



U.S. Department of Transportation



**Georgia Mobility and Accessibility Planner (G-MAP)
Accessible Routing – Pedestrian Impedance Factors and Application**

Georgia Department of Transportation (GDOT)
Safe Trips in a Connected Transportation Network (ST-CTN)

March 12, 2024

Webinar Agenda

- **Purpose of this Webinar**

- Introduce the system development process and how stakeholders are engaged throughout the process to ensure the system will meet user needs

- **Webinar Content**

- ITS4US Program Overview (Norah Ocel)
- Project Background (Kofi Wakhisi)
- G-MAP Routing and Mobility Modes (Jon Campbell)
- Pedestrian Impedance Factors (Randy Guensler and Angshuman Guin)
- Questions and Answers
- How to Stay Connected (Norah Ocel)

- **Webinar Protocol**

- You are welcome to ask questions via chatbox
- The webinar recording and the presentation material will be posted on the ITS4US website

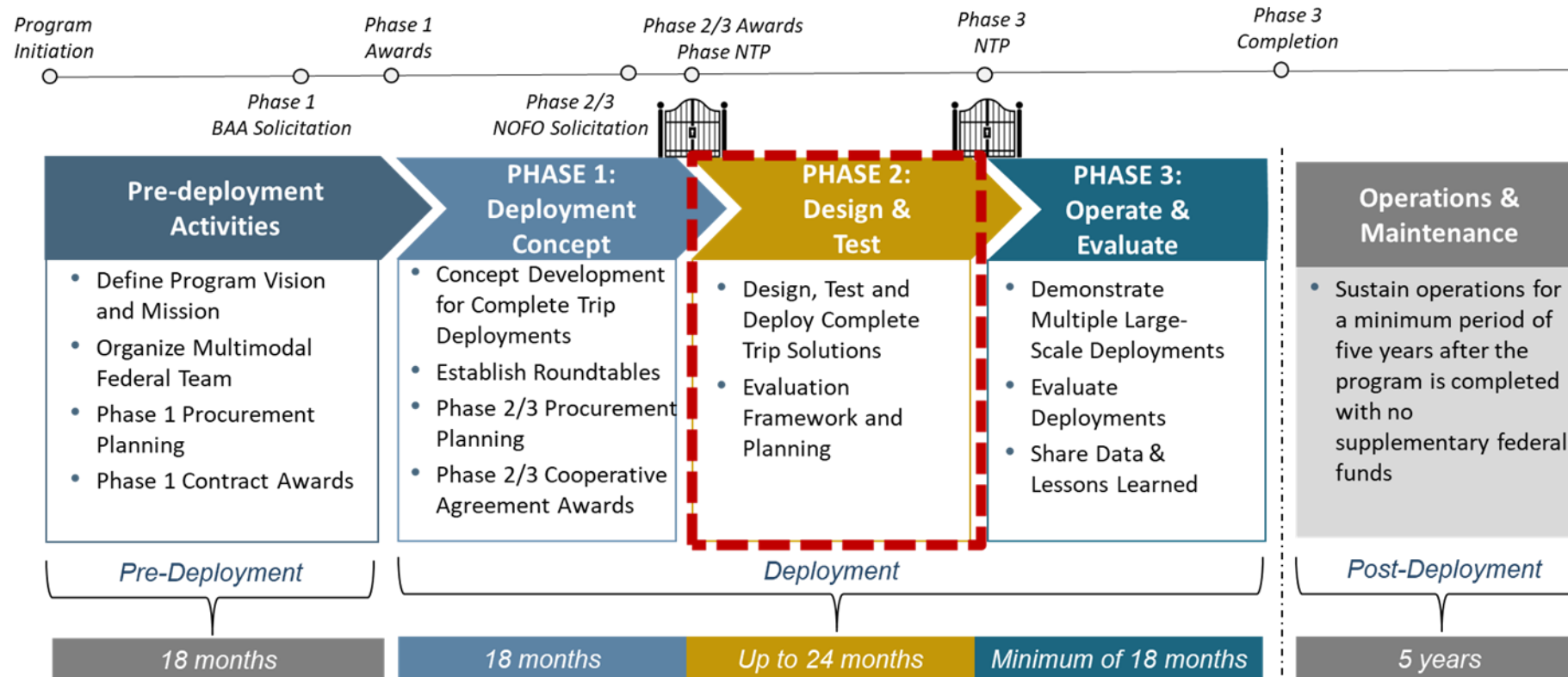
ITS4US Program Overview

- A USDOT Multimodal Deployment effort, led by ITS JPO and supported by OST, FHWA and FTA
- Supports multiple large-scale replicable deployments to address the challenges of planning and executing all segments of a complete trip

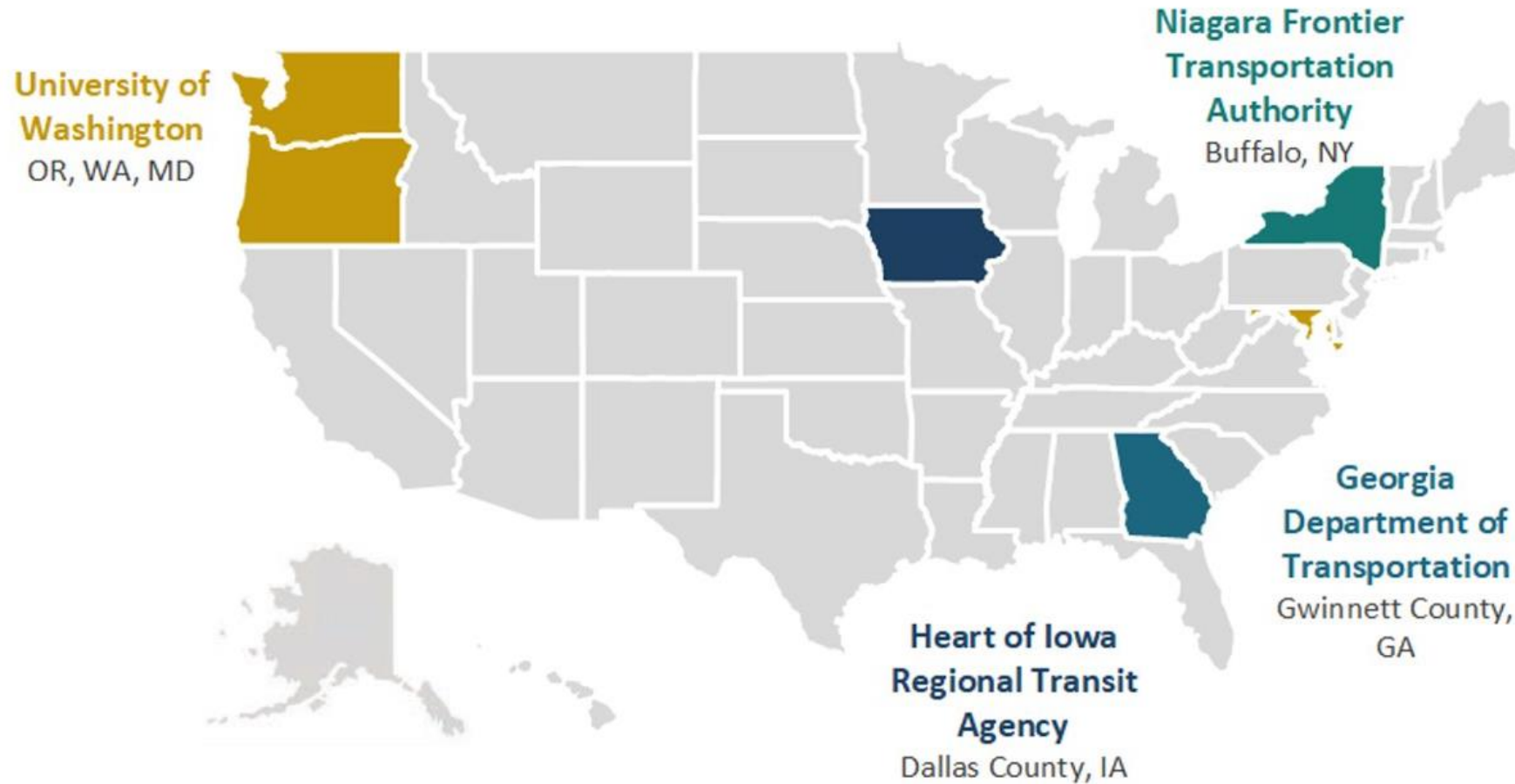


Vision: Innovative and integrated complete trip deployments to support seamless travel for all users across all modes, regardless of location, income, or disability

Deployment Phases



ITS4US Deployment Sites



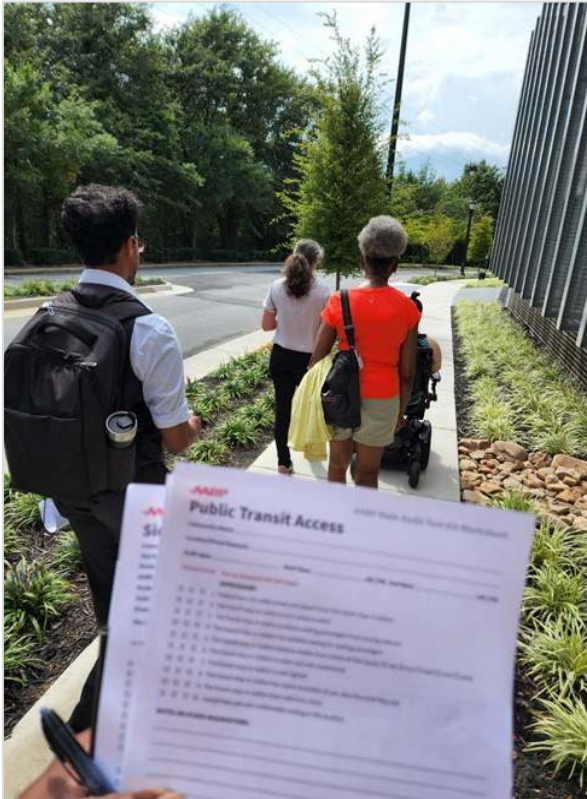
Source: USDOT

ITS4US Team Photo Collage



Georgia Department of Transportation (GDOT) Deployment Project

Existing Mobility Challenges



- Guided by [AARP Walk Audit](#)



- Uneven, Obstructed Paths
- Poor Sidewalk Quality

Existing Mobility Challenges (continued)

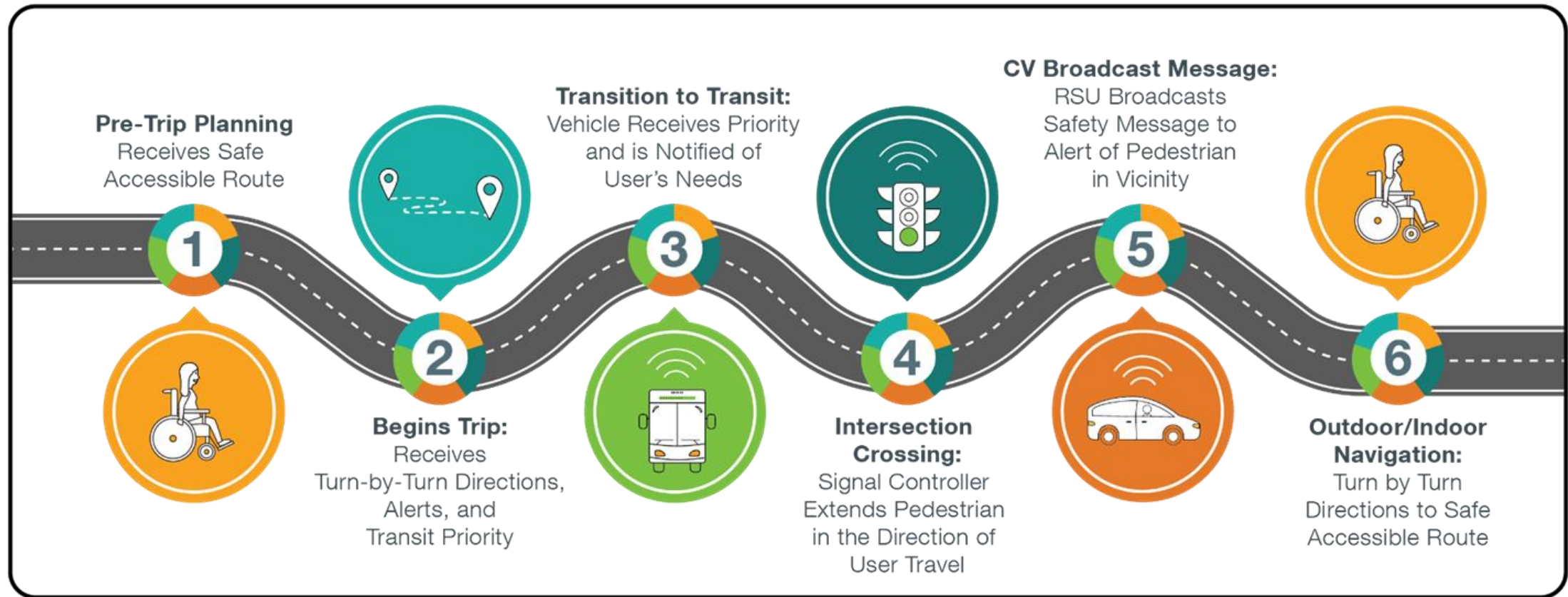


- **Missing curb ramps, not Americans with Disabilities Act (ADA) compliant (ex1)**



- **Missing curb ramps, not ADA compliant (ex2)**

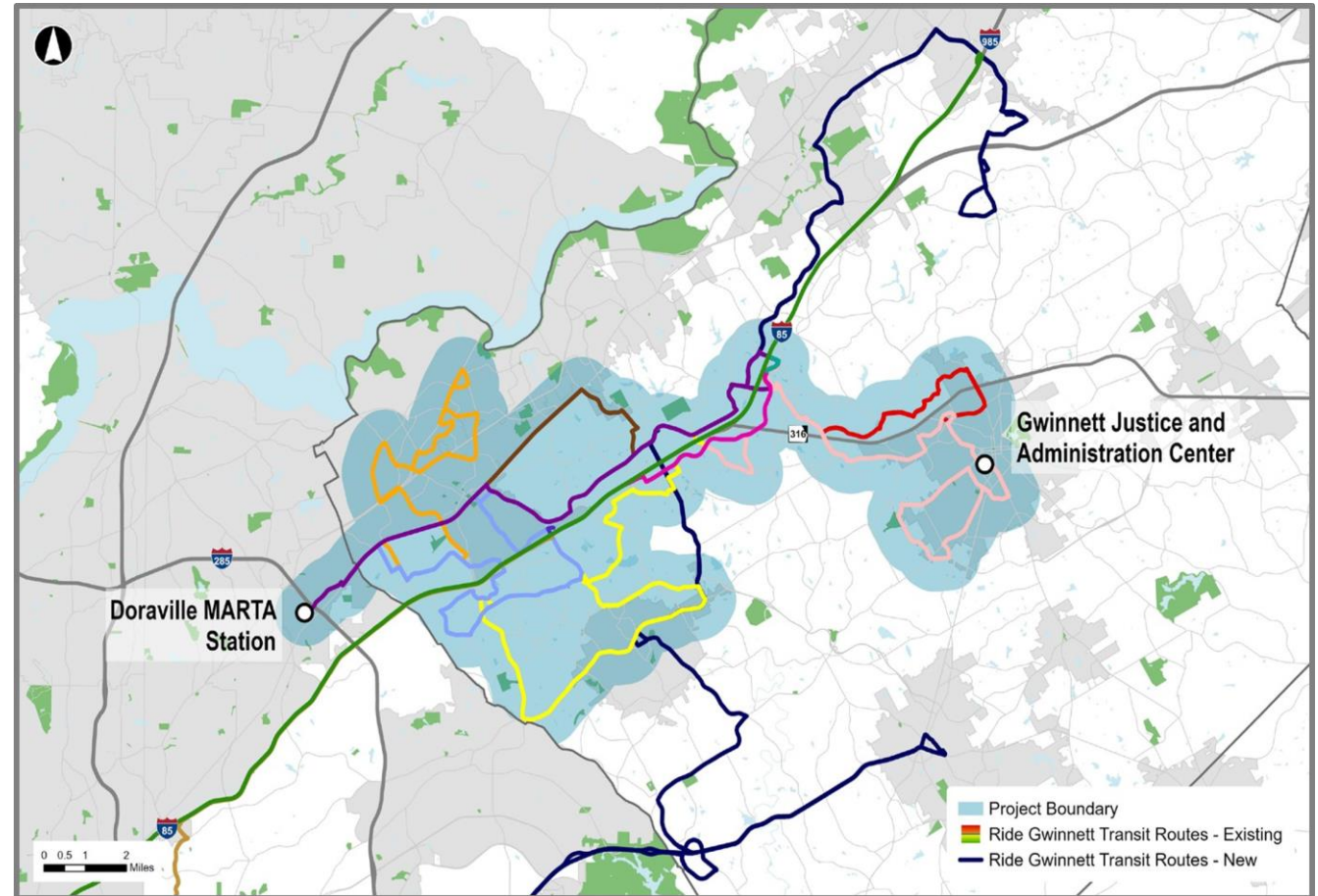
Georgia Mobility and Accessibility Planner (G-MAP)



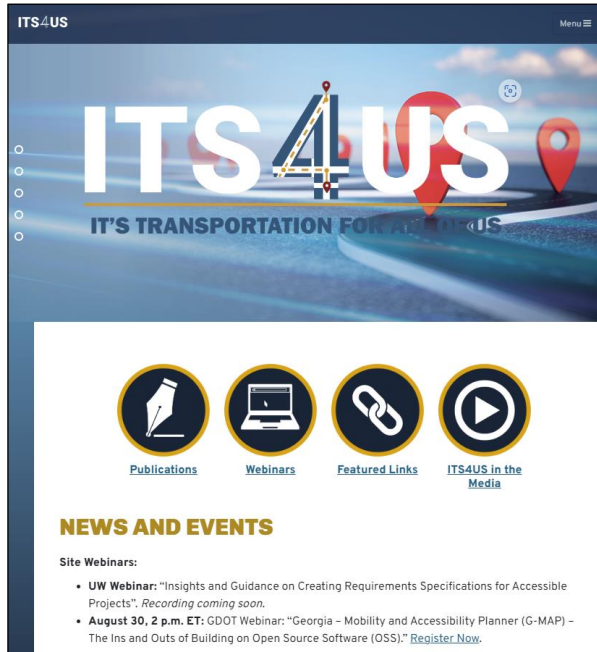
Source: ARC

Project Site – Gwinnett County, GA

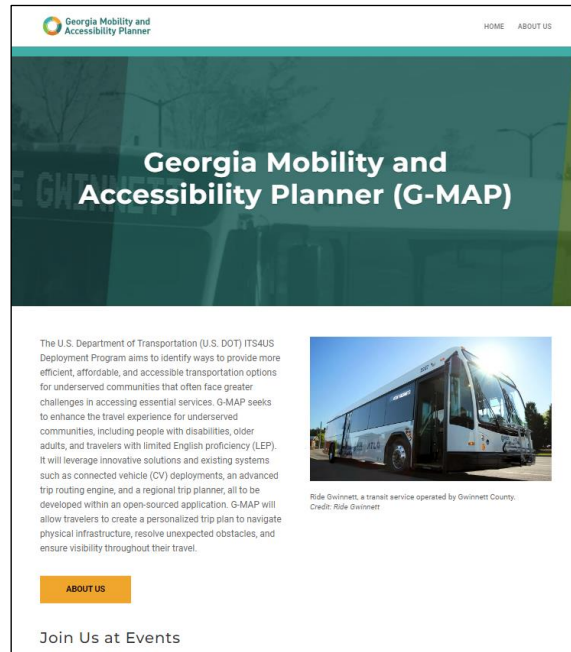
- Richly diverse area
- Major transit hubs
- Suburban land use
- Wide and high- speed roadways
- Inconsistent pedestrian infrastructure



Learn More / Resources



USDOT Website:
USDOT ITS4US



Deployment Website:
Home Page - ITS4US
Deployment Program Project
(georgia-map.com)

G-MAP Routing and Mobility Modes

G-MAP Routing

- OpenTripPlanner ingests GTFS, GTFS-realtime, GTFS-flex, GBFS, OSM, and operator API data to build a network graph of all transportation options
- The transit portions of the trip search use the transit network/timetable to find optimal routes

The screenshot displays the OpenTripPlanner interface with the following details:

- Origin:** 33.95846, -83.98779 (Norcross Post Office, Norcross, GA, USA)
- Destination:** 33.95846, -83.98779 (Sugarloaf Mills P&R Local)
- Mode:** Transit (Walking, Bus 40, Bus 10A)
- Total Time:** 1 hr 22 min
- Cost:** \$0.00
- Route Summary:**
 - 12:46 PM: Walk 0.7 miles to Gwinnett Justice & Admin Center (11 min)
 - 12:58 PM: Gwinnett Justice & Admin Center (Stop ID 67)
 - 1:30 PM: Sugarloaf Mills P&R Local (Stop ID 1055)
 - 2:07 PM: Buford Hwy & Mitchell Rd (Advance Auto) (Stop ID 206)

Trip ID	Trip Headsign	Trip Short Name	Central Avenue Southwest ...	Marlin Lut... Peachtree	Forsyth Street at Marlin Lut...	Central Avenue at Marlin L...	Central Avenue at Wall Stre...	Peachtree Center Avenue a...						
t5DC-b139D-sl2	Indian Trail P&R		15:00:00	15:08:00	15:11:30	15:11:30	15:15:00	15:15:00	15:18:38	15:18:38	15:19:33	15:19:33	15:22:16	15:22:16
t640-b139E-sl2	Indian Trail P&R		16:00:00	16:08:00	16:11:30	16:11:30	16:15:00	16:15:00	16:18:38	16:18:38	16:19:33	16:19:33	16:22:16	16:22:16
t65E-b139F-sl2	Indian Trail P&R		16:30:00	16:38:00	16:41:30	16:41:30	16:45:00	16:45:00	16:48:38	16:48:38	16:49:33	16:49:33	16:52:16	16:52:16
t6A4-b139A-sl2	Indian Trail P&R		17:00:00	17:08:00	17:11:30	17:11:30	17:15:00	17:15:00	17:18:38	17:18:38	17:19:33	17:19:33	17:22:16	17:22:16
t6C2-b139A-sl2	Indian Trail P&R		17:30:00	17:38:00	17:41:30	17:41:30	17:45:00	17:45:00	17:48:38	17:48:38	17:49:33	17:49:33	17:52:16	17:52:16
t708-b139F-sl2	Indian Trail P&R		18:00:00	18:08:00	18:11:30	18:11:30	18:15:00	18:15:00	18:18:38	18:18:38	18:19:33	18:19:33	18:22:16	18:22:16

G-MAP Routing (continued)

- For non transit parts of the graph, all travel factors are translated into time-cost penalties
- Features to be avoided (slopes, major arterials/highways) get higher time-cost penalties
- Features to prioritize (off-street paths, dedicated bike lanes) get lower ($< 1.0x$) time-cost penalties to incentivize their use in routes



Mobility Modes in G-MAP

- Use different impedance factors for different modes under the Americans with Disabilities Act (ADA)
- Categories (18) include persons who:
 - have no mobility limitations
 - have some (self-reported) limited mobility
 - use a mobility device (cane, walker, etc.)
 - use a manual wheelchair
 - use an electric wheelchair
 - use a mobility scooter
 - have low vision
 - are blind
- Interactions between categories 2-6 x low vision and 2-6 x blind

Mobility Profile – Devices

The screenshot shows a mobile application interface with an orange header bar. On the left, there is a hamburger menu icon and a circular logo. The header contains the text "Plan Trip", "View Routes", and "Nearby". On the right side of the header, there are icons for a globe and a square. The main content area is white and contains the following text:

Step 2 of 6

Define Your Mobility Profile

Please answer a few questions to customize the trip planning experience to your needs and preferences.

Do you regularly use a mobility assistive device? (Check all that apply)

- No assistive device
- Manual walker
- Cane
- Stroller
- Mobility scooter
- Manual/traditional wheelchair
- White cane
- Wheeled walker
- Crutches
- Service animal
- Electric wheelchair

At the bottom of the form, there are two buttons: "Back" on the left and "Next" on the right.

Mobility Profile – Devices (continued)

The screenshot shows a mobile application interface with an orange header bar. The header contains a menu icon, a logo, and navigation links for 'Plan Trip', 'View Routes', and 'Nearby'. On the right side of the header are a globe icon and a square icon. The main content area is white and displays 'Step 2 of 6' followed by the title 'Define Your Mobility Profile'. Below the title is a paragraph: 'Please answer a few questions to customize the trip planning experience to your needs and preferences.' The question is 'Do you regularly use a mobility assistive device? (Check all that apply)'. There are ten checkboxes arranged in two columns. The checked options are: Manual walker, Cane, Manual/traditional wheelchair, and Electric wheelchair. The unchecked options are: No assistive device, Stroller, Mobility scooter, White cane, Wheeled walker, Crutches, and Service animal. At the bottom of the form are two buttons: 'Back' and 'Next'.

Step 2 of 6

Define Your Mobility Profile

Please answer a few questions to customize the trip planning experience to your needs and preferences.

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- Manual/traditional wheelchair
- White cane
- Wheeled walker
- Crutches
- Service animal
- Electric wheelchair

[Back](#) [Next](#)

Mobility Profile – Mobility Needs

Step 3 of 6

Define Your Mobility Profile

Please answer a few questions to customize the trip planning experience to your needs and preferences.

Do you have any mobility limitations that cause you to walk more slowly or more carefully than other people?

Do you have any vision limitations?

Pedestrian Impedance Factors

Impedance Factors in Route Choice

- Factors that disincentivize travel along a route
 - Travel time cost
 - Monetary cost (tolls, parking, fuel, etc.)
 - Physical effort or difficulty
 - Safety (real and perceived)
 - Convenience
 - Other behavioral or social factors
 - Impedance is quantified for each transportation link
 - Can be expressed in units of time, money, or utility
- ***How much additional time would you be willing to walk to take a more accessible path?***

ADA Mobility Mode Impedance Factors

- Impedance factors differ across ADA Mobility Modes

ADA Mobility Mode	Examples of Potential Impacts of Missing Curb Ramp on Impedance
No Disability	- potential trip hazard
Low Vision	- significant trip hazard
Manual Wheelchair	- forced to divert to the street - tip over hazard

Factors Affecting Path Choice

- Factors affecting route selection include
 - Travel time impedance
 - Attribute impedance (positive and negative aspects)
- Attribute impedance depends upon the mode of travel
 - Interactions with infrastructure
 - Path design and conditions are important

ITS4US Impedance Calculations

- Start with travel time on every pedestrian link
- Assess conditions and events that affect route choice, e.g.:
 - Walking adjacent to heavy traffic as a disincentive
 - Missing curb ramps (huge impedance to wheelchair travel)
- Impedance factors to link impedance can be:
 - Multiplicative (e.g., uphill grade affects the entire link)
 - Additive (e.g., add time for potholes and cracking)
- Combine travel time impedance and condition/event-based impedance into a single “impedance time” per link

Infrastructure Design and Condition Affects

Infrastructure design and condition affects route viability for specific modes:

- Design and surface condition
 - Width, slope, cross-slope, potholes, trip hazards, etc.
 - Stable, firm, slip resistant
- Path features and conditions
 - Crosswalks*, curb ramps, etc.
- Various factors impede modes of travel differently
 - e.g., manual wheelchair users are more impacted by pavement disjoints than are electric wheelchair users

*The MUTCD defines a “crosswalk” as pedestrian path crossing a road (whether or not a painted crosswalk is provided) and the PROWAG currently defines a “crosswalk” as any pedestrian crossing of a vehicle way (whether or not a painted crosswalk is provided).

ADA Design Standards and Impedance

- Minimum ADA design standards exist for a reason...
 - Sidewalk width, slope, cross slope, etc.
 - Sidewalk obstructions and surface conditions
 - Abrupt changes in level (>1/4" or >1/4-1/2" if not beveled), cracking, potholes, etc.
 - Curb ramp widths, passing space widths, landing widths, etc.
 - Curb ramp slopes, cross-slopes, flare slopes, etc.
 - Detectable warning surfaces (texture pads)
 - Etc.

[Public Right-of-Way Accessibility Guidelines: https://www.access-board.gov/prowag/](https://www.access-board.gov/prowag/)

ADA Mobility Mode Paths

- OpenTripPlanner (OTP) is used for G-MAP routing
 - Complete streets network, transit network (GTFS), complete paths network
- Pedestrian path impedance
 - Assigned to logical pedestrian links that can comprise a path for OTP
 - Eliminate undesirable links from potential paths
 - Exclude links or severely penalize with impedance
- Impedance factors incorporate:
 - Pathway surface design and condition impacts
 - Ramp design and condition impacts on crossings
 - Curb design and condition impacts on sidewalk links
 - Adjacent traffic condition impacts
 - Etc.

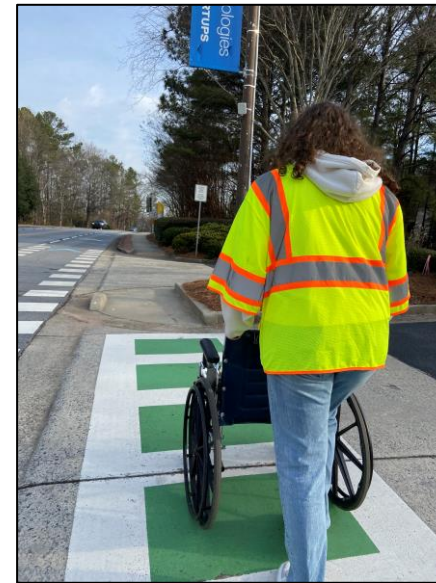
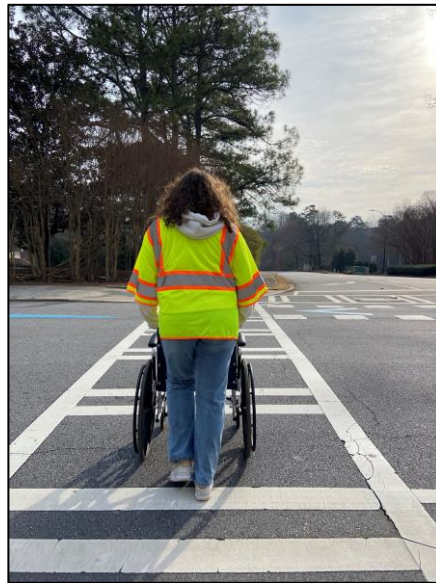
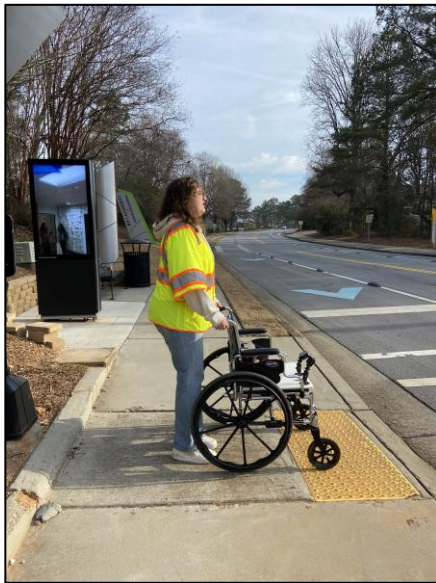
Vehicle Video Data Collection



- Identify sidewalks, ramps, curb cuts, and crossings
 - Manual flythrough
 - Machine vision processes
- Prevents inspection crew dispatch errors
- Lateral videos capture both sides (at set angles) to detect sidewalk presence
- Passenger-side video pinpoints ramps, curb cuts, and crossings for inspection

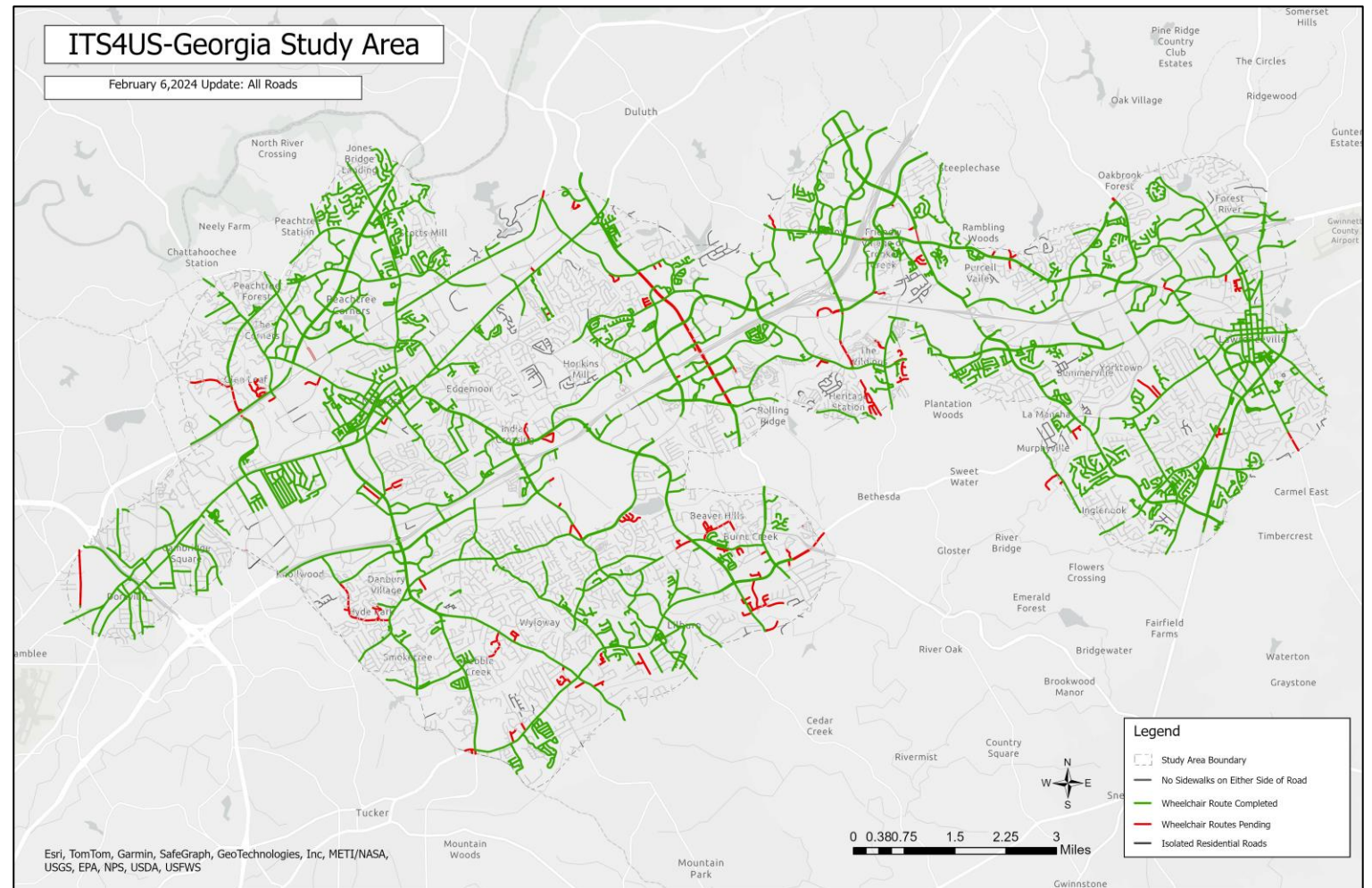
Wheelchair Video Data Collection

- Web-interface video inspections for ADA design and condition data
 - Most ADA design/condition issues can be identified in an online review
- Refine asset location data



Wheelchair Video Data Collection Status

- Study Area:
- ~1,200 road miles
- ~512 miles have sidewalks
- ~477 miles are complete (~97%)



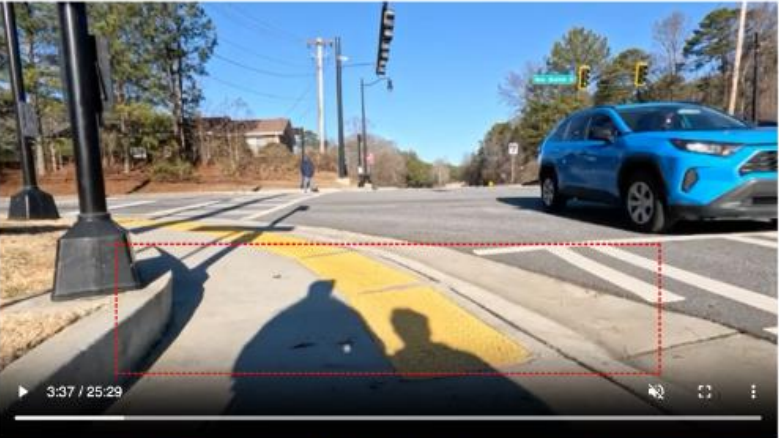
Online Wheelchair Video Review

ITS4US Georgia Tech
Wheelchair Video Inspection Tool v 1.0


Video Timestamp: 2024-01-30 14:45:56

GPS Information [Lat.,Long.]:
(33.9462089, -83.991809)

Frame Number: 6525



3:37 / 25:29



Inspector Info

Name:

New Inspection
 Resume Inspection

Asset Type(syncing)

Sidewalk
 Ramp
 Curb Cut
 Crossing

Problems Types (Check All That Apply)

Sidewalk Present

Sidewalk Absent

Path width < 36"

Slope vs. road > 5%

Cross-slope > 2%

Partial obstruction

Surface disjoint > 1/4"

Path blocked

Surface cracking

Debris

Pothole(s)

Standing water

Surface roughness

Other issues

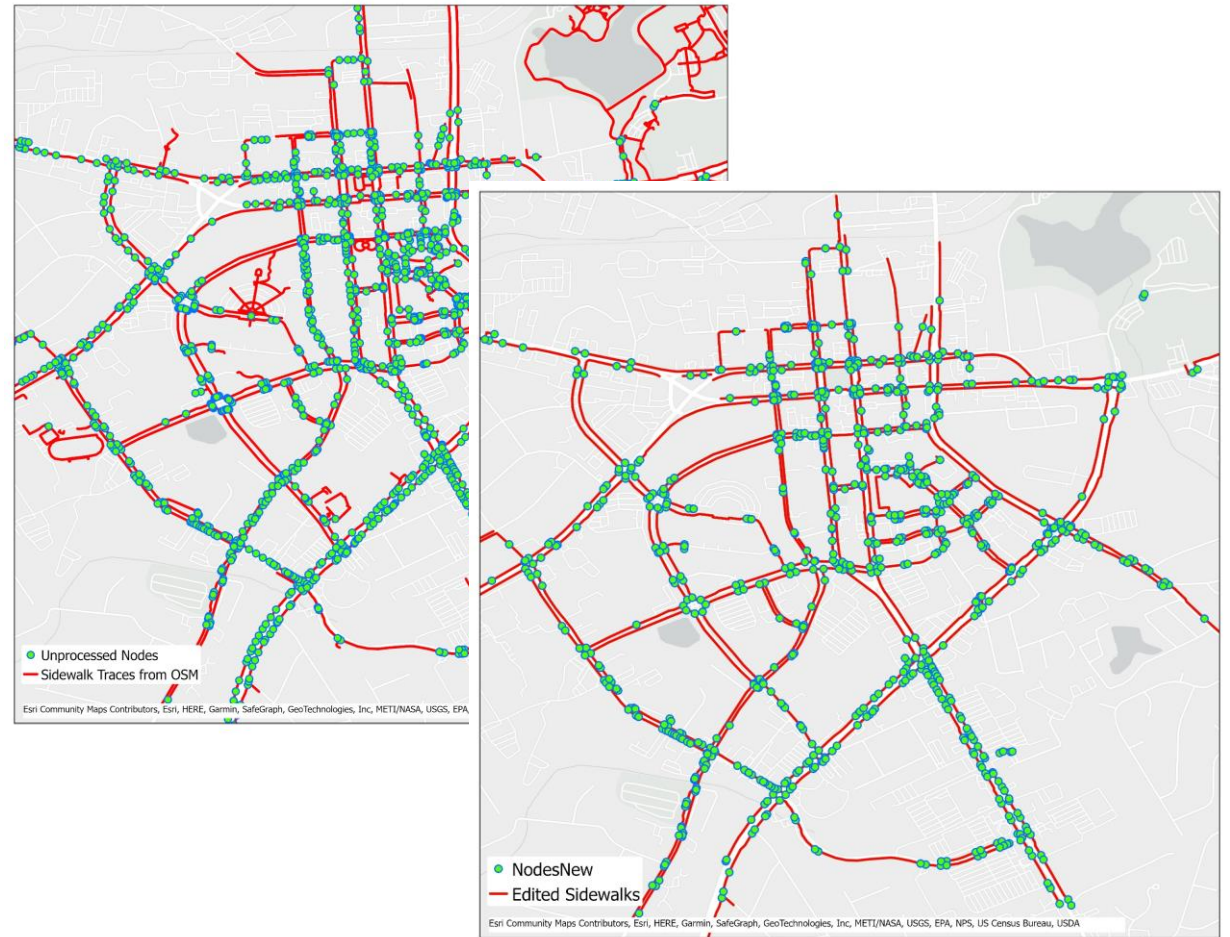
Data Log

Frame	Type	Problem	Delete

Gap: 9.0

ADA Network Reconciliation (OSM-Neptune)

- OSM is used in OTP routing
- OSM pedestrian ways
 - OSM ways \neq logical links
 - Correct ~85% of ways
 - Screen OSM links for ADA paths
 - Exclude parking lots, cut throughs, etc., from navigation
 - Reduce links by ~34%
- Reconcile OSM-Neptune
 - OSM ADA links are carried in Neptune, can be assigned impedance, and can be used in OTP routing



Impedance Calculations in the Cloud

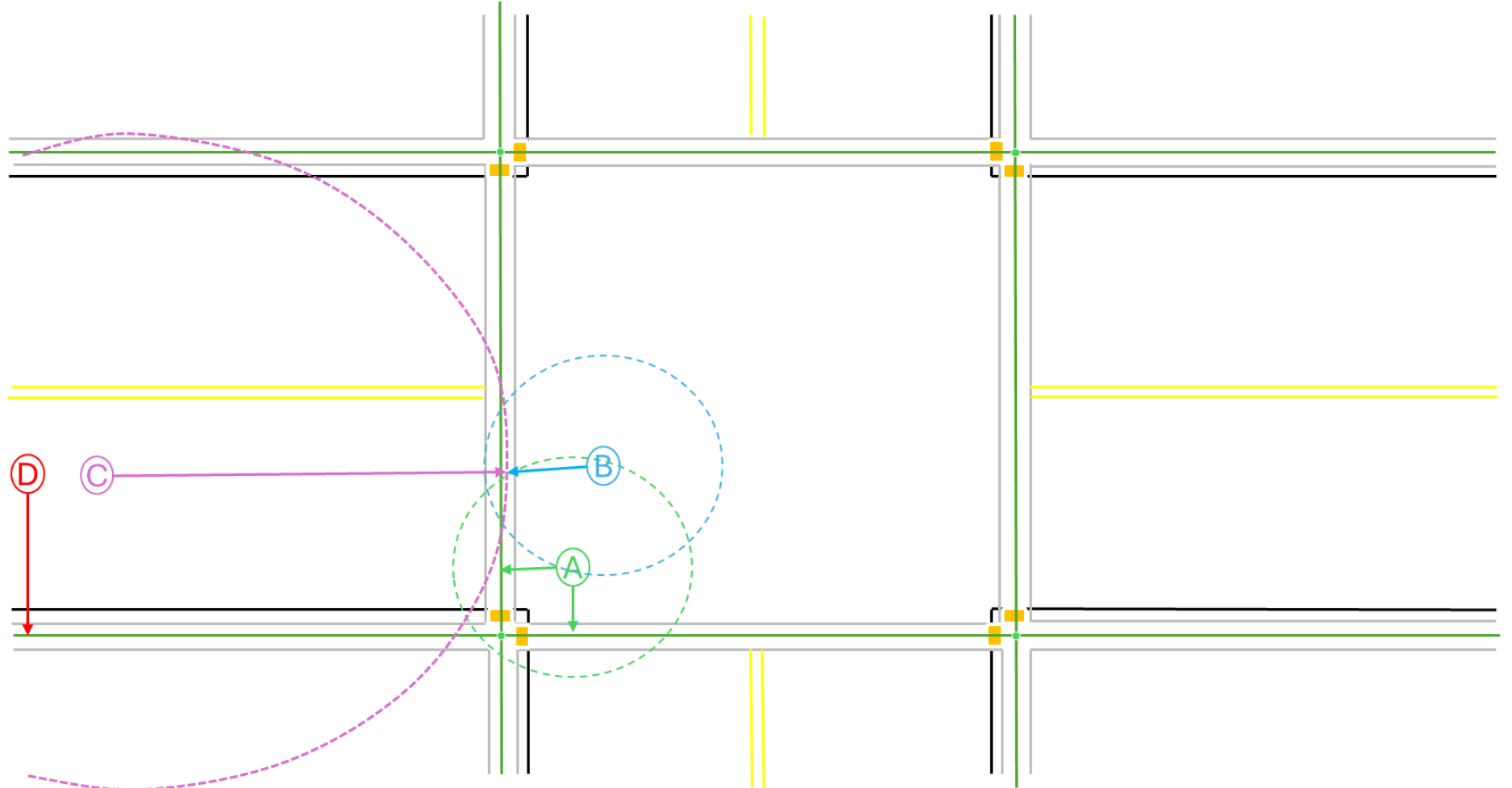
- AWS Neptune (Graph-database) replication of the OSM network
 - G-MAP pedestrian network
 - Subset of OSM with 1:1 link correspondence
 - Employs same IDs for tracking
- Calculate impedance for every link in the G-MAP pedestrian network and transmit
 - G-MAP uses the higher impedance values for routing

Cloud Implementation – Impedance Factor Matrix

- Rows for every impedance factor and condition (enumerated values and measured parameters)
 - Sidewalk design and surface conditions
 - Roadway crossing design and conditions
 - Curb ramp presence/absence, design, and conditions
 - Driveway curb cut (i.e., sidewalk that is perpendicular to vehicle travel) design, and conditions
- Columns for each ADA Mobility Mode (18)
- Cells contain impedance values
- Condition logic (additive or multiplicative)
- Run matrix calculation for every link
- Publish impedance for each link by ADA Mobility Mode (18)

Dynamic Impedance Updates

- Waze
- NaviGator Events



Stay Connected (Program / Site)

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Visit the ITS4US Deployment
Program Website:
<https://its.dot.gov/its4us/>

ITS4US Deployment Program Video
<https://youtu.be/pztl1IRyXAc>

Visit the Georgia-MAP
<https://georgia-map.com/>

Stay Connected (Presenters)

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Questions?