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Disclaimer

Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the Author(s) and do not necessarily reflect the view of the U.S. Department of Transportation.
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Chapter 1. Summary

1.1. PROJECT DESCRIPTION

The Mobility Assistance for People with Cognitive Disabilities (MAPCD) project involves the adaptation and validation testing of an innovative smartphone application (WayFinder) for use by individuals with cognitive disabilities. During the project, the adapted smartphone application will be pilot tested with 15 to 30 individuals in the Columbus region in partnership with the Central Ohio Transit Authority (COTA) and Ohio State University (OSU). The WayFinder system will help to enable persons with cognitive disabilities to transition off costly paratransit services and travel independently on the fixed-route bus system. Phone-based Global Positioning System (GPS) tracking allows WayFinder to safely guide users with step-by-step visual and audio instructions. The WayFinder system was developed through funding from the U.S. Department of Education and the National Institutes of Health. Data generated by the application will be written to the Smart Columbus Operating System (Operating System) to support data analysis and performance measures.

1.2. PURPOSE

The WayFinder3 System, to include the web-based portal and mobile application, was developed to support increased autonomy in community transportation among individuals with cognitive disabilities. Development of the mobile application and performance testing of the WayFinder3 application is an ongoing component of the Smart Columbus MAPCD project.

A test plan was developed to formally test the functionality of the WayFinder3 ecosystem, including both the mobile application (Android only) and the web-based portal. The test plan was developed by a multidisciplinary team comprised of both engineers and clinicians (see personnel section for additional details). The final version of the WayFinder3 system test plan was completed on Jan. 18, 2019, and included an introductory chapter; a systems description chapter to describe the WayFinder3 application, its functions and capabilities; and a chapter that details the test conditions and scenarios to be utilized for evaluating the performance of the system on both walking and vehicle routes.

1.3. VERSION

The current version of the WayFinder3 application is the 3rd major software revision. In addition to the mobile application, the WayFinder3 system utilizes a web-based portal. Both the application and web-based portal house route builder functions. Routes can be created to include personalized instructions and cues in the form of images, text, and audio features. In addition, the portal is designed to provide caregivers with a method of monitoring an application user’s route in real time. A shared database allows communication between the application and web-based portal.
1.4. **TEST ITEMS**

The test plan was designed to identify and evaluate all of the essential and desired system functions. The evaluation criteria for each function were defined by a predetermined metric and successful completion criteria. The test plan was comprised of four categories which centered on specific system platforms and either essential or desirable functions. The test plan procedures were divided into function/platform categories to be carried out through a series of scenarios.

- **Test Plan Stage 1 Scenarios**
  - Route Creation and Access (Portal)
  - Tracking
  - WayFinder3 Application
  - General Transit Feed Specifications (GTFS) Alerts
  - Route Creation (Phone)
  - User Communication
  - Accessibility
  - Desirable Functions

- **Test Plan Stage 2 Scenarios**
  - Walking Routes
  - COTA Routes

The variables recorded during function testing included the following:

- Personnel
- Date and time of assessment
- Completion
- Success or failure
- Descriptive comments

The comment sections were used to report the location of routes, and to record descriptive feedback on visual and usability factors associated with executing functions.

1.5. **ENVIRONMENT**

The test plan was intended to be completed through a series of real-world testing scenarios that would allow evaluation of each function according to its predetermined metric and criteria. Test scenarios encompassed the creation, execution, and monitoring of both walking routes and COTA bus system routes through the application and web-based portal, as appropriate. A total of five (5) walking route test scenarios and five (5) COTA bus system route scenarios were outlined in the test plan. All procedures during completion of the test plan took place within academic and community settings within the greater Columbus area. All phone-based testing was carried out on Android Motorola mobile phones using a Verizon Wireless 4G LTE network.
1.6. SOURCE MATERIAL

The Mobility Assistance for People with Cognitive Disabilities Trade Study describes the process used to identify the essential needs and desired needs, which were used to select the AbleLink Wayfinder for implementation within the Smart Columbus Project. The Trade Study is located at: https://smart.columbus.gov/uploadedFiles/Projects/Smart%20Columbus%20MAPCD%20Trade%20Study%202020180319.pdf.

The essential and desired needs were then transformed into functions as part of the Testing Plan for the WayFinder System as adapted for the MAPCD Project. The Test Plan is located at: https://smartcolumbusprogram.sharepoint.com/_layouts/15/guestaccess.aspx?docid=0b8adc3e8938a4efbaf fed8223755d062andauthkey=AdV_PUhvxZWoZPjpC67xnm4.

1.7. VARIANCES

During completion of the test plan several variances were documented:

- The ability to upload routes to a public library is unavailable for the end user. This will prevent the end user from accidentally changing the public routes that are based on the COTA fixed-route bus system (see Section 2.2 for additional details).
- Cellular coverage remains a fixed value that cannot be retrieved at this point; therefore, coverage could not be evaluated within test plan procedures.

Stage 2 walking and bus route scenarios were initially planned for three (3) research personnel for each individual test, based on anticipated requirements of the system. It was later determined that one (1) to two (2) research personnel could evaluate the functions of interest. Therefore, the requirement for three (3) personnel testers was revised, and these sections of the test plan were completed by one (1) to two (2) research personnel.
Chapter 2. Comprehensive Assessment

2.1. SYSTEM ASSESSMENT

All criteria set forth within the test plan have been evaluated. User Needs from the Mobility Assistance for People with Cognitive Disabilities Trade Study were used to develop the corresponding functions. Table 1 lists and describes the individual essential and desirable functions.

Table 1: Essential and Desirable Functions

<table>
<thead>
<tr>
<th>Source Identifier</th>
<th>Description</th>
<th>Corresponding Individual Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPCD-UN001-V01</td>
<td>Phone-based application</td>
<td>EF4-EF7</td>
</tr>
<tr>
<td>MAPCD-UN002-V01</td>
<td>Knowledge of real-time transit information (COTA GTFS)</td>
<td>• EF5b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF6a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF6b</td>
</tr>
<tr>
<td>MAPCD-UN003-V01</td>
<td>Voice and turn-by-turn directions (visual instructions)</td>
<td>• EF2a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF2b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• DF2a</td>
</tr>
<tr>
<td>MAPCD-UN004-V01</td>
<td>Ability for the traveler to speak to the caregiver</td>
<td>EF8a</td>
</tr>
<tr>
<td>MAPCD-UN005-V01</td>
<td>Ability to send alerts to the caregiver (passive and monitoring)</td>
<td>EF8b</td>
</tr>
<tr>
<td>MAPCD-UN006-V01</td>
<td>Ability to track an individual (active monitoring)</td>
<td>EF3</td>
</tr>
<tr>
<td>MAPCD-UN007-V01</td>
<td>Caregiver experience</td>
<td>EF8c</td>
</tr>
<tr>
<td>MAPCD-UN008-V01</td>
<td>Web Content Accessibility Guidelines (WCAG) 2.0AA standard/Section 508 compliant</td>
<td>EF9</td>
</tr>
</tbody>
</table>

MAPCD TRADE STUDY DESIRABLE ITEMS

<table>
<thead>
<tr>
<th>Source Identifier</th>
<th>Description</th>
<th>Corresponding Individual Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPCD-UN009-V01</td>
<td>Roles-based permissions (caregiver, traveler)</td>
<td>DF5</td>
</tr>
<tr>
<td>MAPCD-UN010-V01</td>
<td>Simple non-cluttered user interface</td>
<td>EF4</td>
</tr>
<tr>
<td>MAPCD-UN011-V01</td>
<td>Ability to customize map (COTA Geographic Information Systems (GIS) web services)</td>
<td>EF2a</td>
</tr>
<tr>
<td>MAPCD-UN012-V01</td>
<td>Ability for user to “check in” on route</td>
<td>DF6</td>
</tr>
<tr>
<td>MAPCD-UN013-V01</td>
<td>Application Programming Interface (API)</td>
<td>DF4</td>
</tr>
<tr>
<td>MAPCD-UN014-V01</td>
<td>Ability to create custom reports</td>
<td>DF1</td>
</tr>
</tbody>
</table>
### Table 2: Test Scenarios and Functions

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Test Scenario</th>
<th>Functions Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>Walking Route – open space (unobstructed GPS signal) – app only</td>
<td>• EF4 (a and b) &lt;br&gt;• EF5 (a and b) &lt;br&gt;• EF6 (a and b) &lt;br&gt;• EF7 (a, b, c, d and e)</td>
</tr>
<tr>
<td>W2</td>
<td>Walking Route – obstructed space (areas with episodes of limited GPS due to buildings and/or foliage) – app only</td>
<td>• EF4 (a and b) &lt;br&gt;• EF5 (a and b) &lt;br&gt;• EF6 (a and b) &lt;br&gt;• EF7 (a, b, c, d and e)</td>
</tr>
<tr>
<td>W3</td>
<td>Walking Route – open space – app only – route deviation</td>
<td>• EF5a</td>
</tr>
<tr>
<td>W4</td>
<td>Walking Route – obstructed space – app only – route deviation</td>
<td>• EF5a</td>
</tr>
<tr>
<td>W5</td>
<td>Walking Route Creation Evaluation</td>
<td>• EF1, EF2 (a, b, c, d and e) &lt;br&gt;EF3</td>
</tr>
<tr>
<td>Test Number</td>
<td>Test Scenario</td>
<td>Functions Tested</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>COTA1</td>
<td>COTA Bus Route – open space – app only</td>
<td>• EF4 (a and b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF5 (a and b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF6 (a and b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF7 (a, b, c, d and e)</td>
</tr>
<tr>
<td>COTA2</td>
<td>COTA Bus Route – obstructed space – app only</td>
<td>• EF4 (a and b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF5 (a and b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF6 (a and b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EF7 (a, b, c, d and e)</td>
</tr>
<tr>
<td>COTA3</td>
<td>COTA Bus Route – open space – app only – route deviation</td>
<td>• EF5a</td>
</tr>
<tr>
<td>COTA4</td>
<td>COTA Bus Route – obstructed space – app only – route deviation</td>
<td>• EF5a</td>
</tr>
<tr>
<td>COTA5</td>
<td>COTA Bus Route Creation Evaluation</td>
<td>• EF1, EF2 (a, b, c, d and e)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• F3</td>
</tr>
</tbody>
</table>

Personnel completed the test plan scenarios, repeating the scenarios in various locations as necessary to complete all requirements of the test plan. Testing took place between Jan. 28 and March 19, 2019.

The WayFinder3 application underwent an update during execution of the test plan, and the updated version of the application was required to complete the GTFS tracking component of Stage 1 testing (see below). Therefore, personnel completing the portion of the testing involving the GTFS tracking were required to obtain and utilize the most recent version of the application following the update on March 1, 2019.

Throughout the testing procedures, issues, comments and solutions were recorded through a series of web-based, shared documents. This format allowed issues to be shared and addressed on an ongoing basis by all personnel, including the WayFinder system developer.

The following sections describe several identified issues.

### 2.2. EVALUATION OF STAGE 1 TESTING

#### 2.2.1. Route Creation and Access (Portal)

This function evaluation was completed by five (5) personnel, each independently creating six (6) routes through the web-based portal. Issues were identified and resolved at this stage of testing as described below.

- Routes could not be uploaded to the public library platform. This was a design decision by the developer and supported by the research personnel. This prevents end users from accidentally modifying the public routes based on the COTA fixed-route bus system. At present we do not have the option to access the public library from our environment and so were not able to test this functionality in the current iteration of evaluation.

- One tester experienced multiple failures when attempting to add verbal prompts to a route during route creation in portal. This issue was recorded in the shared document, and eventually resolved.
• System performance issues such as slow processing speed and freezing of both the Android application and the web-based portal were reported during initial testing. The developers researched the issues and performed minor software updates to resolve these performance issues on an ad-hoc basis during the testing, which allowed the testing to continue.

• Visibility problems within the route creation web portal, such as a “copyright” banner blocking the download button, were identified and resolved by system designers.

2.2.2. Tracking

This stage of function testing was completed by three (3) personnel. Testing took place across the City of Columbus, to include the Center of Science and Industry (COSI), the Ohio Statehouse, and the Smart Columbus Experience Center. This testing category evaluated the ability to track an active user on a route from a remote location using the web-based portal. To accomplish this, corridor data is sent from the phone to track the user’s location. The user monitoring routes has access to a web-based route list in which active routes are highlighted yellow while completed routes are highlighted green. Within active routes the location of the user is indicated with blue dots to indicate that the user is on route or with yellow dots if they have deviated from the route for at least 30 seconds. Issues were identified and resolved at this stage of testing as described below.

• Early in the testing process, it became apparent that previewing the routes (while in a static location) was creating invalid reports of successful route completion on the web-based tracking site. This issue was discussed with system developers and addressed. The software was updated to include the local GPS precision information in the corridor margin of error, which improved the system performance. This more accurate evaluation of monitoring analysis will now be correctly conveyed in future trainings.

• It was reported that some of the email notifications were not being received. However, it was hypothesized that this was an email firewall issue associated with the tester’s medical center email.

• It was reported that notifications were being delivered when the notification setting was turned off. Developers addressed this issue.

• Initially there was an issue with driving route data being reported as off route when the active tester was traveling the correct path. This was determined to be a margin of error discrepancy, which was subsequently addressed by system designers.

2.2.3. WayFinder Application

This series of functional assessments evaluated the usability feature of the mobile phone application component of the WayFinder3 system. Functions were evaluated by five (5) personnel testers. Issues were identified and resolved at this stage of testing as described below.

• Personnel observed picture cropping, which prevented the user from being able to use the picture to identify a location. This issue was resolved by cropping the photos prior to insertion of the photo into the route.

---

1 Corridor data accounts for 20 meters of variability, this prevents unnecessary “off-route” alerts.
2.2.4. **General Transit Feed Specifications Alerts**

This section of the test plan evaluated GTFS alerts that were designed to inform users of bus arrival times and schedule changes. These functions were evaluated by five (5) personnel testers. Issues were identified and resolved at this stage of testing as described below.

- Initially, one tester was unable to see bus arrival information from bus stop location, and it was not able to progress through the route. This issue was resolved by re-entering GTFS information into the route. All other trials were successful.

2.2.5. **Route Creation (Phone)**

This series of functional assessments evaluated route creation and modification on the WayFinder3 mobile phone application. Issues were identified and resolved at this stage of testing as described below.

- Ensuring routes were saved
- Removing visual obstruction to the download button
- Consistently being able to provide audio recording instructions
- Ensuring waypoints could be deleted

2.2.6. **User Communication**

This section of the test plan evaluated the function of the contact button and ability to connect with caregiver function. All testing was completed by five (5) personnel. All features passed the assessment for four (4) personnel. The fifth tester initially had issues with the contact button, but then learned from the system designers that the contact button needed to be pushed for about three to five seconds before the button was activated.

2.2.7. **Accessibility**

AbleLink provided City of Columbus with documentation that WayFinder3 app meets the WCAG2.0AA standard and is 508 Compliant.

2.2.8. **Desirable Functions**

All desirable functions passed the assessment. The following desirable functions were evaluated:

- Audio repetition
- Option to set a delay for audio repeat in settings
- Automatic advancement to next waypoint
- Do not press “OK” button, and next waypoint shows at appropriate time
- Operating System ability to access API information
2.3. EVALUATION OF STAGE 2 TESTING

2.3.1. Walking Routes
The scenarios in this section were used to evaluate the WayFinder3 system accessibility, features and settings, alerts, and route creation functions. All functions were evaluated in relation to use in walking routes. Testing included route creation and modification, evaluating accuracy of route cues while using the application, route deviation to evaluate the alert functionality, and monitoring caregiver notifications.

- Walking Route Open Space – Application Only
  - This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

- Walking Route Obstructed Space – Application Only
  - This function was evaluated by three personnel testers and determined to be functional with no reported issues during test scenarios.

- Walking Route Open Space – Application Only – Route Deviation
  - This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

- Walking Route Obstructed Space – Application Only – Route Deviation
  - This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

- Walking Route Creation Evaluation
  - This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

2.3.2. Central Ohio Transit Authority Routes
The scenarios in this section were used to evaluate the WayFinder3 system accessibility, features and settings, alerts, and route creation functions. All functions were evaluated in relation to use in COTA bus route transit. Testing included route creation and modification, evaluating accuracy of route cues while using app, route deviation to evaluate alert sensitivity, and monitoring caregiver notifications.

- COTA Bus Route Open Space – Application Only
  - This function was evaluated by one personnel tester who completed three iterations of the evaluation scenario. In two of the three trials, the bus arrival time report was accurate within two minutes. In one instance the bus arrival time was inaccurate by > 20 minutes. The issue was conveyed to the developers and was subsequently addressed by modifying the algorithm used to detect bus time.

  - In Preview Mode, an issue with progressing through a bus route was identified. Once the route reached the bus stop location in which the time until bus arrival was featured, the user could no longer progress through the route. This was conveyed to the developers who then reported that they would add the ability to progress through such route stops preview mode so that users would be able to preview the full route. Though previewing the route is still an outstanding issue, the feature is not an essential or desired function for the end user.

- COTA Bus Route Obstructed Space – Application Only
○ This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios. There were issues with saving route modifications completed in the portal after the routes were downloaded from the public library. This issue was conveyed to developers and resolved.

- **COTA Bus Route Open Space – Application Only – Route Deviation**
  ○ This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

- **COTA Bus Route Obstructed Space – Application Only – Route Deviation**
  ○ This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

- **COTA Bus Route Creation Evaluation**
  ○ This function was evaluated by two personnel testers and determined to be functional with no reported issues during test scenarios.

Identification of usability issues through systematic testing allowed application creators to address items prior to the *Go Live* phase (described in subsequent section).
Chapter 3. Summary of Results

The MAPCD team received the final major version of the WayFinder3 application on Jan. 21, 2019. The team then received updates to the application on Feb. 11, March 1 and March 14, 2019. During this period, over 70 trials were completed on the OSU campus, within downtown Columbus, and throughout Franklin County. The trials included walking routes in open spaces and obstructed spaces, travel within automobiles and travel on the COTA fixed-route bus system in open spaces and obstructed spaces.

Based on the creation of over 20 routes and the completion of over 70 trials, over 50 issues were identified and resolved. The issues were due to the WayFinder3 ecosystem (application and portal), the limitations of the smartphone technology, or user error.

Over the approximately 1½-month period, testing occurred for the 23 essential functions/sub-functions and six (6) desired functions/sub-functions. Of the essential and desired functions, the MAPCD team was not able to test one subfunction: the ability for the end-user to upload a route to the public portal. The team determined that it was not appropriate to upload routes to the public portal, because an end-user could accidentally alter the routes and bus stops for the COTA fixed-route bus system.

The defined functional requirements from the test plan were used as the pass-fail criteria for the acceptance testing. Results of the testing can be found at the following locations:

- **Stage 1 Testing:**

- **Stage 2 Testing:**
  [https://smartcolumbusprogram.sharepoint.com/_layouts/15/guestaccess.aspx?docid=03973354f322f489d9e7ca4b3943e9a08&authkey=AU90wozzgppqO8chZh3w930](https://smartcolumbusprogram.sharepoint.com/_layouts/15/guestaccess.aspx?docid=03973354f322f489d9e7ca4b3943e9a08&authkey=AU90wozzgppqO8chZh3w930)

The WayFinder3 ecosystem passed the criteria for 22 of the 23 essential functions/sub-functions and six (6) of the six (6) desired functions.
Chapter 4. Personnel

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Test plan development, test plan execution and report development

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Test plan development, test plan execution and report development

Jeffery Kupko, PE, PTOE – Michael Baker International (transportation engineer)
Test plan development, test plan execution and report development

Sandra Metzler, DSc PE – Mechanical and Aeronautical Engineering (faculty)
Test plan development, test plan execution and report development

Olivia Vega, BS – Doctoral program for occupational therapy (student)
Test plan development, test plan execution and report development

Julie Faieta, OTR/L – PhD candidate (student)
Test plan development, test plan execution and report development

Kaetlyn Culter – Health sciences (student)
Test plan development, test plan execution
Appendix A. Acronyms and Definitions

Table 3: Acronym List contains project specific acronyms used throughout this document.

Table 3: Acronym List

<table>
<thead>
<tr>
<th>Abbreviation/Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>COTA</td>
<td>Central Ohio Transit Authority</td>
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<tr>
<td>COSI</td>
<td>Center of Science and Industry</td>
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<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
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<td>GTFS</td>
<td>General Transit Feed Specifications</td>
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<td>Operating System</td>
<td>Smart Columbus Operating System</td>
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<td>Web Content Accessibility Guidelines</td>
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<td>Center of Science and Industry</td>
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Source: City of Columbus