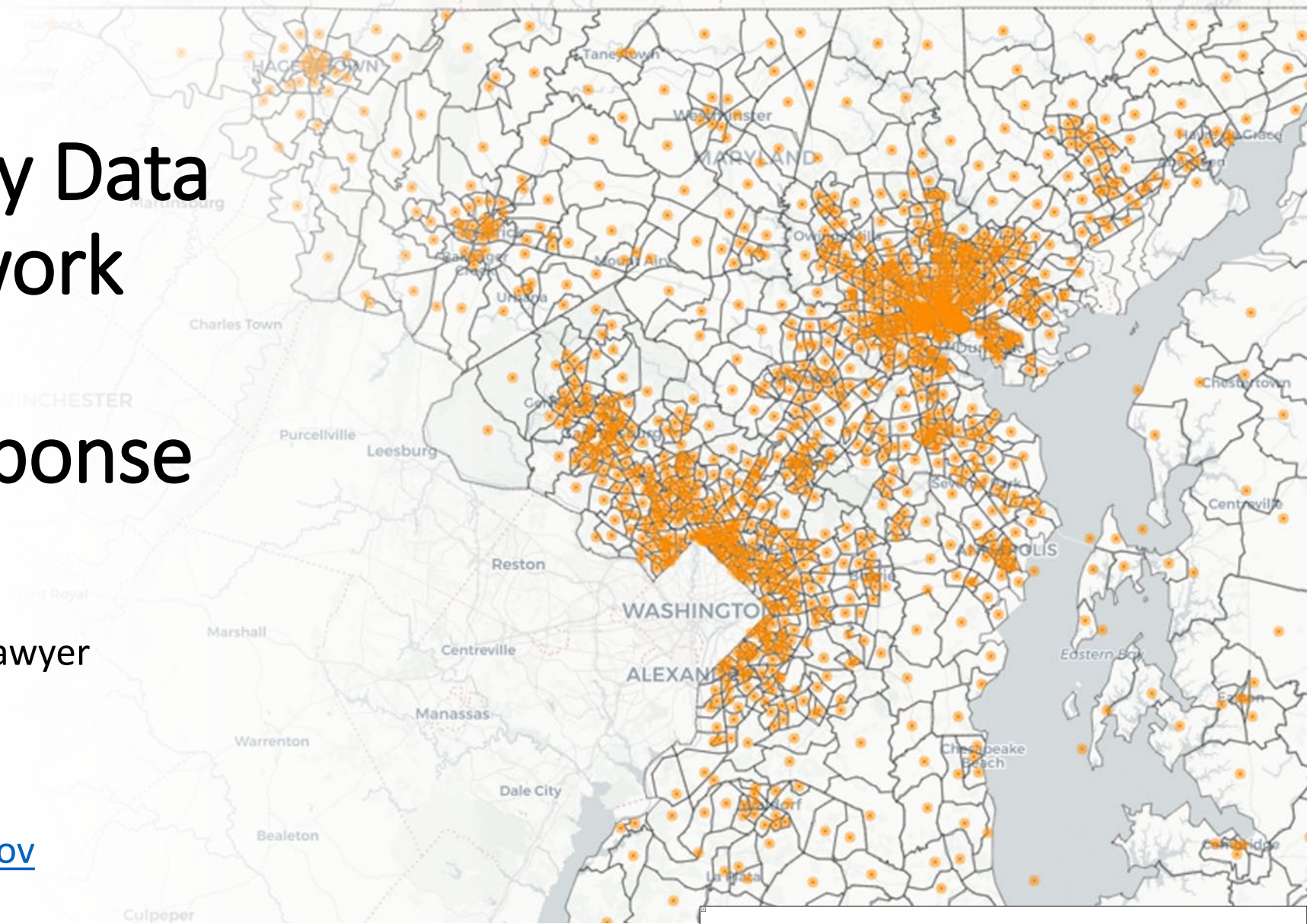# Enriching Survey Data with Road Network Analysis for Emergency Response

Authors: Joey Marshall, Chase Sawyer
Bethany DeSalvo, Heather King
U.S. Census Bureau

Contact: joe.marshall@census.gov

Overview

- **FEMA Request**
  - Can we know the logistical impact for commuters **directly** impacted by the Key Bridge collapse? Can this scale up for other disasters? Could we build something with the **Community Resilience Estimates** Program that can be used for evacuation routes for future response efforts?

- **Consultations and background research**
  - JTWMSB; OnTheMap/LEHD; US DOT; Maryland Department of Emergency Management.

- **Method**
  - Calculate driving route to work for American Community Survey respondents
    - Subset ACS microdata (5yr 2018-2022) to car-commuting workers.
    - Geocode residence tract and place of work tract to population-weighted tract centroid (or use place of work if tract is unavailable).
    - Use road network data and routing algorithms to calculate the optimal driving route from origin centroid to work centroid.
  - Compute results:
    - Compare bridge and non-bridge commuters.
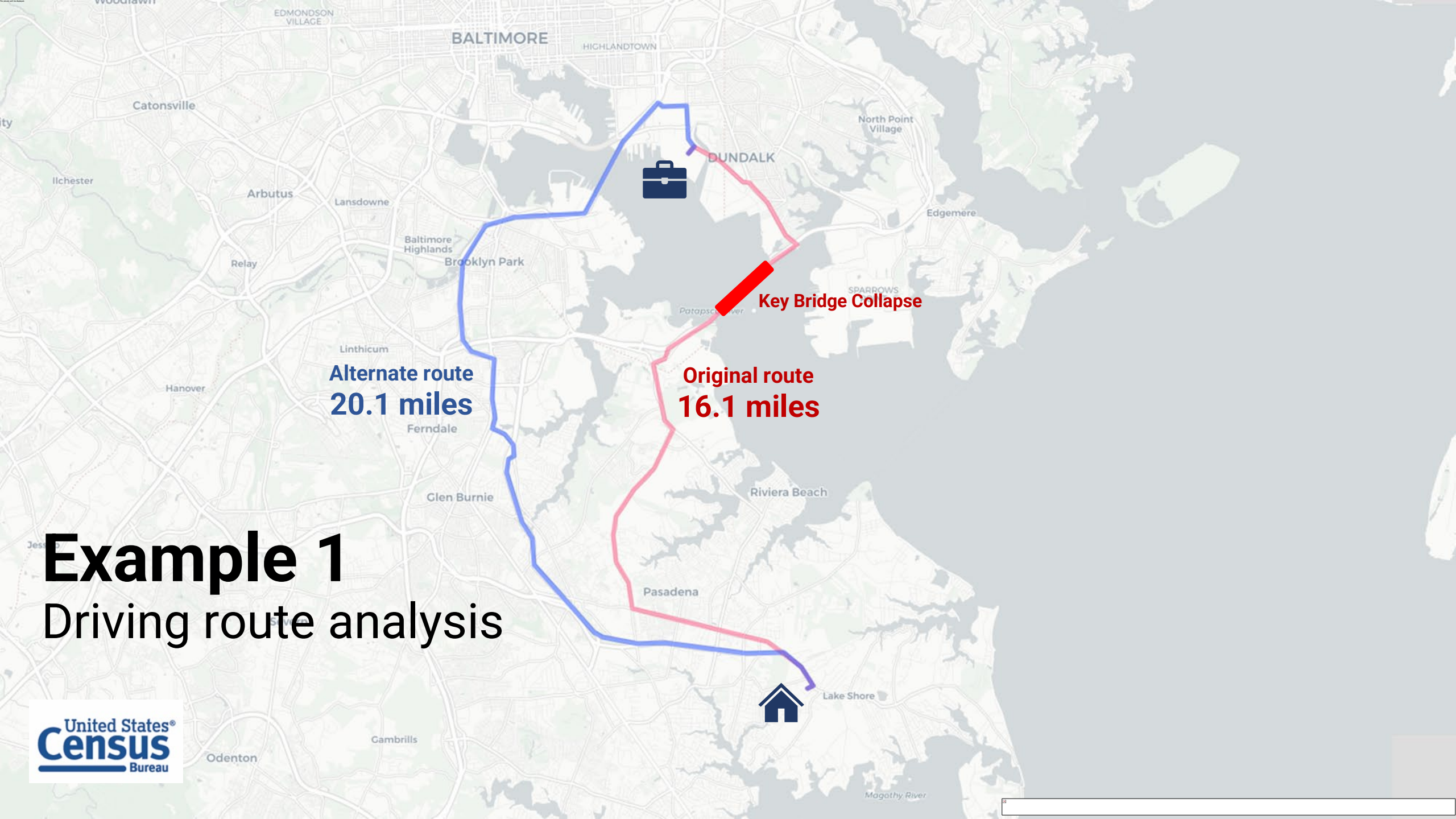   - Average driving distance before and after Key Bridge collapse.

Key Bridge Collapse

Alternate route
20.1 miles

Original route
16.1 miles

Example 1
Driving route analysis

Tract
Centers of
population
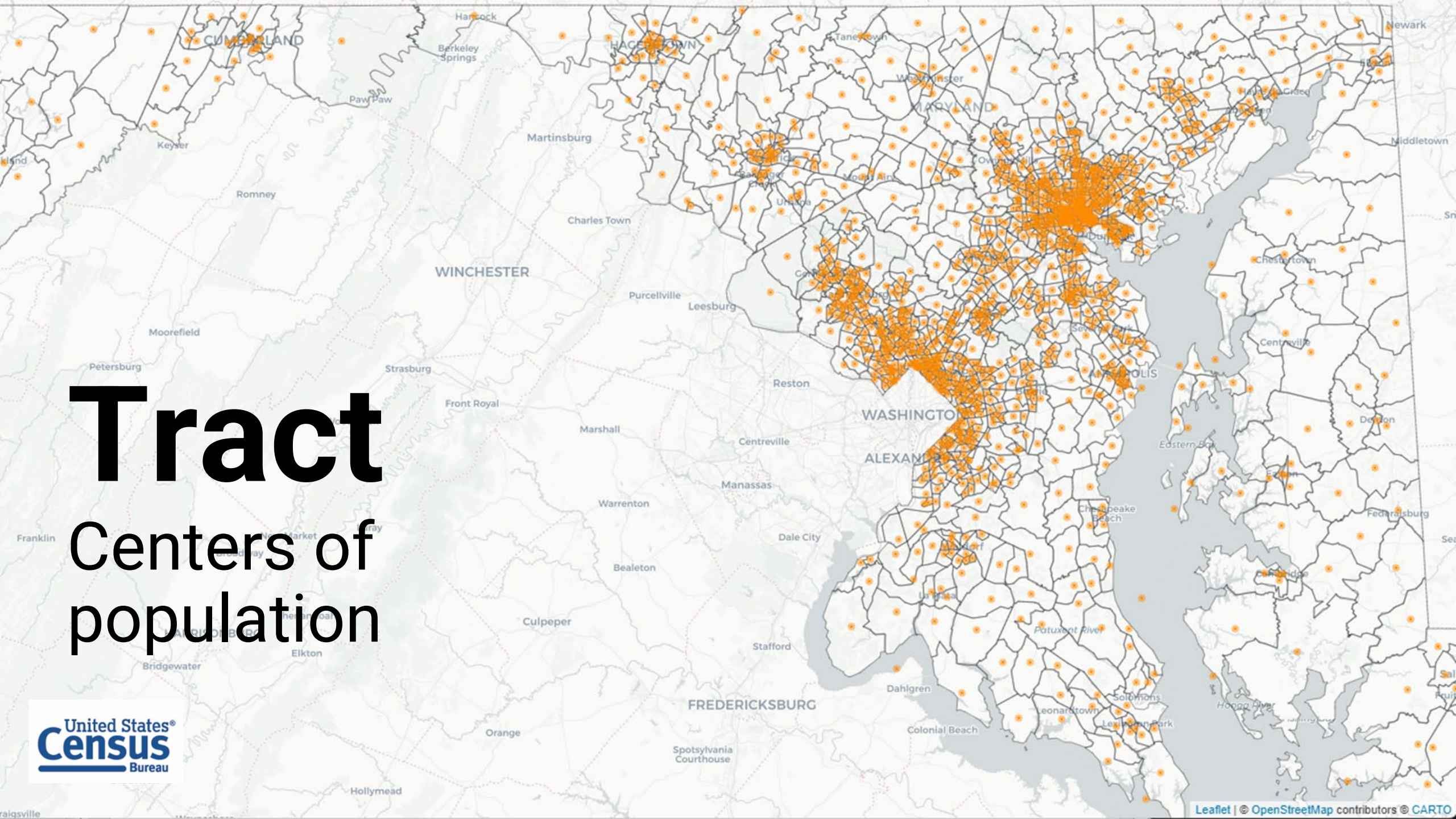
Place
Centroids
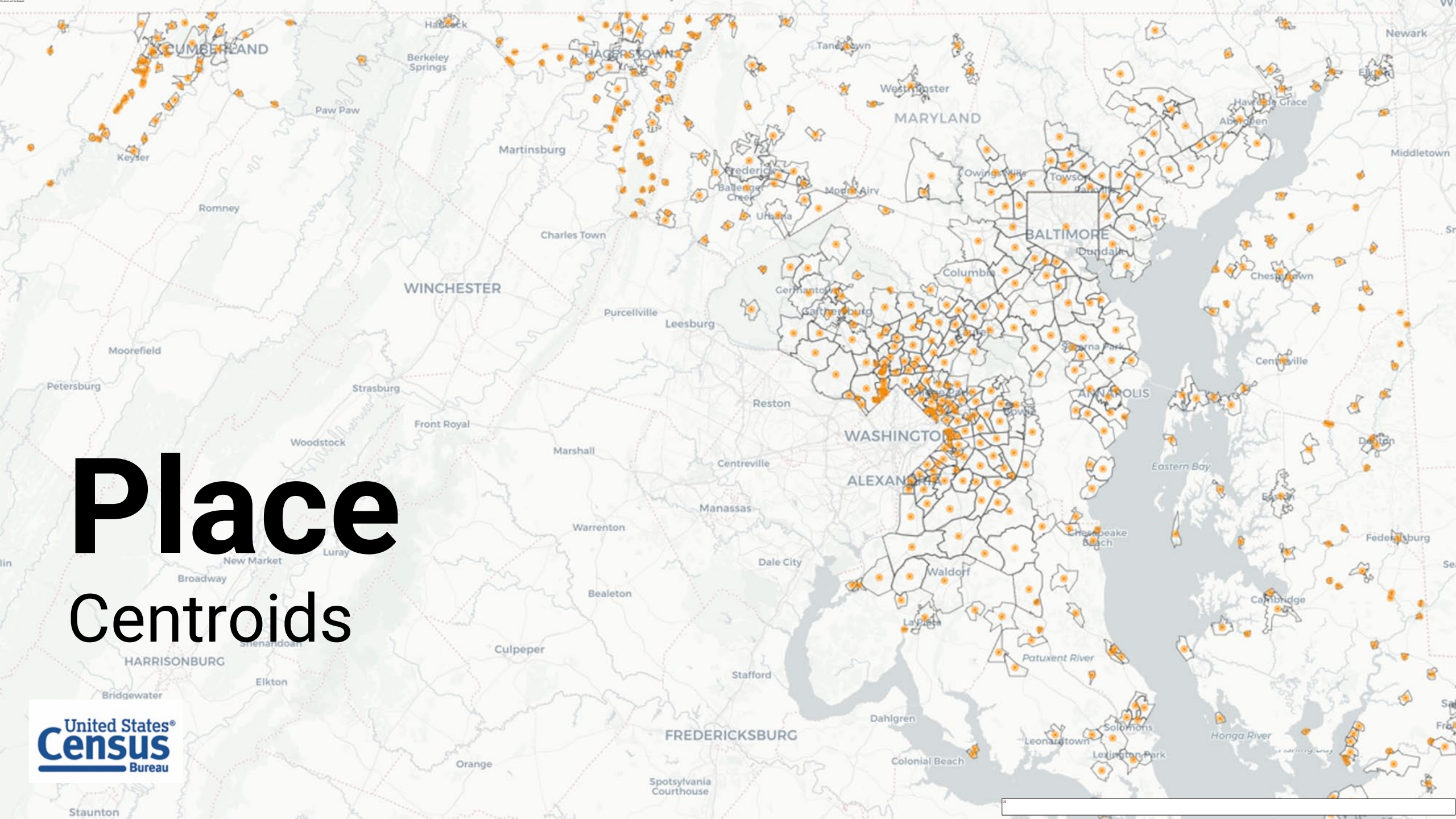
Road Network and Routing Data

- Open Source Routing Machine (OSRM)
  - Runs in a Dockerized environment on a local machine or server.
  - Historical road network data available; e.g., from before and after FSK Bridge collapse.
  - 2-clause BSD license.

- OpenStreetMap
  - Hosted by Geofabrik.
  - Maryland data available at frequent intervals back to 2014.
  - Open Database License (ODbl).

Characteristics of Baltimore Car Commuters
(Percentages)

● Bridge commuters   ● Nonbridge commuters

Length of commute

	Bridge	Nonbridge
Less than 20 minutes*	9.2	26.9
20 to 24 minutes	14.6	15.3
25 to 29 minutes*	17.8	7.9
30 to 34 minutes*	26.5	17.9
35 to 44 minutes	9.0	10.5
45 to 59 minutes	14.4	12.4
60 or more minutes	8.4	9.2

Departure time for work

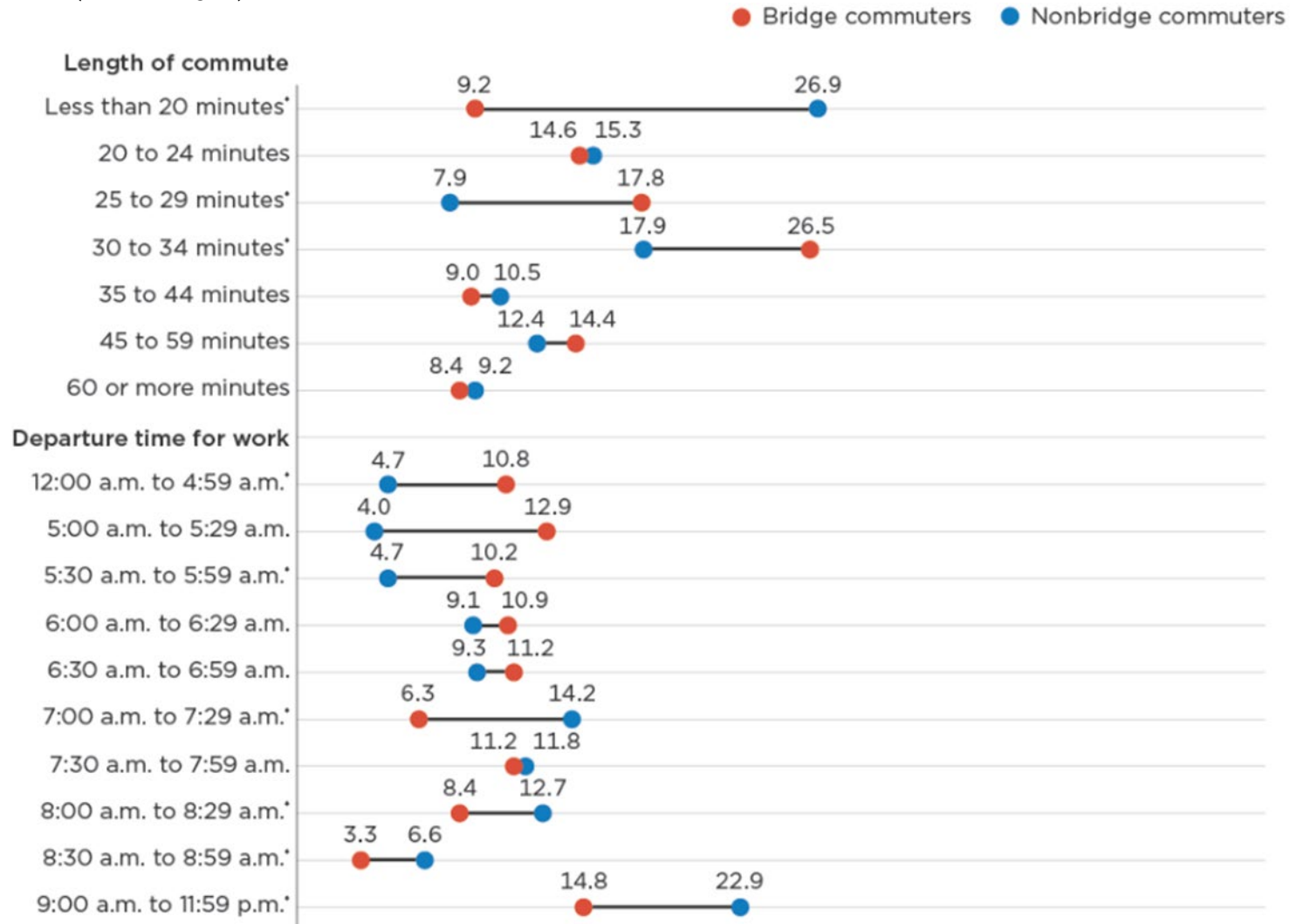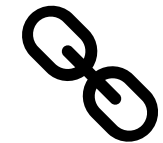|	Bridge	Nonbridge
12:00 a.m. to 4:59 a.m.*	10.8	4.7
5:00 a.m. to 5:29 a.m.	12.9	4.0
5:30 a.m. to 5:59 a.m.*	10.2	4.7
6:00 a.m. to 6:29 a.m.	10.9	9.1
6:30 a.m. to 6:59 a.m.	11.2	9.3
7:00 a.m. to 7:29 a.m.*	6.3	14.2
7:30 a.m. to 7:59 a.m.	11.2	11.8
8:00 a.m. to 8:29 a.m.*	8.4	12.7
8:30 a.m. to 8:59 a.m.*	3.3	6.6
9:00 a.m. to 11:59 p.m.*	14.8	22.9

* Difference is statistically significant
Note: Analysis of survey respondents who live or work in Baltimore city or County and who drive alone or carpooled to work in a car, truck or van. Bridge commuters are those whose driving route to work likely included the Francis Scott Key Bridge prior to Collapse.
Source: U.S. Census Bureau, American Community Survey 2018-2022, OpenStreetMap, Open Source Routing Machine.

[Link to published research](#)

United States® Census Bureau

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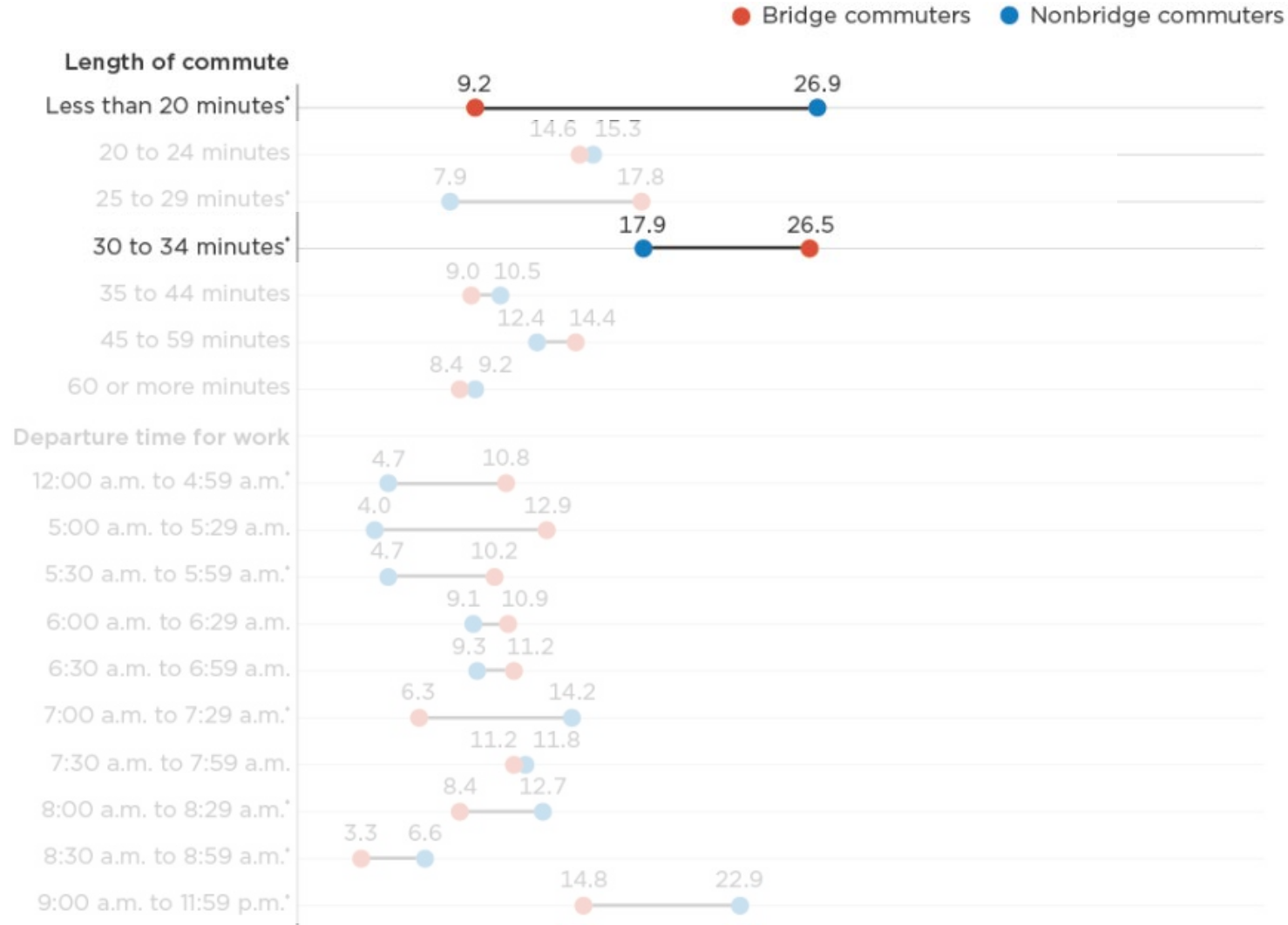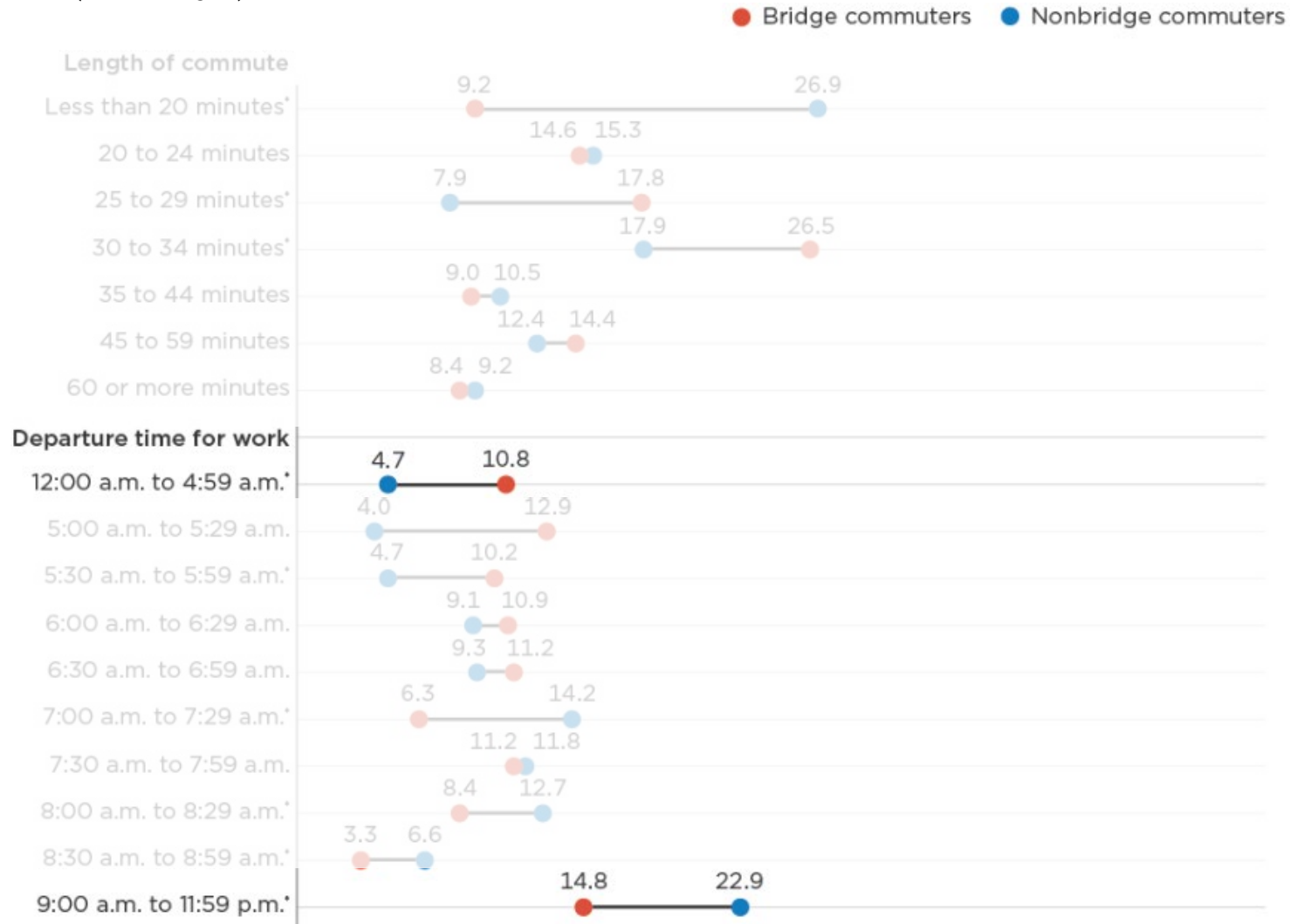|	Bridge	Nonbridge
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United States® **Census** Bureau

Disclosure Review Board (DRB) approval number: **CBDRB-FY24-SEHSD003-052.**

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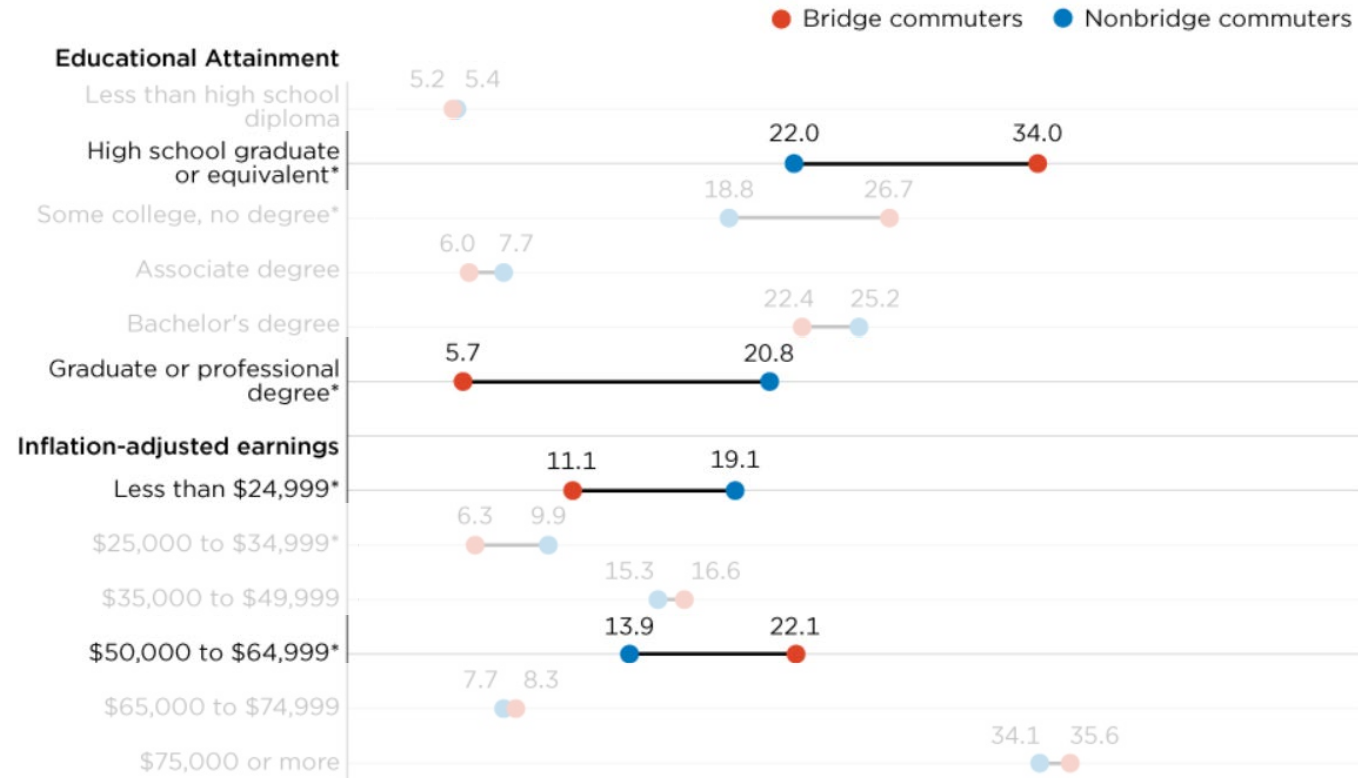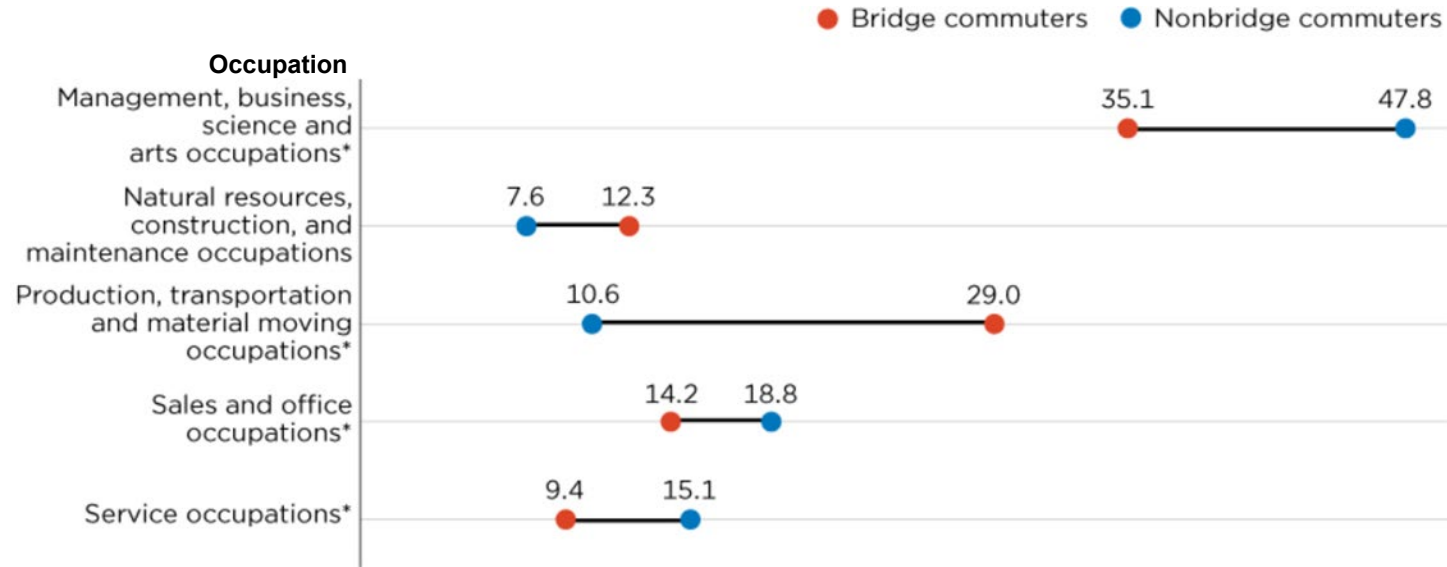Source: U.S. Census Bureau, American Community Survey 2018-2022, OpenStreetMap, Open Source Routing Machine.

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Characteristics of Baltimore Car Commuters
(Percentages)

● Bridge commuters   ● Nonbridge commuters

Educational Attainment

Less than high school diploma — 5.2   5.4

High school graduate or equivalent* — 22.0   34.0

Some college, no degree* — 18.8   26.7

Associate degree — 6.0   7.7

Bachelor's degree — 22.4   25.2

Graduate or professional degree* — 5.7   20.8

Inflation-adjusted earnings

Less than $24,999* — 11.1   19.1

$25,000 to $34,999* — 6.3   9.9

$35,000 to $49,999 — 15.3   16.6

$50,000 to $64,999* — 13.9   22.1

$65,000 to $74,999 — 7.7   8.3

$75,000 or more — 34.1   35.6

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Characteristics of Baltimore Car Commuters
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● Bridge commuters ● Nonbridge commuters

Occupation

Management, business, science and arts occupations* 35.1 47.8

Natural resources, construction, and maintenance occupations 7.6 12.3

Production, transportation and material moving occupations* 10.6 29.0

Sales and office occupations* 14.2 18.8

Service occupations* 9.4 15.1

* Difference is statistically significant
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Example 1 Summary

- Road network data can be combined with microdata to parse certain categories of commuters.

- Compared to non-bridge commuters who live or work in Baltimore City or County, bridge commuters:
  - Tended to have longer commutes.
  - Arrived at work earlier.
  - Tended to work in production, transportation and material moving.
  - Had higher earnings.
  - Were more likely to have a high school degree only; less likely to have a graduate degree.
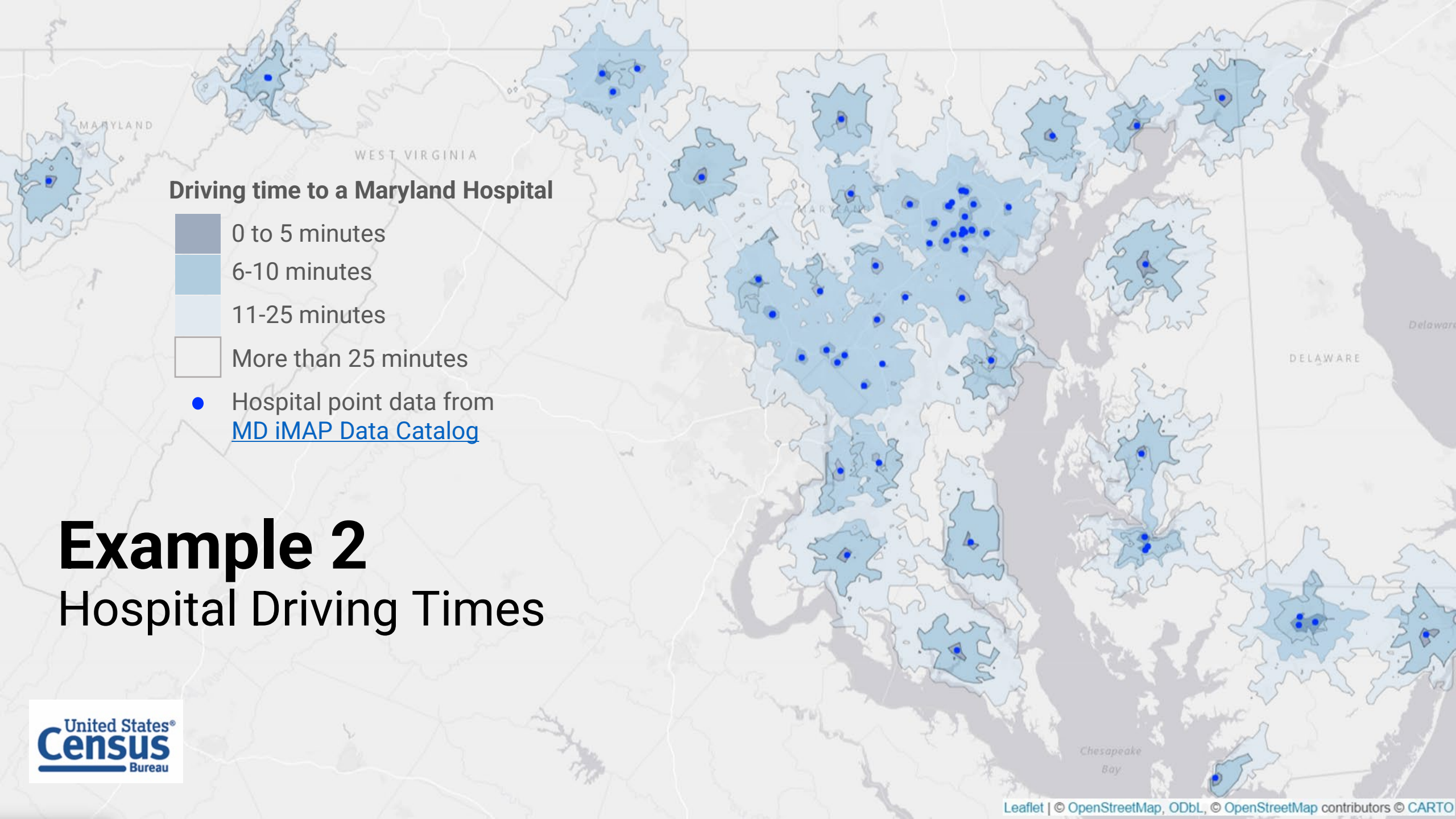
Driving time to a Maryland Hospital

- 0 to 5 minutes
- 6-10 minutes
- 11-25 minutes
- More than 25 minutes
- Hospital point data from MD iMAP Data Catalog

Example 2
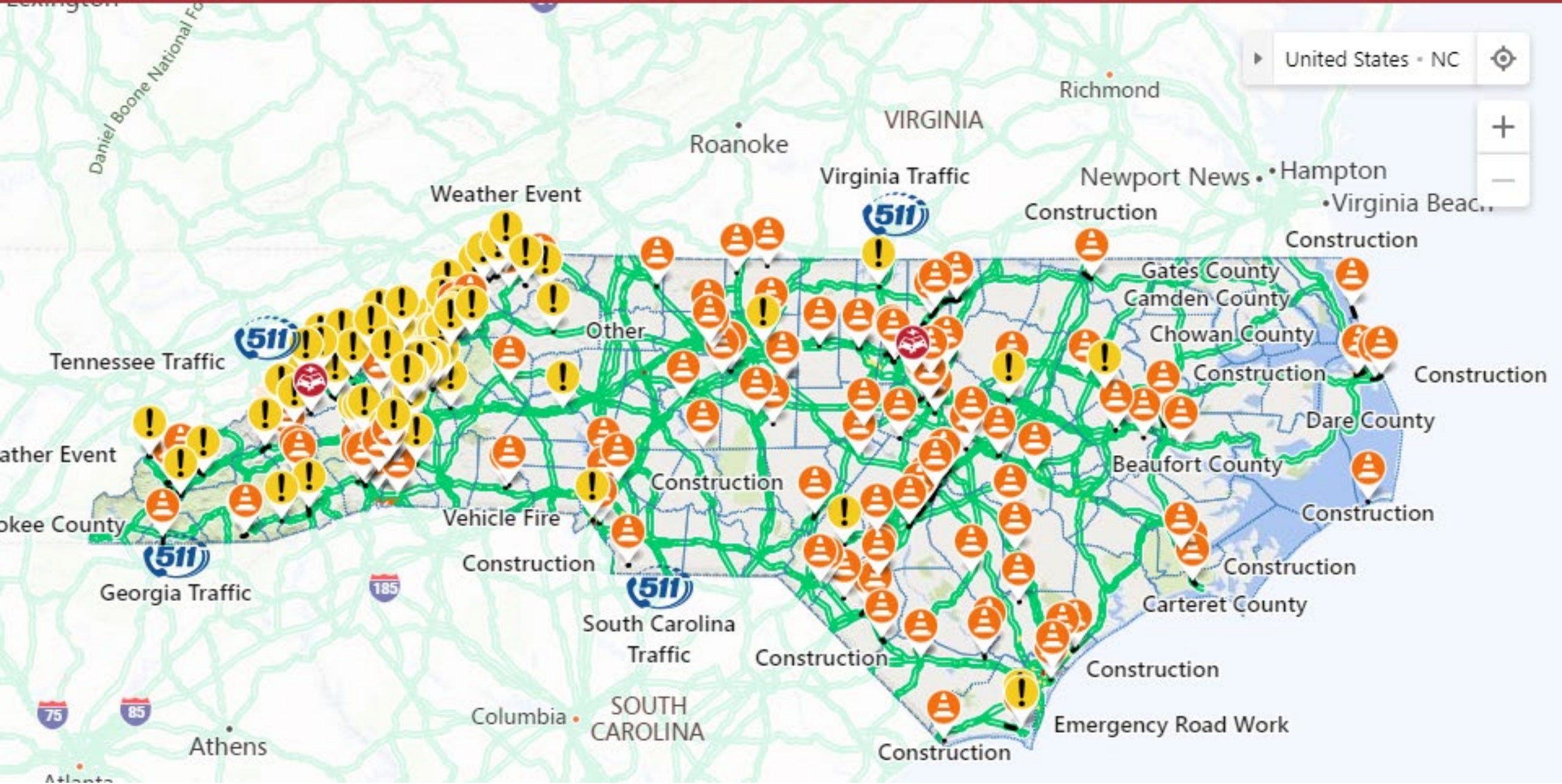## Hospital Driving Times

United States® Census Bureau

POTENTIALLY HAZARDOUS ROAD CONDITIONS IN AREAS IMPACTED BY HELENE

I-40 is closed at the TN/NC line. The estimated reopening time is unknown. I-26 is closed in Tennessee, near the

Open

United States · NC

Richmond

VIRGINIA

Roanoke

Virginia Traffic

Newport News • • Hampton

Construction

• Virginia Beach

Construction

Weather Event

511

Other

Gates County
Camden County

Chowan County

Construction

Tennessee Traffic

511

Dare County

...ather Event

Beaufort County

...okee County

Construction

Vehicle Fire

511

Construction

Georgia Traffic

Construction

South Carolina
Traffic

Carteret County

Construction

Construction

Construction

Columbia •

SOUTH
CAROLINA

Emergency Road Work

I-75 I-85

Athens

Construction

...Atlanta

ROADMAP

ROute Analysis for Disaster Management And Preparedness

Part of the broader **Community Resilience Estimates Program (CRE)**, this method uses road network data to plot driving, walking or other transportation routes to assist members of the public and government partners in emergency management in identifying the characteristics of vulnerable populations.

Transportation routes

+

Census data

Example 1

Francis Scott Key Bridge Collapse

Following the collapse of the Key Bridge in Baltimore, analysts identified a subset of American Community Survey respondents who likely drove over the bridge as part of their regular commute to work. This was accomplished by **plotting the likely driving route to work for every car-commuting ACS respondent** who lived or worked in Baltimore city or County. This revealed distinct sociodemographic differences between bridge and non-bridge commuters.

Key Bridge Collapse

Alternate commuting route
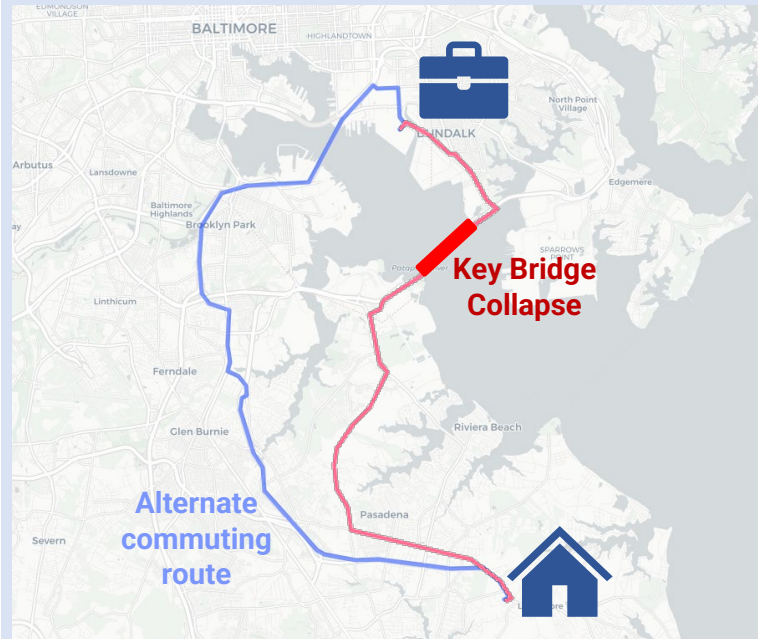
Example 2

Driving Distances to Critical Infrastructure

This method can be used to identify catchment areas for critical infrastructure. In this analysis, shaded areas represents areas represent driving times to the nearest hospital in the state of Maryland. The same analysis could be applied to any set of geographic points such as shelters or community cooling centers during heat waves. For disaster route contingency planning, the underlying map data can be transformed to simulate when key road networks are altered.

Driving time to a Maryland Hospital

- 0 to 5 minutes
- 6-10 minutes
- 11-25 minutes
- More than 25 minutes
- Hospital location

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