalk changing the side of the road, and 1 safety, beyond well-lit areas.

DISCUSSION + CONCLUSION

1. FUTURE WORK

Based on the results, I identified four specific ways to improve the design. Making these changes does not make it complete.

First, taking time and effort to explore the order and placement of the toggles for each data point would be worthwhile. The order should be based on user priority, with the points most runners are concerned with in the most prominent location.

Second, additional information in general needs to be provided. Some of this information might be immediately readable, and other information might be one interaction away, such as hovering over an item. Additional information that should be considered includes, but is not limited to, the reason for the road closure (event name, construction, etc), details about each data point (what the bathroom is, exactly what "well-lit" means, what makes up air quality), and in non-technical terms, the algorithm behind the "Generated Routes" results.

Third, a design to allow users to input their desired thresholds for each toggle, such as max temperature, to enable to "Generate Routes" feature.

Fourth, the phrasing of the notifications for the "Export to Watch" feature need serious copy consideration.

I focused my efforts solely on the web interface, and left any interaction with the watch, or smartphone, to future work. This would involve notably different considerations involving the design of wearables. For example, attention would need to be devoted to how notifications are received (audio, vibration) and the constraints of a small interface on a watch.

Additionally, there are other extensions of the platform that are worth exploring. The data in this iteration are assumed to be generated by the sensor boxes or already (or possibly) exist in some city dataset. Another potential way to generate data is through crowdsourcing by users from the platform, whether actively by the participants or interpreted from the data they generate. The design could be extended to and modified for other active citizens, including walkers and particularly cyclists.

2. RECOMMENDATIONS

Notably, all five user testing participants included sidewalks in their top three data points. The most logical conclusion would be that runners should run in areas blessed with a plethora of sidewalks, or more generally, paths. However, what happens when they don't exist? The frustrations participants mentioned when discussing sidewalks, such as the lack of sidewalks, sidewalks switching sides of roads, and poor conditions leading to tripping, illustrates Atlanta's limited pedestrian-friendly areas.

Also notably, none of the runners testing the prototype were interested in air quality. Overall, runners were more interested in data that would not be generated by the planned sensor boxes, such as sidewalks, and restroom and water fountain locations. Well-lit areas and vehicle speed were the only points in any of the runners' top three interests. The brightness sensor addresses the first point, and as of now the camera and microphone would have to be engineered to sense the second, rather than a sensor specifically for vehicle speed.

From these observations and relationships, we can draw a few conclusions and recommendations for the city and for the runners.

For the city, we can recommend prioritizing open data and pedestrian-friendly infrastructure. In the case of runners as a group of residents in Atlanta, open data is more important than sensor boxes. The prototype of this platform could exist using data that is not generated by the sensor boxes. However, it could not exist without an open data platform that is available for third party developers to build with. The emphasis on sidewalks and overwhelming consensus from the user research leads to a recommendation of solving the root problem - creating more pedestrian-friendly areas. Again, this is one project within the broad space of smart cities, so a final recommendation would be to explore how other residential populations might benefit from the smart city data.

For the runners, the results from the prototype testing indicate enough interest to proceed with the design and development of mapping tools with city data. It is reasonable to conclude, that even if Atlanta rises to the challenges of creating pedestrian-friendly environments, certain challenges for runners will remain. For the foreseeable future, there were will be crosswalks to cross, bathrooms and water fountains to find, and speed of vehicles to worry about.

REFLECTION

I spent a significant amount of time devoted to background research and user research. I am pleased with this outcome as I have accepted a position where I will be a UX designer first, and a researcher second. In this position, I am guaranteed to hone my design skills, so it was ideal to focus on my research abilities in this context. I learned techniques and practiced analyzing qualitative interview results.

Having a project that extended two semesters gave me perspective on longer timeframes that many companies work with. If I include my independent study course on smart cities in general, then it's an even more extended timeframe. This, along with concurring work in DiSalvo's lab, provided me with an opportunity to learn about a complex subject and become more or less an expert.

I was lucky in that reaching my user population was incredibly easy, thanks to the Director of Community Outreach and Membership at ATC, Sue Payne. Interviewing the participants at their training events was a hectic, but honest, environment. Runners were in their running environment, which likely yielded higher quality interview results. It also provided challenges, such as finding chairs, speaking with people while they were stretching, dealing with interruptions, and the heat of the sun and the glare on the computer screen. I was able to relate this to my summer internship, where we interviewed baseball players in their practice environment. However this time, it was only me so I dealt with everything and made the decisions.

Finally, as even the table of contents of this document shows, I experienced a non-linear design process. While we are taught a process involving steps, we are also told that they are rarely followed in order, and rather it's a cyclical, messy process. Knowing this is helpful, experiencing it firsthand means we're more prepared for the "real" world.

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APPENDIX

APPENDIX A - FICTIONAL SCENARIO

Mallory groggily rolls out of her bed at 7 a.m. and throws on her Nike shorts and tank that she laid out the night before. She grabs her smartwatch and bluetooth headphones from the nightstand, both fully charged and already paired.

In the kitchen, she puts a slice of bread in the toaster for pre-run fuel and opens her running app on her smartphone. Even though it's officially fall, the weather still hasn't cooled off enough to her liking, which is starting to seriously interfere with her training for her second half-marathon. She pulls up a map of the area around her, selects "View by amount of shade" and constrains the timeframe to 7-9 a.m. A quick animation plays, informing Mallory of the shade in the area over the time intervals. Noticing some variation between streets and time, she decides to go out to the Beltline one way and back another.

Mallory then creates a new run to log today. Since she is relatively familiar with the area, she doesn't want a turn-by-turn route, but she does want today be informed during her run of particularly crowded areas and new detours or construction. To make this happen, she turns on "Dynamic Routing." She also pulls up the route preferences menu and makes sure she has notifications and suggested reroutes turned on for crowds, detours, constructions, and shade.

Previously, Mallory ran low-tech compared with the rest of her friends who run - she doesn't like carrying her phone since it's bulky and she only sometimes listens to music. However, a combination of frustration with her training not going well, new money from her first job out of college, and recent tech improvements encouraged her to give it a chance.

Eating her bread, now covered in peanut butter, she puts in her headphones and straps on her watch, walking towards the door. The watch does all the work, so she leaves her phone on the kitchen table. Shoes on, Brooks - nothing fancy - she leaves her apartment in the trendy neighborhood of Edgewood and starts her five-minute slow-run warmup down Hardee St. With her music playing, she sees a few other early birds driving down the street. Two blocks away from Moreland, her watch vibrates and she hears "Active construction now beginning at Moreland and Hardee." Not wanting to be delayed, or

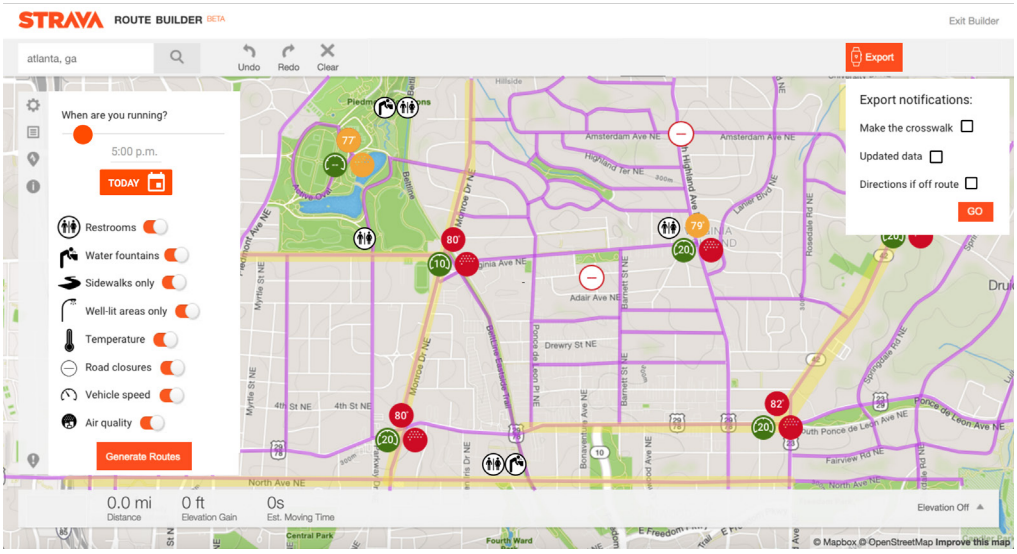
breathe in gross dust particles that she is probably allergic to, she takes a side street and crosses Moreland two intersections away from where she originally planned to.

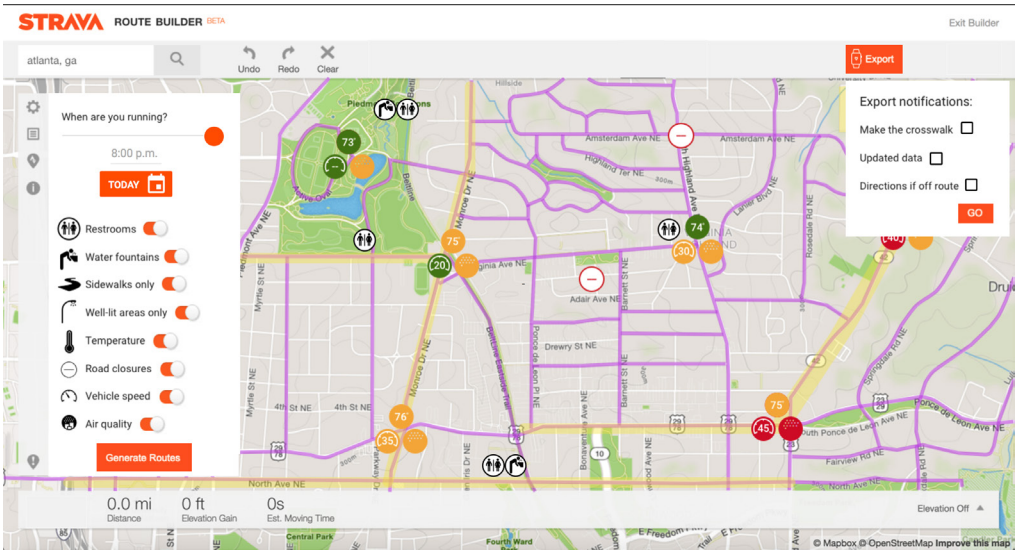
Now west of Moreland, Mallory continues to make her way to Krog Street Market, where she will pick up the Beltline to take all the way to Piedmont Park. Since it's still relatively early, she only sees other serious runners and some cyclists trying to get in the miles before there are too many pedestrians. Passing the empty skatepark, minus a group of yogis in the field next to it, she checks her watch to see she has gone 2.2 miles and is running at a 9:08 pace.

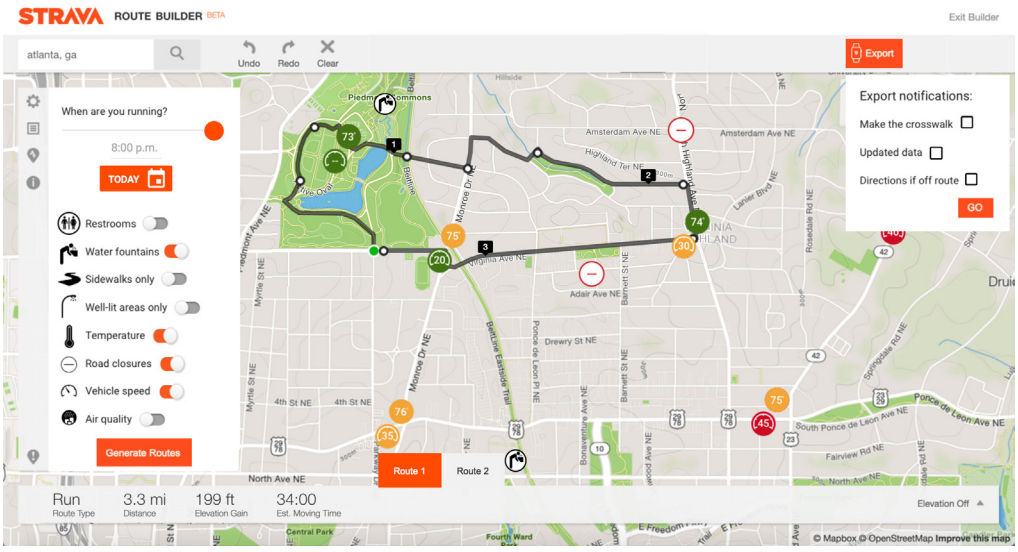
Once she passes Ponce City Market, it becomes a little more crowded since it's closer to Piedmont Park. However, there still aren't enough people to slow her down. Leaving the Beltline, she adds a few more miles in Piedmont Park. Then, about to return to the Beltline at 10th and Monroe, her watch vibrates again and she hears "Unusual crowds between this intersection and Ponce City Market." Thinking it must be some event that missed her radar, for this many people to be there after it was so empty, she begrudgingly continues towards the area since she wants to stay on the Beltline. As she approaches the crowded area, her music dies down so she can hear her surroundings more clearly. She sees people dressed for walking, and hears "We will begin The Walk in Her Shoes walk at 9 a.m." A bell rings behind her, so she steps slightly to the right to allow a cyclist to pass her. Soon past the crowd, her music returns to its original, higher volume, and Mallory enjoys the morning on the Beltline for another mile.

Upon leaving the Beltline, Mallory starts to retrace the route she took to start. Not a minute later, her watch vibrates and she hears "You are not on the route with the most shade. Would you like to receive turn-by-turn directions to put you on the route with the — " "Yes," Mallory responds and immediately hears "Take a right onto Chester Ave." She takes the turn, and leaves the directions on to avoid the increasing heat of the sun. Back at her apartment, she slows down and stretches, listening to her watch read out the stats of her run.

APPENDIX B - ADDITIONAL INTERFACE SCREENSHOTS







APPENDIX C - INTERVIEW GUIDE

Introduction *Understand participant's background, specifically in relation to the city and the environments they spend their time in. Understand them as a runner.*	
How long have you lived in Atlanta?	
Where do you live?	
What's your occupation?	
Where do you work?	
How do you commute to work?	
Do you own a smartphone? What kind? How comfortable are you with it?	
Do you own any wearables?	
Do you own any other tech? e.g. Amazon's Echo	
Tell me about your hobbies - what do you do in your spare time?	
How long have you been running?	

Introduction *Understand participant's background, specifically in relation to the city and the environments they spend their time in. Understand them as a runner.*	
How many miles do you run a week, on average?	
Do you run races? Train for them?	
What tech do you use while running?	
Before running? After running?	

Introduction *Understand participant's background, specifically in relation to the city and the environments they spend their time in. Understand them as a runner.*	
Do you track any data related to your running?	
What do you use Strava for?	
Do you listen to music while you run?	
Do you run solo, with a group, with a partner?	

Thoughts on scenario:

Key (LOCATION) Questions *Understand how the participant perceives (LOCATION) and the surrounding area, and what they might want to know through new sensors.*	
Find out location: Where do you typically run? For long runs?	
Think about (LOCATION) and the streets that surround it. What kind of information would you want to know about (LOCATION) and the surrounding neighborhood?	
Before coming here?	
Once you are here?	

Key (LOCATION) Questions *Understand how the participant perceives (LOCATION) and the surrounding area, and what they might want to know through new sensors.*	
Are there intersections that you dislike having to go through?	
Let's think specifically about the intersection of x and y. Can you describe that intersection to me? The activities that go on there?	
Is there anything that frustrates you while at (LOCATION)?	
The City of Atlanta is planning on installing environmental sensors at the intersection. They will will record things like temperature, light levels, sound levels, and pollution. Can you think of how any of that data might be of use to you?	
Is there other data that you would be interested in?	

Key (LOCATION) Questions *Understand how the participant perceives (LOCATION) and the surrounding area, and what they might want to know through new sensors.*	
Is there another intersection you would be interested in learning about?	

Use Case Questions *Understand specific ways in which the participant might want to make decisions based on the data.*	
Do you take walks or run in the city? (If yes) Do you consider anything like temperature before you go? Air quality? Crowdedness?	-
When you are driving/cycling/walking to a place, what influences your route choice? Road conditions? Sunlight/shade?	-
Do you make decisions about where to go based on how crowded a place may be? How noisy it may be?	-
Think about the location of your house/apartment. Would you want sensors around the area?	-
How would the data they generate be of use to you?	-
Base other questions on learned information.	-

Conclusion	
Is there anything else that came to your mind during the interview that we didn't discuss?	

APPENDIX D - EVALUATION GUIDE

Questionnaire - 10 min	
How long have you lived in Atlanta?	
Where do you live?	
Do you own a smartphone? What do you use it for?	
How much time do you spend around 1) Piedmont Park, 2) Virginia Highland, and 3) Ponce City Market/Beltline?	
How long have you been running?	
How many miles a week do you typically run?	
Where do you typically run?	
Do you run with any technology?	
Do you track any data related to your running?	
Do you use digital tools to build routes? Which ones?	

For each task, ask what they are thinking.

Strava - 10 min

Have participants explore https://www.strava.com/routes/new. Tell them:

Are you familiar with Strava?

(If yes) What do you know about it?

(If no, or if they don't know a lot) Strava is an app cyclists and runners use to record their workouts. It is not important that it is "Strava", but rather only that it is a tool to build routes with. As much as you can, ignore the "Strava" branding. You can click on the map to make your route, and on the bottom bar you can see stats like the elevation gain and distance.

TASK: Take a few minutes to explore the interface by creating a route you might run.

City Run

Now we are going to look at a rough prototype of additional features for the interface. You will notice you can't build a route within this, but just remember that you actually can if it were fully functioning.

TASK: Toggle the features on the left panel.

TASK: With at least the Temperature, Vehicle Speed, or Air Quality toggled on, use the time slider a the top to explore.

TASK: Click on the Export Notifications button.

Scenario

You are planning a 3-mile route for yourself or someone else to run after work at 3 p.m. You want the run to be in areas below 80 degrees, pass at least one bathroom, and avoid road closures.

TASK: Map a run that meets this requirements using only the panel on the left.

Follow-up Questions	
What are the 3 most important data points to you? Why?	
Do you feel like any data is missing? Something else you would want to know?	
Wild cards - however participants' responses prompt you	