Wayfindr LA Metro Trial Report

Los Angeles, April-May 2019

Overview

LA Metro wishes to understand how best to deliver independent guidance and advice for vision impaired people around their transport network. The best approach to deliver this was determined to be a live trial of current technology within Los Angeles Union Station to understand the experience and response from members of the local vision impaired communities. LA Metro commissioned Wayfindr as the international leader in this field to identify and deploy the most appropriate technology and run the trial with around 50 people. This report describes how this was done and the results that emerged.

Open Standard for Audio Navigation

285 million people are estimated to be vision impaired worldwide: 39 million are blind and 246 million have low vision, according to the WHO. One of the biggest challenges they face is not being able to navigate independently.

Research conducted in the UK revealed that nearly half of vision impaired people would like to leave their home more often. In response, in 2014 UK charity Royal Society for Blind Children (RSBC) and London-based digital technology innovators UsTwo came together to develop a ground breaking global approach to enable vision impaired people to navigate independently – Wayfindr Open Standard.

Wayfindr Open Standard is a comprehensive set of guidelines, tools and techniques to integrate audio navigation into existing digital navigation products. The Wayfindr Open Standard has been accepted by the International Telecommunication Union under Recommendation ITU-T F.921. Throughout the rest of this report the ITU -T F.921 is referenced.

Wayfindr provides digital navigation makers and owners of public spaces with the skills and techniques to provide vision impaired people with consistent, high quality digital navigation services. Wayfinding uses various technologies to track a person's location and activate audio instructions on their mobile phone at the right time in order to get them to their destination.

In this way, Wayfindr seeks to enable vision impaired people to navigate the world using audio instructions from their smartphones.

The main objective of this pilot was to test whether an application such as the Wayfindr Open Source (an open source demonstration app for iOS) using the ITU-T F.921 *Audio-based indoor and outdoor network navigation system for persons with vision impairment* would impact their view about public transit use.

The complete text of the ITU-T F.921 is available to download from the ITU website (https://www.itu.int/rec/T-REC-F.921).

Project

The purpose of the trial was to investigate and understand the usability of audio navigation system in public transit use; in particular the Los Angeles Union Station by vision impaired people. Previous trials and pilots have led to the standardisation of audio instructions. In this trial, Wayfindr would provide technical insight and user feedback to Los Angeles County Metropolitan Transportation Authority (LACMTA).

Three areas were investigated:

- User engagement with audio navigation
- Technology selection and outcomes
- Deployment and implementation

Wayfindr worked with LACMTA to design a typical passenger route through Union Station using the Access drop-off area as the starting point. Wayfindr selected and licensed a new indoor location engine from Cambridge Consultants in UK (commissioned by Waymap Limited) TRACE and integrated it into the Wayfindr Open Source Demo iOS App. Wayfindr deployed the technology on demo phones and implemented the routing instructions through on-site survey, app development and on-site tests.

Wayfindr designed two test routes and used the Wayfindr Research Framework (openly available from the Wayfindr website) as the basis for the user research. The two test routes were designed to provide the necessary data to test the accuracy of TRACE through real-world scenarios and provide the users with an experience of independent travel within Union Station. The open source app was enhanced to incorporate the Virtual Waypoints introduced in the previous Las Arenas pilot in Barcelona. The app was then configured to provide the shortest/optimum route based on the personal abilities of the user: a further enhancement to the first version of the Wayfindr iOS Open Source.

LACMTA recruited 53 participants from local vision impaired communities and finalized the recruitment of the Research Assistants.

User Research - Methodology

53 vision impaired people were invited to participate in the trial. The group had an even gender split. About 20% of the participants were under 35; 50% between 35 and 60; and the remaining 30% were over 60 years old. 45% of the participants were blind and 55% were partially sighted but all registered as legally blind. There were 8 guide dog users (20%) while the remaining 80% were long cane users.

Upon arrival at Union Station, the participants were greeted and invited to complete a consent form and a release form allowing for the public use of all recorded media. All participants completed both forms. After completing both routes, the participants were asked to complete a questionnaire.

The participants were not told the destination of each route: they simply followed an instruction to start. Only when they reached their destination, did an announcement informed them that they had completed the route. This ensured that no participant was able to pick up clues as they approached their destination thus allowing a non-biased approach to the final waypoint. As a safety precaution, the participants were guided at the top of the Gold Line platform stairs by an Assistant to return to the stairs and continue the route, thus keeping them safe and away from the tracks.

Participants were given necessary information en-route to help familiarise themselves with the environment and enhance their perception of an unfamiliar environment. The instructions were identical for each participant but provided different levels of detail for cane and dog users as well as those who used no mobility aid. The participants were offered a choice of these options. They were also able to choose whether to use the escalators or the adjacent stairs leading to the Red/Purple Lines mezzanine.

The Research Assistants configured the App to match the participant's needs and choices. The App was configured to announce the instructions 6m in advance as per ITU F.921 Recommendation and, in addition, to provide reassurance messages at intervals ranging between 10m and 15m.

All data has been transferred by the LACMTA team to electronic records to facilitate further processing.

The participants were supplied with two iPhones to wear at their waist over their belt or in a supplied fanny pack. One phone used the Open Source Wayfindr App and the other was used for route data collection.

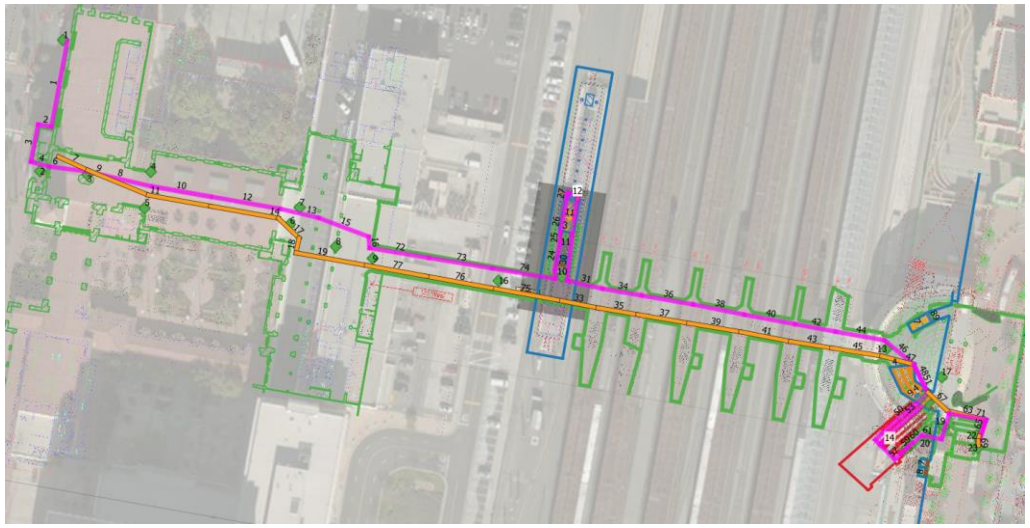
The Routes

The routes were planned around the scenario of a vision impaired person arriving at the general car and Access drop-off point at the West Portal of Union Station, visiting the Gold Line platform and then moving towards the East Portal Restrooms via stairs or escalators or an elevator. The return route was a simpler, single level route taking the participants to the allocated area of the Research Assistant's desk located near the Information Desk.

Before the first route the participants took a short calibration walk for the App to measure and understand their walking pattern.

Route One

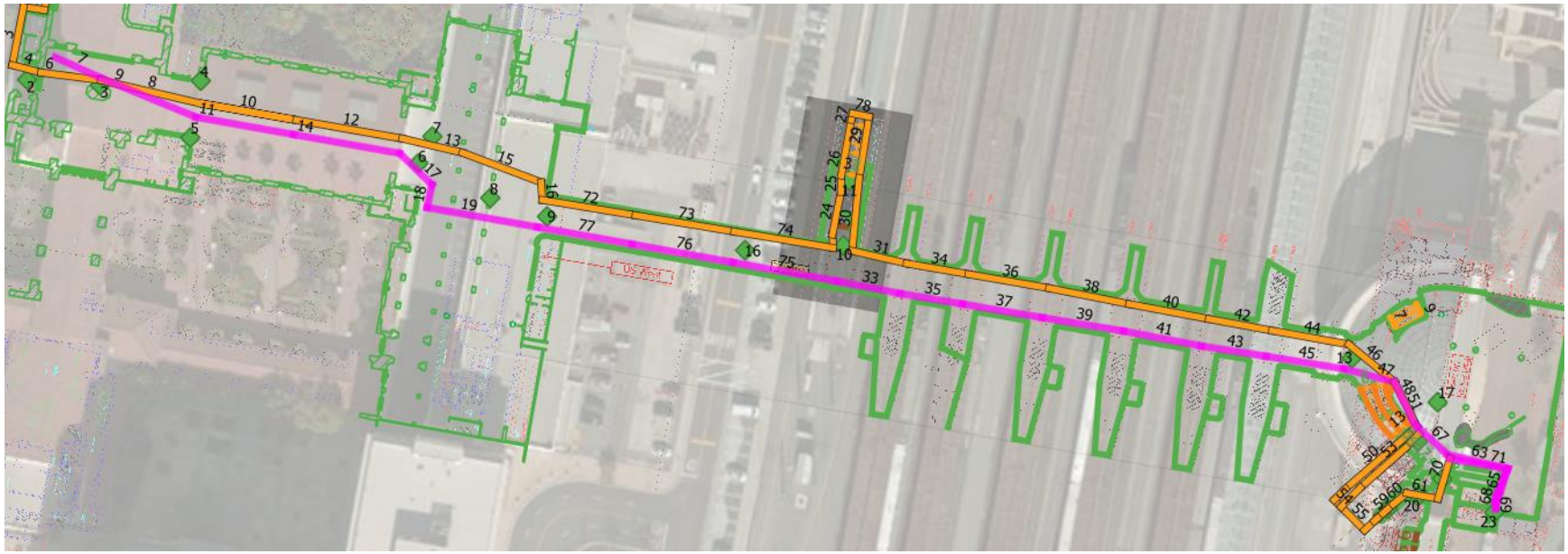
The first route was designed to simulate the arrival of a vision impaired person at the station by private car or by the Access service. The starting point of the route was a few steps from the typical drop-off point outside the West Portal where Access services deliver and collect passengers. The participants were instructed to walk next to the wall and enter the station through the West Portal doors before passing the Information desk and the two restaurants alongside the long corridor towards the end of the Waiting Room. After crossing the Waiting Room, they continued on a straight line through the ticketing area, they were asked to veer right to join the beginning of the west side of the passageway. The walk along the passageway itself was designed to follow the left-hand side towards platforms 1 and 2. The public tends to walk in the opposite direction to the planned route. This was intentional as the participants are guided to turn left at the Gold line platforms 1 and 2 thus avoiding the need to cross the passageway without a wall reference next to them. Following the left turn, they were instructed to bypass the elevator keeping it to their right-hand side before they would pass the TAP validating posts and up the stairs to the Gold Line platform. The Research Assistants would then turn them around at the opposite side of the stairs to continue along the left hand side of the passageway until they reached the East portal. At the East Portal they were directed to cross and pass the stairs and plants to their right before they turned right to join the down escalators or stairs for the Red/Purple line mezzanine. From there they were guided to the elevator and then through the door to walk next to the Barista coffee shop toward the restrooms of their choice.




East Portal
US East

Route Two

The second route was designed to return to the Research Assistant's desk: a shorter and simpler route. Participants were asked to trail the left-hand side of the corridor and turn towards the Research Assistant's desk close to the Information desk.



Participants

53 of participants invited by LCTMA attended. Four participants did not complete one or both routes due to known timing issues and commitments unrelated to the trial. Six participants did not complete the final questionnaire at the end of the trial. The LACMTA Research support staff are due to follow up on those questionnaires but at the time of analysis the data from those participants was not available.

Of the participants' who completed the questionnaire:

Gender

Male	25
Female	22

Mobility Aid

Guide Dog	10
White Cane	34
None	3

Age Group

18-24	2
25-64	33
65+	12

Results

Question 1

Did you find it easy or difficult to understand the instructions?

Answers:

1 very difficult
2 quite difficult

3 neither difficult nor easy
4 quite easy
5 very easy

There were 47 responses. Four participants returned comments. One of them, that gave a score of 2, commented: “Information given too early. Did not repeat prompts”. The remaining comments were from participants that scored 4 or 5 and related to the speed and clarity of speech.

Results by Rating, Count and Percentage:

Rating 1, count 0, 0%

Rating 2, count 2, 4%

Rating 3, count 7, 15%

Rating 4, count 23, 49%

Rating 5 count 15, 32%

The median score is 4 (quite easy).

The top two ratings aggregated indicate satisfaction at 81%.

Statistical analysis shows a uniform distribution across gender and mobility aid with a median of 4. Ages 18-14 and 65+ scored median 4 and the age group 25-64 a median of 4.

Median by Age

18-24 5

25-64 4

65+ 5

The high score in this section would indicate that compliance with the ITU F.921 standard provides for strong user satisfaction. It is strongly recommended that any LACMTA controlled app for vision impaired users conforms to the ITU F.921 standard.

Question 2

Did you find it easy or difficult to find your way by following the instructions?

Answers

1 very difficult
2 quite difficult
3 neither difficult nor easy
4 quite easy
5 very easy

Of the 47 responses, three participants returned comments:

- Male, White cane user, age 25-64 - “Sometimes easy, but unfamiliar route. Easy when people are around me.”
- Male, White cane user, age 25-64 - “Needed assistance a couple of times”
- Male, Guide dog user, age 25-64 - “Challenging with guide dog, walking on the left side.”

Results by Rating, Count and Percentage:

Score 1,	count 0	0%
Score 2	count 1	2%
Score 3	count 10	21%
Score 4	count 27	57%
Score 5	count 9	19%

The median score is 4 (quite easy) across all data as well as by age, gender and mobility aid.

Aggregation of the top two ratings gives a satisfaction rating of 77%.

Question 3

Right now, how confident would you feel using the system to find your way around Union Station, along with your cane/guide dog?

Answers

1 not at all confident
2 not very confident
3 somewhat confident

4 quite confident
5 very confident

There were 47 responses. Two participants returned comments:

- Female, White cane user, age 25-64 - “Instructions slightly off, not 100 percent accurate.”
- Female, White cane user, age 25-64 - “Info about nearby items not necessary.”

Results by Rating, Count and Percentage:

Rating 1 Count 0 0%.

Rating 2 Count 3 6%.

Rating 3 Count 15 32%.

Rating 4 Count 17 36%.

Rating 5 Count 12 26%.

The median score is 4 (quite confident) across all data as well as all as by age, gender and mobility aid.

The top two ratings aggregated bring a satisfaction of 62%.

The second best and neutral ratings bring a total of 68%.

The top three ratings, from neutral to very easy bring a total score of 94%.

Confidence of using such a system in its presented state is primarily neutral or increased.

Confidence is most likely to grow with familiarity and experience.

The lowest confidence, indicated by median 3, was for the 18-24 group with two participants.

Question 4

4. Right now, how confident would you feel using the system to find your way around a public place you are not familiar with such as another transit station or mall, along with your cane/guide dog?

Answers

1 not at all confident
2 not very confident
3 somewhat confident
4 quite confident
5 very confident

Results by Rating, Count and Percentage:

Rating 1	Count 1	2%
Rating 2	Count 7	14%
Rating 3	Count 16	34%
Rating 4	Count 16	34%
Rating 5	Count 8	17%

The median score is 3.5 (between neutral and quite confident).

The top two ratings aggregated bring a satisfaction of 51%.

The second best and neutral ratings bring a total of 68%.

The top three ratings, from neutral to very easy bring a total score of 85%.

Question 5

How stressed did you feel travelling through Union Station while using the audio navigation system?

Answers

1 A lot less stressed than I would feel travelling without audio navigation
2 A little less stressed than I would feel travelling without audio navigation
3 No difference in my level of stress
4 A little more stressed than I would feel travelling without audio navigation
5 A lot more stressed than I would feel travelling without audio navigation

Results by Rating, Count and Percentage:

Rating 1	Count 20	43%
Rating 2	Count 15	32%
Rating 3	Count 10	21%
Rating 4	Count 1	2%
Rating 5	Count 8	2%

The median score is 2 (A little less stressed) across age, gender, mobility aid.

The top two ratings aggregated bring a satisfaction of 74%.

The top three ratings, from neutral to very easy bring a total score of 96%.

Question 6

To what extent do you agree with the following statement: “When using audio navigation, I had a good experience travelling through Union Station”?

Answers

1 I strongly disagree
2 Disagree
3 Neither agree nor disagree
4 I agree
5 I strongly agree

Results by Rating, Count and Percentage:

Rating 1	Count 1	2%
Rating 2	Count 0	0%
Rating 3	Count 5	11%
Rating 4	Count 17	36%
Rating 5	Count 24	51%

The median score is 5 (I strongly agree) across all data.

The top two ratings aggregated bring a satisfaction of 87%.

Question 7

If this system was widely available in train stations and bus terminals would you be more or less likely use public transit?

Answers

1 Much less likely
2 Somewhat less likely
3 Neither more nor less likely
4 Somewhat more likely
5 Much more likely

Results by Rating, Count and Percentage:

Rating 1	Count 0	0%
Rating 2	Count 0	0%
Rating 3	Count 2	4%
Rating 4	Count 11	23%
Rating 5	Count 34	72%

The median score is 5 (Much more likely) across all data.

The top two ratings aggregated bring a satisfaction of 96%.

Question 8

When you have the option of travelling by car or using public transit which do you prefer?

Answers

1 Strongly prefer car
2 Prefer car
3 No Preference
4 Prefer Public Transit
5 Strongly prefer Public Transit

Results by Rating, Count and Percentage:

Rating 1	Count 11	23%
Rating 2	Count 7	15%
Rating 3	Count 9	19%
Rating 4	Count 8	17%
Rating 5	Count 12	26%

The median score is 3 (No Preference) across all data.

The ratings towards public transit preference aggregated shows a preference of 43%.

The ratings towards car use preference aggregated shows a preference of 38%.

The difference between the car and public transit is down to 2 persons.

Question 9

If this system was widely available in train stations and bus terminals would you prefer to travel by car or public transit

Answers

1 Strongly prefer car
2 Prefer car
3 No Preference
4 Prefer Public Transit
5 Strongly prefer Public Transit

Results by Rating, Count and Percentage:

Rating 1	Count 5	11%
Rating 2	Count 4	9%
Rating 3	Count 4	9%
Rating 4	Count 15	32%
Rating 5	Count 19	40%

The median score is 4 (Prefer Public Transit) across all data as well as by age, gender and mobility aid.

The top two ratings aggregated bring a satisfaction of 72%.

Question 10

If this system was widely available in train stations and bus terminals would you be more or less confident to travel on your own?

Answers

1 I would be a lot less inclined to travel on my own
2 I would be a somewhat less inclined to travel on my own
3 It would make no difference
4 I would be somewhat more inclined to travel on my own
5 I would be a lot more inclined to travel on my own

Results by Rating, Count and Percentage:

Rating 1	Count 0	0%
Rating 2	Count 1	2%
Rating 3	Count 4	9%
Rating 4	Count 12	26%
Rating 5	Count 30	64%

The median score is 5 (I would be a lot more inclined to travel on my own) across all data as well as by age, gender and mobility aid.

The top two ratings aggregated bring a satisfaction of 89%.

Question 11

In the past, have you tried to avoid passing through Union Station when making journeys on public transit?

Answers

Answers were in form of Yes or No

Results by Rating, Count and Percentage:

Yes, Count 18 36%

No, Count 32 64%

The results in details are as shown below:

By Age	Yes	No	Yes (%)	No (%)
18-24	1	2	33%	67%
25-64	12	22	35%	65%
65+	2	11	15%	85%
Total:	15	35	30%	70%

By Mobility Aid	Yes	No	Yes (%)	No (%)
Guide dog	3	6	33%	67%
White cane	13	22	37%	63%
None	1	4	20%	80%
Total:	17	32	35%	65%

By Gender	Yes	No	Yes (%)	No (%)
M	8	20	29%	71%
F	6	15	29%	71%
Total:	14	35	29%	71%

Question 12

Which of the following statements best describes how you travel through Union Station?

Answers

- I always travel by myself through Union Station
- I usually travel by myself but sometimes am accompanied by another person
- (4) Most of the time I travel through Union Station with another person
- (5) I only ever travel through Union Station when with another person

Results by Rating, Count and Percentage:

The recorded data show values ranging from 1 to 5. However, the answers were not numbered on the feedback forms. The LACMTA team will need to review these answers and update the corresponding spreadsheet.

The assumption is that the last two answers correspond to the 4 and 5 and that the remaining answers may belong to 1 or 2.

The current figures show the following scores:

1	4	9%
2	8	17%
3	2	4%
4	17	36%
5	16	34%

If the above assumption is accurate, then the 70% of the participants are accompanied on most journeys through this station.

Question 13

From a scale from 0 meaning *not at all likely* to 10 meaning *extremely likely*, how likely is it that you would recommend this system to other blind people?

Answers

The answers were presents as a scale from 1 to 10 without a specific narrative attached to each figure.

Results by Rating, Count and Percentage:

Score 0	Count 0	0%
Score 1	Count 0	0%

Score 2	Count 0	0%
Score 3	Count 1	2%
Score 4	Count 0	0%
Score 5	Count 0	0%
Score 6	Count 1	2%
Score 7	Count 2	4%
Score 8	Count 8	17%
Score 9	Count 5	11%
Score 10	Count 30	64%

The median score is 10 (Extremely likely to recommend) across all data as well as all as by age, gender and mobility aid.

One person scored it as 3. Their comments include recommendations on the instruction repeat function, frequent reminder of the area they are walking through, detailed orientation information (i.e. “what is around me”) and detailed instructions.

Question 14

How can we improve the system? What would make it easier to use or more effective?

Answers

The answers on this section are summarised in the Trial Implementation and Considerations section of this document.

Question 15

LA Metro is considering developing an audio navigation system for at Metro trains/subway stations and bus terminals. Do you have any comments for LA Metro to help with developing the audio navigation system?

Answers

The answers on this section are summarised in the Trial Implementation and Considerations section of this document.

Question 16

Do you have access to an iOS (Apple) or Android device/smartphone?

Results by Device, Count and Percentage:

iOS Only 31

Android Only 8

Both Operating Systems 4

No smartphone 9

The total use by operating system is:

iOS Apple, 35 participants, 74%.

Android, 12 participants, 26%.

No smartphone, 9 participants, 19%.

Trial Implementation and Considerations

Setting up the App

Before each participant used the App, they had to perform a straight walk for the TRACE engine to calibrate their stride length and the position of the phone on their body in relation to the walking forward direction. The TRACE engine needs to understand which way the phone is located on the participant's body so when a move takes place, it interprets this as the correct direction. The engine uses the phone's sensors and data feedback from the step detector, magnetometer, accelerometer, altimeter and gyroscope to estimate the direction and distance the participant is walking through a process similar to 'dead-reckoning'. The initial measurement is taken by an app supplied by Cambridge Consultants, the Motion Data Logger (MDL) which also records the data from the walk for analysis.

The MDL returns the stride length and an estimated position of the phone. These measurements are entered in the Wayfindr Demo App. The same measurements are taken from the second phone which only uses the MDL.

TRACE position estimate

The TRACE engine requires to start from a known location. As the participant walks, it detects the steps, direction of movement and estimates their location. TRACE uses beacons placed at key locations to confirm its estimate of location. TRACE does not require continuous beacon coverage to operate thus allowing it to operate in large open spaces where it is not possible to install beacons. During the trial, we observed a few times when the orientation of the phone on the participant changed whilst walking and this resulted in an incorrect estimate of the position.

Participants did not always walk in a forward and straight direction. In particular, in the ticketing hall where there is a higher level of ambient noise, many participants tended to veer off the instructed course resulting in a loss of position. This was particularly evident during the first week of the trial before an update was made to TRACE to address this. After the update, the accuracy of location improved greatly and as TRACE continued to learn the participant's walking style during use, it self-corrected to regularly deliver a near flawless second route; the return journey to the research assistant's desk.

This was a key learning from the trial that would not be a problem for a personal smartphone. The re-use of a shared phone meant that each user had to re-calibrate the system and the longer a person used it, the more accurate TRACE became.

TRACE requires a starting position with a non-fluctuating magnetic environment. This proved difficult for a small number of participants where the phone's compass needed to be recalibrated. One participant had a brain implant which produced electric impulses and it was not possible to initialise the phone.

Instruction delivery

Instructions were delivered to the participants via a Bluetooth collar speaker using the iOS Voiceover feature. Participants were asked to select a comfortable speech rate and volume before they started the routes.

The ITU F.921 Recommendation states that the optimum distance to deliver a message is 6m before the decision point. This distance is used in the app to confirm the proximity to the next virtual waypoint in the route. In cases where the route legs are shorter than 6m, the app automatically delivers the message at a point 70% of the leg's length allowing the app time to speak the next set of instructions. As the instructions are announced, the participant continues along the route and by the time the instruction is fully delivered, the participant is in close proximity of the decision-making point.

For this trial, the participants were advised to take either immediate action or seek the next opportunity for the announced action. For example, a 'Turn Left' instruction may be taken immediately, or at the next opportunity available to the participant. Guide dog users were given shorter instructions to allow for the participant to pass the instruction to the dog.

Participants were informed that instructions with the word ‘Keep’ and a side left or right, means that they should follow to the shoreline on the announced side. The majority of the participants followed the request and the research assistants also reminded them, as part of their duties, to stay on the requested side.

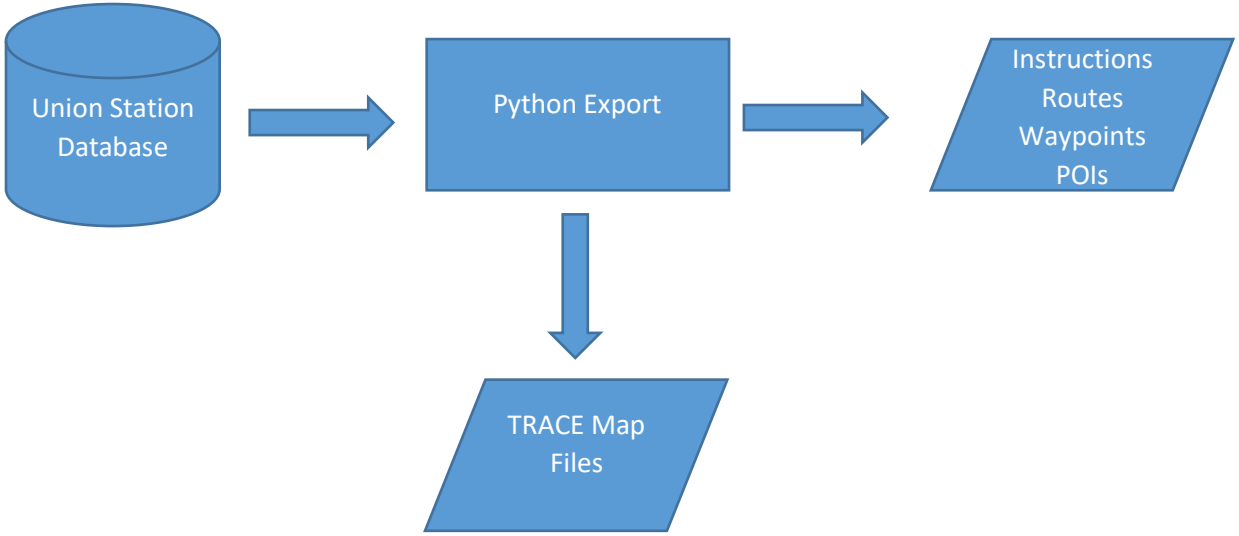
Instructions for short distances were often interrupted by the Voiceover when the participant approached the next virtual waypoint as it was not possible for the app to detect whether the Voiceover had completed the announcement. This resulted in delivery of incomplete instructions in the first week of the trial before an amendment was made to aggregate the instructions for waypoints close together. However, the outcome of this was that sometimes, the instructions were too long and the user was unable to absorb them. At this stage, the research assistants repeated the voiceover instruction and repeated the instructions verbally, where necessary.

This was another key learning from the trial. Designing and delivering instructions requires a deep and practical understanding of the user experience and any app delivering audio-navigation will need to accommodate different user needs.

Technology

Maps and Instructions

This version of the Open Source is using a SQLite database with information on the Union Station layout, waypoints and instructions. The dataset used in this trial comprised the SQLite file with SpatiaLite geometries, a set of Python libraries to export the data from the Spatialite database to create the TRACE files, instructions, waypoints, points of interest and routes.



This version of the Open Source is using QGIS, an open-source GIS system to map Union Station for the purposes of using the TRACE location engine, mark the virtual waypoints, draw the route segments, build the instructions and mark the Points of Interest.

TRACE requires knowledge of the walls, stairs, escalators and elevators. Detailed information on how the map data is described and relates to surrounding areas, is available in a separate technical definition document.

App source

The App comprises the routing functionality from the first iteration of the Open Source App (master branch of the GitHub repository) and the implementation of Virtual Waypoints and iOS accessibility implementation from the Las Arenas branch.

This version is using the WGS84 Latitude and Longitude co-ordinates to place the waypoints, points of interest and the beacons in the Union Station map. This is feature makes this version of the Open Source to integrate with GPS/GNSS co-ordinates passed from the Core Location of

the iOS and the corresponding service, later on Android. It is now possible to seamlessly integrate indoor and outdoor maps without the necessity to convert to any local X-Y reference systems as it was the case with the code branch for Las Arenas.

The source is available on a private repository at the Wayfindr's GitHub account and will be made available to LACMTA in a separate delivery.

User feedback

Below are key considerations for the app:

- Adapt to the user's speed of walking and announce the instructions in advance. The demo app had fixed distance announcements and fast walker overshot the turning points.
- Guide dogs are trained to follow the clear route, walking around obstacles. At the trial we received feedback from users that their dogs were either trained or preferred to walk either the left or right side of the walls. Route planning should take into consideration the dog's training and whether the dog is able to guide through open spaces or trace walls.
- Deliver complex instructions in simpler sentences and provide a 'Pause' and 'Replay' feature.
- Provide options to announce all, one or selected Points of interest en-route.
- Configure the system to provide reassurance messages that relate to timing or distance in relation to the speed of walking. ITU F.921 recommends a reassurance message to announce every 10m but for slow walkers this distance may be shorter.
- Link the arrival and departure times for trains and buses in the app.
- Provide a choice of directional instructions as listed in the ITU F.921 Recommendation. The demo app had fixed clock face instructions which were enhanced by simple explanations at the beginning of the second week.
- The app needs to correct the user's direction if they turn to face the opposite direction from the one they are instructed to follow. Some users with orientation challenges will find this useful.
- Add a 'Where Am I' feature.
- Provide emergency notification to Security Staff and Services
- Provide estimate of distances with number of steps based on the average stride length of the user. The demo app uses hard-coded instructions: participants were advised of this and research assistants recommended to increase or decrease the number based on the user's walking style.

App Design

The app was designed to fit the purpose of this trial and specifically the routing challenges around the short visit to the Gold Line platform. As this is a demonstration app, it was not expected to present the participant with the flexibility a production quality app would do. The known restrictions are:

- Instructions are hard-coded. Each instruction spoken does not take into consideration possible change to the path.
- Ability to recalculate route is limited. The re-calculation was limited to jumping to the next waypoint if the proximity to the next one was closer. This was limited specifically for the visit to the Gold Line platform: an efficient algorithm would either have a multiple-stop-points or bypass it altogether.
- The voice synthesizer playback was switched off. The first iteration had a bug where the app failed. The Spanish development team was unable to find and fix it and proceeded to implement a fully accessible and approved implementation of the Las Arenas open source branch.
- Screen flashing is not implemented. Screen flashing was implemented as part of the Wayfindr Open Standards in the first version. The two subsequent versions do not have user interaction and so screen flashing was not carried forward.

Appendix

Instructions

This as well as previous trials required a fixed set of routes. This means that a flexible set of instructions was not required. In this trial we added a feature whereby we created the necessary placeholders for variable routing/re-routing.

The first two generations include a fixed instruction path with a format compatible with the General Transit Feed Specification (https://gtfs.org/).

This version introduces a fixed set of instructions that can map over a graph data set in triplicate rather than doubles. The triplicates comprises the start node, the end node and the next node, giving the system the flexibility to have different instructions for a path depending on what is coming up next. For example, if the participant was walking along the path to a T junction, we need an instruction to turn left or right depending on where our calculated path needs to go.

The instructions will need to include information and details that are useful to vision impaired users but are not currently listed as features in known mapping formats. These include information about the number of steps in a flight, location of elevator buttons and the floor designation, location of Braille or raised/large print signs outside doors.

QGIS Use

Introduction

QGIS, the Open Source GIS system is used to create the maps and the necessary information about the routes, waypoints, beacons and instructions.

We use QGIS version 3.4.2-Madeira on Windows 10. More recent versions have introduced a bug where it is not possible to import successfully text files with data. This import is important when setting up new features within QGIS. This reported feature has been reposted as fixed and should become available in a forthcoming release.

The QGIS layers use the World Geodetic system 1984 (WGS84) for all data reference and it is referred to within QGIS as EPSG:4326. The Projection used is the WGS 84/Pseudo Mercator referred to within QGIS as EPSG:3857. The projection is used for all screen-based operations and all files, layers and data are under EPSG:4326, the latitude/longitude reference system.

QGIS Plugins

Use the following Plugins:

- Advanced Line Editor
- Coordtransform
- Freehand raster georeferencer
- GeoCoding
- Layer from clipboard
- OSM Tools
- OSM Downloader
- POI Exporter
- Zoomtopaste

Use the following links to create XYZ Tiles (Browser Window):

Google street maps: http://mt0.google.com/vt/lyrs=m&hl=en&x={x}&y={y}&z={z}

Google sat view: http://mt0.google.com/vt/lyrs=s&hl=en&x={x}&y={y}&z={z}

Open Street Map: http://a.tile.openstreetmap.org/{z}/{x}/{y}.png

Bing Maps: http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1

Database

All data is saved within a single sqlite file using the Spatialite data structures. To help populate and configure the database, we use a number of GeoJSON text files that are imported. These are used as the data definition files of the database.

Creating a new data table is as simple as importing a corresponding template file and renaming it to describe its purpose.

Template files are listed at the appendix.

Layers

A Layer for use in TRACE and instructions is defined as the distinct set of data tables that describe the purpose of the layer. There are five types of layers:

a) Flat floor layer - A flat surface of similar altitude.
b) Transition layer. - A layer that links two flat floor layers.
c) Elevator/Lift layer - A layer that links multiple flat floors.
d) Exterior layer. - A layer that can be under GPS signals and not necessarily flat.

e) Information layer - This is a layer that holds administrative and other information that is not related to a physical layer.

Flat Floor Layer

The flat floor layer comprises the following data sets:

- Wall Lines - Single or multiple lines representing impassable walls.
- Wall Surfaces - Closed multi-line surface representing impassable walls. The surface helps with pillars where the start and ending points are identical.
- Transition Lines - Lines that when crossed, the users change to a different layer (stairs, elevators etc).
- Beacons - The point location and identity of the Bluetooth beacons in place at that layer.
- Perimeter - A closed multi-line/surface where the GPS data is unreliable (e.g. close to buildings or indoors).

Transition Layer

The transition layer comprises the following data sets:

- Wall Lines - Single or multiple lines representing impassable walls.
- Transition Surface. - A close multi-line area where the transition takes place such as stairs or escalators.
- Transition Lines - Lines that when crossed indicate that the user has changed to a different layer such as another floor.

Lift/Elevator Layer

The transition layer comprises the following data sets:

- Wall Lines - Single or multiple lines representing impassable walls.
- Transition Surface - A close multi-line area where the transition takes place such as stairs or escalators.
- Transition Lines. Lines that when crossed indicate that the user has changed to a different layer such as another floor.

Information Layer

This layer holds the information about the venue, routes, waypoints and instructions.

Data sets include:

- Venue
- Venue Levels
- Instructions
- Waypoints

- Intended Path
- Routes

Building a Layer

To create a layer, use detailed images of the floor plan. Using the satellite views (see links to the XYZ Tiles) and the Freehand raster plugin, place the floor image at the most appropriate location on the map.

Once the images are placed in a good location, import the templates for each data set for the layer, remove the sample data and then start creating the data set for each data type.

Exporting a Layer

When ready, use the Python code to run and generate the files. Examples and instructions are included in the Python Code. Make sure you are referencing the correct SQLITE data file and have all Python libraries installed.

The Union Station map as used in the trial:

Building a new venue

Use the following links to collect the default elevation and the magnetic characteristics of the area:

Elevation information: https://www.freemaptools.com/elevation-finder.htm

Magnetic Signature: http://www.geomag.bgs.ac.uk/data_service/models_compass/wmm_calc.html

Use the Inclination (I), Declination (D) and Total Intensity (F) in the venue characteristics and the elevation (AMSL) to complete the single record of the venue.

Adjust the geofencing polygon to match the buildings and the surrounding area.

Create the necessary levels in the 'venue-levels' table (including floors, transition stairs/escalators and elevators) and give these an individual number. Estimate/measure the floor height difference from the reference level. The figure is in metric metres and is positive for floors above the reference floor and negative for floors below the reference floor.

Give each venue level a unique consecutive positive number. The lowest/deepest of the floors will have a floor level of 0 (zero) and each floor above it is increased by 1. For example, a building with three basement floors one ground/reference and 2 above it, will have floor IDs from 0 to 6. Its reference floor will be ID 4.

-- ENDS --