Safe Routes PARTNERSHIP
*Active Paths for Equity & Health*

# ROUTES OF HEALTH

## Exploring the Effects of Navigation Systems on Community Mobility, Safety, and Livability

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# I Introduction

Until the last decade, figuring out how to meet a friend at a new destination meant writing down directions or looking on a map for the main roads creating a direct route from origin to end point. Today, many travelers simply consult apps on smartphones or in-dashboard navigation systems – even for routine journeys – seeking to avoid unexpected traffic and select the best (i.e. quickest) route.

With new technologies, we are adjusting to the omnipresence of detailed information about our world, often with a learning curve that can seem overwhelming at first. But the navigation and routing revolution is creating a vast, largely unnoticed shift in the usage of our streets. As private cars, ride hailing services, and commercial vehicles are directed to side streets and previously unknown local neighborhood routes in the quest to shave mere moments off a trip or avoid a traffic light, communities are seeing increased vehicle traffic in precisely the spots that planners have deliberately sited away from major arterials and vehicular danger zones. Navigation systems are directing harried drivers into sensitive street zones. As drivers flood the streets near schools and parks, driving along children's routes to schools or on communities' designated bicycle networks, children and adults who are walking or biking to local destinations are exposed to the dangers and discomforts of increased traffic and air pollution. With little attention or regulation, this shift in our traffic patterns and behaviors has potentially devastating consequences for our goal of creating a culture of health, threatening active transportation, children's health and safety, and the vitality of streets surrounding our parks, schools, senior centers, and other community hubs.

## About This Project

This project began with the aim of working with five communities across the United States to better understand the effects that navigation systems are having on local level mobility, accessibility, and livability, and to identify promising strategies to address any negative effects. In 2020, the Safe Routes Partnership put out an invitation to communities within our network and others to share their experiences and concerns with navigation systems and participate in the project. Five communities were chosen as case studies and partners in this work: Atlanta, Georgia; Bellevue, Washington; Charlotte, North Carolina; Montgomery County, Maryland; and Orlando, Florida.

During initial conversations with local planning and transportation staff, community organizations, and transportation advocates in the case study communities, a number of key questions and issues were raised:

- How do we know that our community's transportation challenges can be attributed to these new navigation technologies? We suspect navigation systems are influencing local conditions, but how can we be certain?
- How can we understand the magnitude of the issue?
- What solutions have other communities tried and have they been successful? What can we learn from the experiences of these other communities?

As a result of the questions that the five case study communities had, and understanding that other communities in the US likely had the same questions, this project has focused on:

- Exploring the effects that navigation systems are having on local level mobility, accessibility, and livability;
- Undertaking data analysis and developing a methodology to understand the effects of navigation systems on communities; and
- Identifying community-informed policy and other strategies to address the challenges to transportation safety, accessibility, and other local priorities created or exacerbated by navigation systems.

Through conversations with local stakeholders including residents, community organizations, government agencies, and others, we heard firsthand how navigation technologies have influenced traffic patterns and created concerns for health, safety, and equity on the ground.

Parallel with engaging community stakeholders, the project team also undertook a literature review, identified news stories related to navigation technology, conducted legal research, and held key informant interviews to identify research in this area to date as well as real-world strategies implemented by jurisdictions in the US. The project team also identified what data was available and useful to illustrating the effects of navigation systems in order to develop a data analysis methodology that was tested and refined through working with the data available in the five case study communities.

## Organization of the Report

Following the Introduction, **Section II** of this report provides an overview of navigation systems including a brief history of their development. **Section III** describes current usage of navigation systems in automobiles and summarizes the effects researchers and transportation practitioners have identified on traffic patterns and congestion, driver behavior, health, and equity. **Section IV** describes the methodology developed by this project to assess impacts of navigation systems in neighborhoods. **Section V** explores strategies to address challenges posed by navigation systems, including strategies tried by other communities in the United States and potential strategies identified by researchers and practitioners. **Section VI** outlines promising strategies and recommendations for the five case study communities and others to move forward in addressing challenges posed by navigation systems. Finally, the report ends with concluding remarks and thoughts on future explorations. **Appendices** for each of the five case study communities provide more detailed background on the local policy and planning context, a summary of the local community engagement process and findings, and local traffic data analysis.

# II An Overview of Navigation Systems

## A Brief History

Use of navigation systems by automobile drivers and other road users is a relatively new phenomenon when compared to the decades of transportation planning and road infrastructure development in the U.S. Early in-car navigation systems were developed as early as the 1960's.[1] However, the first commercially available in-car navigation system was not available until 1981[2] and GPS (global positioning systems) navigation systems was first offered in a mass produced car in the US starting in 1995.[3] Garmin introduced their first portable StreetPilot GPS navigation system for automotive use in 1998.[4] It was not until 2000 that the full capabilities of GPS technology were installed into commercial vehicles.[5]

From there, public use of navigation systems increased significantly. People began using in-dashboard and portable navigation systems in their cars for routing, relying on the system to give them turn-by-turn directions. They also started using mapping systems like Google Maps, which was launched in 2005, on their computers to explore the world and get directions before leaving for their destination. The introduction of the smartphone brought upon portable navigation systems in the form of navigation apps like Apple Maps, Google Maps, and Waze that are some of the most widely used handheld navigation tools today. While automobile drivers are still the primary audience for most navigation apps, some include interfaces or tools for other road users including pedestrians, cyclists, and transit riders.

### What Navigation Systems Does This Report Focus On

Much of this project and report focus on navigation apps like Google Maps, Apple Maps, and Waze that are primarily used on smartphones, given their proliferated use by private drivers in recent years, their underlying presence in propriety systems used by business like Lyft, and the shift away from in-dash or other stand-alone devices. A 2015 Pew survey found that 67 percent of smartphone owners use their phones at least occasionally for turn-by-turn navigation while driving, while 31 percent said they frequently do.[9] In 2020, Google Maps was the most downloaded navigation app in the US with 23.42 million downloads. Waze followed, with 11.22 million downloads.[10] More than 100 million people are believed to be using Waze across the world, making it one of the most popular smartphone navigation applications.[11]


Beyond mainstream navigation apps on smartphones, this project also acknowledges the continued use of in-dashboard navigation systems affixed to the vehicle and portable navigation systems like Garmin, TomTom, and Ohrex products that provide maps and routing to the driver. In addition to these products used by individual consumers, businesses such as ride hailing and delivery companies also use their own systems. Ride hailing leader Uber uses its own priority system. Commercial delivery leader UPS uses its own system within its vehicles.[12] These navigation systems are all developed and provided by private companies either for the use by their employees as part of business operations, or as a free or paid service to the general public.

### Defining Key Terms

- *Navigation system - An electronic system in a vehicle or mobile device that provides a real-time map of the current location and step-by-step directions to a requested destination. Often called a "GPS," a navigation system receives signals from the satellite-based global positioning system (see GPS).[6]*
- *Navigation app/routing app - An application in a smartphone that provides navigational directions in real time.[7]*
- *Global Positioning System (GPS) - a U.S.-owned utility that provides users with positioning, navigation, and timing services. This system consists of three segments: the space segment, the control segment, and the user segment.[8]*
- *Crowdsourcing - the process of acquiring services or information by seeking contributions from different communities, particularly from those that are online, on social media, or using an application.*

## RELATED TECHNOLOGIES: CONNECTED VEHICLES AND AUTONOMOUS VEHICLES

*Although smartphone navigation apps, in-dashboard navigation systems, systems used by ride hailing services, and even systems used by autonomous vehicles are distinctively different, they are similar in that they use crowdsourced information to provide users with an artificial intelligence (AI)-empowered service to aid transportation.*

*Smartphone app developers and ride hailing companies use artificial intelligence to process crowdsourced information to track users' behavior. Newer and updated in-dashboard navigation systems also operate as smart devices, not just learning users' preferences and using data connections for timely updates, but crowdsourcing sensor information from connected vehicles to assess traffic problems and road conditions like a newly formed pothole.[13] The crowdsourced information is stored in a cloud for easy access to make updates, as opposed to being locally stored. The crowdsourced traffic and navigation app owned by Google is joining the SmartDeviceLink Consortium and working with automakers and developers on open source protocols for connecting smart phones to cars.*

*Like the technology used in newer in-dash navigation systems, autonomous vehicles (AVs) use crowdsourced sensor and image information from various cameras, sensors, GPS, LiDAR, IMUs, and data from other drivers to route driverless navigation.*

*LiDAR, typically used as an acronym for ""light detection and ranging"", is essentially a sonar that uses pulsed laser waves to map the distance to surrounding objects. It is used by a large number of autonomous vehicles to navigate environments in real time.*

*Inertial measurement unit (IMU) can, without input from any other sensors, inertial sensors can detect the movement of the vehicle. An IMU can be used for more than air-bags and vehicle stability; an IMU can track full vehicle position and orientation in real-time.*

*The crowdsourced sensor and image information is used for a simultaneous localization and mapping algorithm (SLAM) to build a 3D view of a region for purposes of navigation. SLAM is an important technique for robotic system navigation. Due to the high complexity of the algorithm, SLAM usually needs long computational time or large amount of memory to achieve accurate results.*

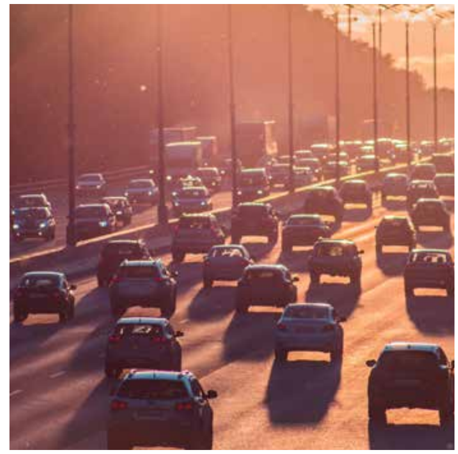
*Unlike regular web maps or smartphone navigations services, AVs require high definition (HD) maps that represent the world at an unprecedented centimeter resolution to be able to routinely execute complex maneuvers such as nudging into a bike lane to take a turn and safely passing bicyclists.*

*Connected cars use the computer systems like traction control and stability systems in vehicles to gather information on road conditions like icy roads and transmit the information back to a centralized information system that integrates the feedback and shares it with other vehicles using the same platform sensors. This adds another layer of crowdsourced information that does not rely on active user reports to steer other drivers away from unwanted road conditions by giving them a preemptive warning or modifying routing to avoid an area.*

## *How Do These Systems Work?*

Navigation systems use a database that contains information about where road infrastructure is and the features (number of lanes, signals, freeway ramps, etc.) of those roads. The system uses satellite data (GPS) to understand where the user is located. Each system then uses its own proprietary algorithm to create routing for the user based on inputted destination and other preferences (i.e. avoiding toll roads). Older in-dash and portable systems had fixed databases of information that could only be updated by installing a new CD-ROM or software update. Nowadays, systems are connected to the internet and can receive information updated almost in real-time, which is part of the business proposition of companies like Waze.

Waze and other companies integrate information gained through crowdsourcing. Crowdsourcing is the process of acquiring services or information by seeking contributions from different communities and individuals, particularly from those that are online, on social media, or using an application. Smartphone app-based systems like Waze use crowdsourced data collected from users' devices and



GPS signals to report police presence, speed enforcement zones, crashes, and other things that would affect the driving experience.

## *Goals of Navigation Systems*

What are the goals of navigation systems? The primary goal of all navigation systems is to get the user to get from point A to point B. But in order to keep users engaged and using the particular navigation system, each navigation system provider has to be competitive against others by giving reliable information and providing what they think users want. While the actual inputs and algorithms that drive each navigation system are proprietary (meaning not disclosed to the public), the navigation providers are businesses and by design, the business models for these technologies primarily focus on gathering as much data as possible to enhance the experience of their users or consumers. Because the U.S. has a culture that by and large prioritizes driving private vehicles over other modes of transportation, enhancing the experience typically means making it more convenient and quick for a driver to get from place to place. The navigation systems seemingly assume that all users have the same priorities, needs, and goals in mind when they use navigation apps. They assume users want to get from point A to point B in the quickest way possible, avoiding traffic congestions or other obstacles (construction roadblocks, DUI checkpoints), and maximizing speeds.

Some navigation system providers have added extra features to make their system more appealing. For example, Waze says it "provides real-time traffic updates, plus all kinds of cool social and geo-gaming elements that actually make commuting fun."[14] Some systems are adding on additional layers of information to help drivers better navigate the roads. For example, Apple Maps tells you when you are approaching a traffic signal or stop sign – presumably to make sure the driver is prepared to stop or slow down. Google Maps will be rolling out a similar feature.[15] Waze uses crowdsourced data to warn other users of traffic collisions and other hazards, as well as warnings for drivers that are approaching areas such as railroad crossings.[16]

In addition to navigating people to destinations, some navigation app companies have added on components to increase their money-making potential. For example, Waze has advertising space for businesses like restaurants, banks, and gas stations along the routes of potential customers.[17] Waze also more recently added carpool matching capabilities - it matches neighbors and co-workers commuting to and from nearby destinations. Drivers can charge riders up to the standard mileage reimbursement rate set by the IRS. Currently, Waze does not take a commission for the rides, but it could in the future.[18]

Navigation systems developed for and used by businesses may have additional goals, typically around employee efficiency. United Parcel Service (UPS) uses algorithms that optimize routes to make it easier and more efficient for drivers, for example, routing that avoids left turns for efficiency and safety. It also processes UPS delivery data alongside its internal maps to make routes between stops as cost-effective as possible.[19]

## A Mismatch of Goals

Navigation systems bring upon a whole new level of access to information for users. So, what's the problem? Many suggest that the technologies possess route optimization features based on information gathered by crowdsourcing or artificial intelligence that do not account for roadway design or functional capacity, non-arterial roads, or the effects that routing has on residential neighborhoods. They use a form of artificial intelligence to process crowdsourced information to achieve outcomes largely market-driven for competition purposes.[20] Currently, free mainstream navigation apps are very automobile centric. While some include or are building out features that help people walking or biking get to their destinations,[21],[22] and some integrate transit information, navigation systems are primarily still focused on the needs of drivers. As a result, the needs of and impacts to non-drivers receive less attention and priority. For communities that are actively moving away from auto-centric transportation planning to better serve all users through a Complete Streets approach, are seeking to improve transportation safety through a Safe Systems approach, or are investing in active transportation, the goals and impacts of navigation systems run contrary to local goals and priorities. Route optimization that occurs within navigation systems promotes short-term, individual wins rather than long-term, system-wide needs like reducing congestion, reducing emissions, and improving environments for people walking, bicycling, and taking transit. According to Laura Bliss, co-author of The Future of Transportation, "This gets to the heart of the problem with any navigation app—or, for that matter, any traffic fix that prioritizes the needs of independent drivers over what's best for the broader system. Managing traffic requires us to work together. Apps tap into our selfish desires."[23]

***"Managing traffic requires us to work together. Apps tap into our selfish desires." -Laura Bliss***

### FUNCTIONAL CLASSIFICATION OF ROADS

*Roadways are classified by how they function within a transportation system. Roadways are grouped into classes, or systems according to the character of traffic service that they are intended to provide.This helps plan appropriate design components for each type of road. Classifications are determined by the jurisdiction that owns and operates the roads and terminology and specifics vary from place to plan.Typically, roadways are classified in three categories: arterial, collector, and local roads. Arterials typically include interstates and expressways, as well as roads that carry most of the traffic entering and leaving urban areas. Access is controlled or limited, which allows for high traffic volumes and speeds. Collectors provide traffic circulation within residential, commercial, and industrial areas and carry trips to and from arterials. Local roads include most residential and other small streets. Local roads provide limited mobility and are the primary access to residential areas, businesses, farms, and other local areas.*

# III Consequences of Modern Navigation System Use

While we recognize the potential benefits that navigation systems can provide in terms of sharing valuable data with agencies for planning purposes, and helping people navigate using active modes of transportation and transit, the current design and use of navigation systems have vast potential to negatively impact communities. One of the primary negative consequences is around changing traffic patterns with detrimental effects on vulnerable areas. There are also negative effects related to interfering with emergency operations and contributing to distracted driving and other poor driving behaviors. Like many issues with our transportation systems in the U.S., the negative consequences are often inequitably distributed and low income neighborhoods and communities of color face the brunt of the negative effects. This section summarizes the consequences or effects of navigation system use that have been identified by researchers or practitioners.

## Changing Traffic Patterns

While an imperfect system, modern road design and operations (where streets are built, how they are designed, how they are maintained, and use of signals and traffic controls) are based on established transportation planning practices. Planners have historically predicted traffic on the basis of residential density while acknowledging there are some other factors that need to be considered.[24] Many local communities are trying to use road design and operations policy and practices to undo decades of auto-centric design, which takes time, but they are doing it based on transportation planning practices that rely on historically predictable traffic patterns and driver behaviors. Navigation systems provide information to users that changes their behaviors, without allowing planning agencies access to all of the navigation system data and algorithms. Building physical infrastructure cannot keep up with the shifting algorithms, driver behaviors, and traffic patterns. At best, planners and engineers can guess at the algorithms by their own trial and error (for example, entering origins and destinations into a navigation app at different times of the day to see what routing it spits out), or reactively implement traffic calming or other measures once it becomes apparent to the local community that there is a concern. Changes to traffic patterns include increased traffic on local and collector streets and in neighborhoods where the roads were not designed to accommodate the volumes. Communities find that navigation systems may direct traffic on roadways not designed to handle additional rerouted vehicles, causing a whole host of concerns from increasing congestion[25] and an increase in cut-through traffic on streets where before community members would feel comfortable walking, biking, and playing in or alongside the street in low volume/ low speed traffic. Especially concerning are increases in car traffic in vulnerable areas around schools, parks, community centers, and senior centers, where residents are likely to be walking and biking, or where the local community wants to encourage more walking and biking. Increased traffic in these areas introduce more points of conflict between different modes, resulting in more potential for crashes and making it less safe and inviting for people walking and biking. Increased traffic on these streets also creates more wear and tear and affects pavement maintenance schedules.

## Questionable Effects on Reducing Traffic Congestion

Planners and researchers also argue that navigation systems do not necessarily do a good job reducing congestion, even though their goal is help people avoid congestion. A spokesperson for Waze is quoted saying, "Waze works to spread congestion evenly across public roads to make the driving and commuting experience better for everyone."[26] But researchers argue that the individualistic nature of navigation systems exacerbate collective delay and overall traffic congestion. Research shows that transportation networks could accommodates twice as many cars if traffic were optimized system-wide rather than on an individual basis.[27] Lack of coordination between navigation providers adds to congestion. Each vehicle is competing for the fastest routes to its destination and each navigation system or app operates independently.

***Research shows that transportation networks could accommodates twice as many cars if traffic were optimized system-wide rather than on an individual basis.***

Each app only collects data from its users, they do not share across platforms so none of them have the complete picture of all road users.[28]

Simulations done by researchers in California showed a rise in travel time and traffic on arterial roads as the number of app users increases.[29] Researcher Alex Bayen has developed numerous simulations, including one that shows how drivers reacted to a car crash on the highway with and without the help of a navigation system. Bayen's model demonstrated that when just 20 percent of drivers were using navigation apps, the total time that all drivers spent in traffic actually increased. When the navigation apps suggest "faster routes" on surface streets, the simulation resulted in back up on exit ramps as drivers exited the highway. The back-up sent ripples into the travel lanes behind them, creating delays for highway drivers. In addition, there was an increase in vehicles on local roads not designed to handle the through-traffic.[30]

Others describe the situation using the "Nash equilibrium," developed by mathematician John Nash where "in a system of decision-making actors, nobody is motivated to make a different decision than the one they are making, because a different decision would leave that individual worse off, even if it would improve overall group welfare." In other words, it means that a bunch of individual self-interests work against the good of all.[31] Translating this to traffic, individual drivers will always choose what they are told is the fastest route available, even though taking a longer, more circuitous route would help spread out traffic and ease congestion for other drivers across a city.

It should be noted that the effects of navigation systems on traffic patterns and communities vary from place to place in the United States. Street design may also play a role. A transportation engineer has observed that "cities with old-fashioned grid patterns… tend to distribute traffic more evenly. It is in suburbs with heavily used arterials and hard-to-find back roads that the apps have made their greatest impact."[32]

### Interfering with Emergency Operations

One clear area where communities have been impacted by lack of coordination and communication between navigation systems and local agencies has been in emergency situations and natural disasters. In Los Gatos, California, the community reported that navigation apps were creating traffic that blocked the only evacuation route during a wildfire.[33] In Los Angeles, California during the 2017 Skirball fire, some drivers using navigation apps to get around the fire ended up being routed into active fire areas in neighborhoods under evacuation orders.[34] This speaks to the need for clear communication protocols between agencies in charge of public safety and the navigation systems so that navigation apps provide accurate, timely information that does not contradict local emergency operations.

### Contributing to Distracted Driving and Other Poor Driver Behaviors

There are also concerns around the use of in vehicle navigation systems and distracted driving and other dangerous driver behaviors. While navigation systems are providing drivers with potentially beneficial information, they are adding to the things that may divert a driver's attention from the road and how they are actually operating the car. Numerous studies have demonstrated that automated guidance divides a driver's attention between the navigation system and their surroundings.[35] One study indicated that phone-based apps (like navigation apps, but others as well), specifically, are contributing to increased rates of distracted driving.[36] In another study, researchers studied a small sample size and found some increase in speeding with use of navigation systems, as well as a significant amount of interaction or manipulation of navigation systems while driving, decreasing attention to the task of driving.[37] Another study where volunteers participated in a driving simulator where they drove with the distractions of having phone conversations, texting, route guidance, and destination entry, found that participants generally drove significantly slower in all distracting conditions, and found that the secondary tasks required more effort. Navigation route guidance has been found to decrease mental workload, increase speed, and improve drivers' lateral performance.[38] The level of interaction or attention required for the navigation system may also affect driver behavior. Researchers say that notifications distract from the environment and allocate attention to the navigation system.[39]

Some studies have explored the differences between looking at a phone or device for directions versus using just the audio directions. Studies found that drivers who listen to the directions are more likely to be aware of their surroundings on the road. Drivers who have their phone on the dash may have slight distractions when it comes to driving. However, when the phone is lower in the car, such as in a driver's hand or on their lap, it diverts drivers attention away from the road.[40] Inattention to the roadway for only a few seconds can lead to deadly consequences. Researchers have studied older adults' navigational behavior ability and use of a navigation system given their functional driving declines in vision, reaction times, and cognitive processing skills. The subjects participating in a driving simulator performed significantly worse in effectively using the in-vehicle navigation systems instructions than other age groups. Research found older drivers to have an increased duration of glancing at the screen than any other user group, which has significant safety implications and compromises the control of the vehicle. Older drivers rely heavily on the audio information and are less likely to be able to use information displayed on a navigation screen, such as speed limits of roads currently travelling on and upcoming speed limit changes.[41]

While a solution may be to encourage use of the audio functions of navigation systems and decrease or discourage drivers from looking at the device, some research has shown that navigation apps have limitations in conveying information verbally to drivers. For example, navigation apps can be imprecise in understanding the distance to an intersecting street when there are multiple street-like features crossing the path of a car and the navigation app may lead to drivers driving into wrong way roads and railroad tracks.[42]

## Health Impacts

The relationships between transportation and health have been well-documented over the past several years. Increased volume and/or speeds of traffic on roadways increases the risk and severity of crashes and negatively impacts air, noise, and water quality. High speeds and traffic volumes can also be a deterrent to active forms of transportation, such as walking and bicycling. The distribution of these impacts is rarely equitable, with communities of color, low-income communities, and the young and old often disproportionately affected.

Traffic congestion is shown to increase vehicle emissions, degrade air quality for the surrounding communities, and has impacts on morbidity and mortality for drivers, commuters, and residents. Studies have found that alternative routing systems, such as Waze or Google Maps, are tied to increased traffic congestion in neighborhoods and negative health impacts.[43] One study, examining the impacts of increased fine particulate matter and air pollution from increased traffic congestion, found that increased numbers of fine particulate matter are associated with premature mortality. The study found that neighborhoods in dense, urban areas have the highest values of particulate matter from increased traffic congestion. In particular, urban areas in California and the Midwest had the greatest proportion of public health impacts from increased congestion.[44] A second study found that increased traffic congestion appeared to increase incidences of air pollution-associated diseases, such as higher rates of asthma, cardiovascular disease, premature infants, childhood leukemia, and premature death.[45] Another study on noise from increased traffic congestion found that exposure to increased residential road traffic increased the risk of depressive symptoms.

## Impacts that Exacerbate Inequities

Increasing use of navigation systems has the potential to exacerbate inequities already present when it comes to transportation systems in the U.S. Low-income communities and communities of color often bear the brunt of negative externalities of traffic. Low-income communities are already more likely to have poorer pedestrian and bicycle infrastructure and more high-speed, high-traffic roads.[46] While almost 90 percent of high-income areas have sidewalks on one or both sides of the street, in low-income communities that percentage drops to 49 percent.[47] Streets with street lighting are also significantly more common in high-income areas than in low-income communities.[48] Streets with marked crosswalks are significantly more common in high-income areas than in low-income communities.[49] Traffic calming features, such as traffic islands, curb bulb outs that shorten crossing distances, and traffic circles, are found almost three times as often in high-income areas compared with low-income communities.[50] From 2010-2019, Black people were struck and killed by drivers at a 82 percent higher rate than white, non-Hispanic Americans. For American Indian and Alaska Native people, that disparity climbs to 221 percent.[51] The fatality rate in the nation's lowest-income neighborhoods was nearly twice that of middle-income census tracts and nearly three times that of higher-income areas.[52]

At the same time, low-income households and households in communities of color are less likely to have access to a car or commute to work by car. Low-income people have the highest rates of walking and bicycling to work – the very highest rates of walking and bicycling to work are among those who make under $10,000 per year, with high rates also seen for those making under $25,000 per year.[53] Households headed by people of color overall are less likely than white households to have access to a vehicle in both urban and rural states.[54] Navigation systems today prioritize individual car drivers over those who choose or have to walk, bike, or take transit. With a baseline of less supportive infrastructure for walking and bicycling, increased traffic or rerouting of cars onto streets not designed to accommodate them makes it more uninviting and dangerous for people walking, bicycling, and taking transit.

# IV A Proposed Methodology to Assess Impacts of Navigation Systems in Neighborhoods

Given the relationships outlined above, we hypothesized that if routing technologies lead to an increase in traffic and/or speeds on streets within a community, there could be negative impacts for people who live and/or travel along a suggested route. Measuring these impacts is difficult due to limited longitudinal localized data and the challenges of assessing causal impact. Therefore, the methodology in the next section will focus on the measurement of changes in traffic patterns that may be associated with routing technology.

Understanding traffic change is essential to evaluate the impact of routing apps in neighborhoods. More specifically, cities must understand the proportion of vehicle trips diverted by the apps into the total traffic at a given street or area. This task can be complex, especially when accurate and complete data is lacking. Ideally, cities could pursue partnerships with app developers to obtain specific data on traffic detours through local neighborhoods and the proportion of trips that are cut-through traffic. Nonetheless, the motives of local jurisdictions and app developers can be misaligned. While some app developers have entered into data sharing agreements with some cities, working partnerships are very limited in the overall picture.

This section of the report develops a methodology to estimate the potential magnitude of traffic diverted into neighborhoods when direct data from the app developers are not available.

The approach outlined here intends to provide an overview of the alternatives and essential aspects that cities should consider when evaluating routing apps' impacts.

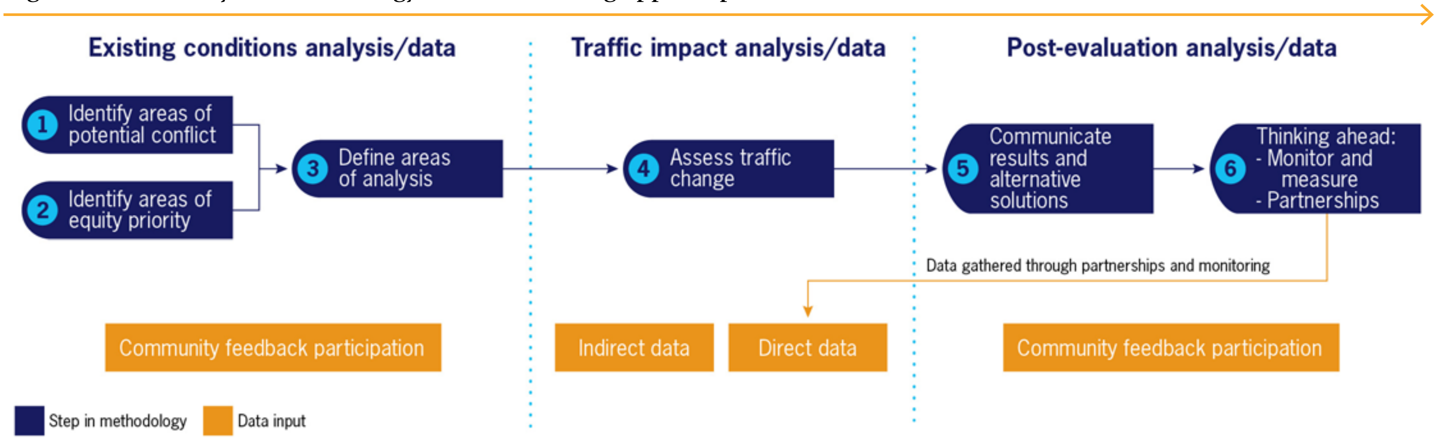
Although traffic change is a central element, there are other elements in the analytical framework equally important. For example, local jurisdictions can identify areas with potential conflict zones, emphasizing disadvantaged communities where people face barriers to engaging in the traditional participatory planning efforts. Ensuring these communities have an opportunity to voice their concerns also triggers the need for a tailored approach for community engagement, like partnering with community-based organizations or schools' parent associations.

Figure 1 summarizes the methodology steps that cities can use as a guide to conduct their assessments. Rather than a prescriptive method, this approach highlights critical elements to consider, different data to use, tools available, and strategic next steps, including:

- Identify areas of potential conflict
- Identify areas of equity priority
- Define areas of analysis
- Assess traffic change
  - Indirect data: estimate travel flows and potential traffic diversion
  - Direct data: calculate traffic change
- Communicate analysis results and alternative solutions
- Thinking ahead
  - Implementation
  - Monitor and measure
  - Seek partnerships
  - Data management

Next, we develop each of these steps and provide specific examples associated with the five case studies in this project. The goal is to showcase how different jurisdictions implement many of these steps and serve as examples for other peers. For a more detailed evaluation of each of the five jurisdictions, see the Data Analysis sections in the appendices.

**Figure 1. Data analysis methodology to assess routing apps' impact on traffic**



## *Step 1: Identify areas of potential conflict*

For communities starting to explore the impact of routing apps, an existing condition analysis can help to identify priority zones. The purpose of the analysis is to locate areas of high-traffic and/or high conflict. Examples of data needed to conduct this assessment are:

- **Annual average daily traffic (AADT)**. It provides a count of the daily average number of vehicles that travel through a specific street. An advantage of this information is its availability. State DOTs or other transportation entities frequently collect this information using automated traffic counters located on the road. Although AADT may be only available for major roads, it can still indicate hotspots where local roads receive traffic overflow.
- **Regional travel demand data.** It is typically developed by Metropolitan Planning Organizations (MPOs) using transportation demand models. The data provides the origin and destination of trips aggregated at traffic analysis zones.
- **Large trip generation/production places.** Although not a direct measure of vehicle activity, identifying sites such as large employers, stadiums, shopping centers, commercial corridors, or tourist attractions can help identify areas of potential concern. Since many of these places are not directly related to commuting trips, the use of routing apps may be disproportionately higher due to people being unfamiliar with the area or using transportation network companies (TNCs), like Uber and Lyft.
- **High injury network (HIN)**. This dataset is critical to identify high severity collisions concentrated along specific corridors or streets, emphasizing pedestrians and bicyclists. It is also possible to use crashes' raw point data; nonetheless, there are some accuracy challenges. In many cases, police collect and report crash data. Those reports might lack specific details about collision severity or include incorrect locations. Additionally, some crashes might not even be reported to the police, and therefore underestimate total crashes. As part of the Vision Zero plans, many jurisdictions develop a HIN that reflects police-reported crash data and other sources, such as first responder, trauma and community engagement data. Producing a HIN can also put more weight on crashes involving more vulnerable populations or communities of color and low-income areas. If already developed by communities, the HIN can leverage previous work to investigate if routing apps correlate with more hazardous corridors.
- **Incident management data**. Information on road closures, weather-related incidents, special events, constructions, and other incidents different from crashes, can highlight roads with frequent congestion and potential routing app diversion. These data might be difficult to procure as they might not exist or may be collected by different departments within a jurisdiction. Even identifying the need for this type of information can present the opportunity for communities to think about collecting this data.
- **Community feedback.** As part of larger planning efforts such as Mobility Plans or specific projects like Safe Routes to Schools, cities engage and constantly hear from their communities. The information obtained through engagement can help identify potential areas of conflict.

Additionally, this step in the methodology is an opportunity to depict a more complete overview by overlaying other datasets. They provide context on the existing infrastructure, ongoing and previous efforts to mitigate traffic, and other relevant policies. The following list provides some examples:

- **Road network classification (major arterials, minor arterials, collectors**). It helps to understand where the roads can carry higher vehicle loads and where the local roads can receive traffic overflow.
- **Speed street classification.** Like road network classification, speed classification provides the maximum speed allowed in streets. Low-speed streets can be more vulnerable to traffic routing, especially if drivers are unaware of facilities like schools or community centers and potentially distracted by their cellular phones.
- **Pedestrian and bicycle network.** Data on existing sidewalks and bicycle infrastructure inform areas where people are likely to be walking and biking. Furthermore, the same data identify gaps in pedestrian and cycling infrastructure, potentially increasing crash risks.
- **Traffic calming measures.** Measures like speed humps, raised intersections, or roadway narrowing intend to reduce vehicles' speed and mitigate cut-through traffic. Local roads with a lack of these measures might be more exposed to negative impacts from routing apps.
- **Previous studies.** Although past analyses might be outdated, reviewing them can provide a starting point to assess conflict areas. They can serve to change and to understand trends within the communities.
- **Current mobility plans.** These documents provide up-to-date information and context. They also allow staff to harness potential synergies between routing impacts and other projects and ensure the city's approach is consistent across projects.

### NAVIGATION SYSTEMS AND THE CASE STUDY COMMUNITIES

*In each of the case study communities, we engaged residents, local government staff, community organizations, transportation advocates, and other community stake-holders through questionnaires, focus groups, and/or listening sessions to better understand perceived effects of navigation systems on local neighborhoods, community perceptions of navigation systems, and if any work had been done locally to address the effects of navigation systems.*

*What we heard:*

- *Navigation system challenges are perceived to be linked to population growth. New development has led to increased traffic as well as people new to the area navigating to and through neighborhoods relying on navigation apps. In some of the case study communities, gentrification and displacement, specifically of lower income residents and people of color, have led to increased driving as community members commute to schools and other destinations in their former neighborhoods. Navigation systems have added to the local challenges by routing additional traffic through these same neighborhoods.*
- *Navigation system challenges are perceived to cause cut-through traffic that impacts neighborhoods.*
- *Community members see benefits to navigation apps such as finding the fastest routes, but noted that using a navigation app can be distracting. More education is needed on how to use navigation systems as a tool, but in a safe manner.*
- *Out of the case study communities, Bellevue, Washington is the only one that made on-the-ground changes to try to address the effects of navigation systems on neighborhoods.*

*More detailed information about the engagement process and findings from each community can be found in the appendices.*

## Step 2: Identify areas of equity priority

An increasing priority for many jurisdictions is to include an equity assessment in transportation projects to encourage investment based on greatest need, which may be defined by income, race/ethnicity, health indicators, access, and historic disfranchisement of Black, Indigenous, people of color, and low-income communities. For routing apps impact, considering areas of equity priority is essential since these communities are likely to receive disproportionate adverse effects of traffic overflow.

Jurisdictions may have specific equity metrics already developed and a spatial assessment conducted through previous work. These equity metrics can be overlaid on the previously described data to identify if and where areas of disparity may exist. This would also be the stage to incorporate health data such as measures of PM2.5 (fine particulate matter), sedentary behavior, and chronic disease, if available at the local level and not yet incorporated as part of an equity metric. Data on key destinations within the community can also be added to the analysis to examine where constraints on access may vary and may be associated with other variables such as environmental conditions, mode splits and crash data. If equity metrics have not yet been identified, jurisdictions can work with a representative group of community stakeholders to define equity and identify relevant metrics and data sources to incorporate equity into the analysis.

Regardless of where jurisdictions are in the development of equity metrics, they are encouraged to develop an approach to assessing equity that considers the local context.

## Step 3: Define areas of analysis

The last step of the existing condition analysis consists of overlaying the areas of potential conflict and the areas of equity priority to define zones for traffic impact analysis. This is also an important step due to the ever present reality of limited resources, so cities might need to narrow down to priority areas for evaluation. Rather than an exact prescription of how to process information and define areas of interest, and potentially prioritize them, this methodology highlights different patterns that communities might take. It recognizes that communities' characteristics might be significantly different, and the data availability and quality could be quite heterogeneous.

To define the areas of interest, communities can take one of three approaches based on the availability of data and their preferences. A community or city can rely more on quantitative data, more on qualitative data and community feedback, or a combination of both. These categories demonstrate how cities can lean on different approaches according to the availability of data and their preferences, but it is important to note that no type of data or approach is more important than the others.

### APPROACH ONE
### Leading with quantitative data: Putting the pieces together

Communities in this category have a good amount of data available, including traffic counts, high injury networks, access to travel demand data, and other contextual information (e.g., bike and pedestrian infrastructure, geolocated community assets, etc.). They can also leverage access to other stakeholders for data procurement: Metropolitan Planning Organizations (MPOs), state and local department of transportation, planning departments, health authorities, and data vendors among others.

The availability of these data provides a solid starting point to those communities looking to obtain an overview of potential cut through traffic hotspots. In the community cases evaluated in this report, The City of Charlotte, North Carolina is an example of this approach. They track several city-wide datasets including traffic counts and a high-injury network.

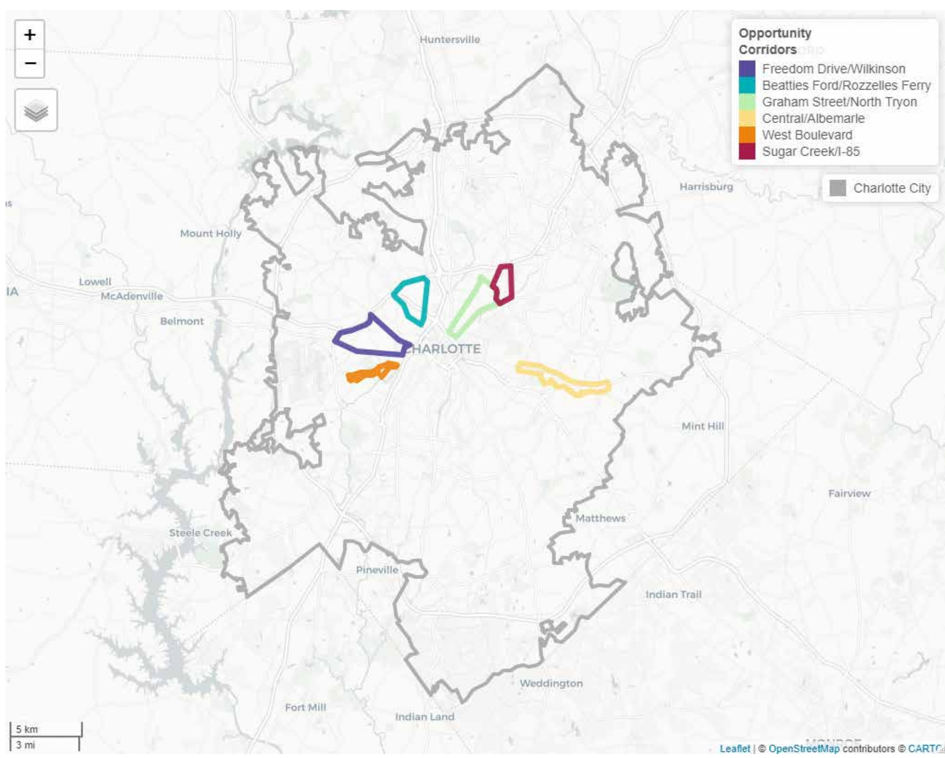



**Figure 2. Corridors of Opportunity in the City of Charlotte**

Also, in collaboration with Mecklenburg County, The University of North Carolina at Charlotte, the city developed a public-facing dashboard to communicate quality of life through indicators in the transportation, health, environment, among others.[55] Additionally, the City has a corridors of opportunity program. The five opportunity corridors represent priority areas for investment and promotion of economic growth, with an emphasis on equity (Figure 2).

It is also possible other cities rely on data collected in past studies or projects to mitigate cut-through traffic. Those studies and the associated implementation and monitoring data are helpful to assess other areas. The City of Bellevue, Washington is an example of this approach. Sound Transit's Light Rail East Link Extension project in the Puget Sound region is constructing six stations in Bellevue. The construction of South Bellevue and East Main stations near the Bellecrest, Enatai, and Surrey Downs neighborhoods started in 2016. As a result of light rail construction activity on major arterials, the city implemented a three-month pilot turn restriction project aimed at discouraging commuters from cutting through the neighborhood at SE 16th St/108th Ave SE and SE 16th St/Bellevue Way during light rail construction. Turn restrictions are regulatory in nature. Navigation platforms cannot suggest routes if there are regulatory signs that prohibit movements, hence, why this tool was selected. Traffic volumes were down in the location of the pilot and there were no observations of spillover traffic elsewhere as a result of the construction or turn restrictions. The data on change in traffic volumes collected by the city in the pilot program was a key input to evaluate the intervention effectiveness and as a learning experience for city staff to apply in other areas.

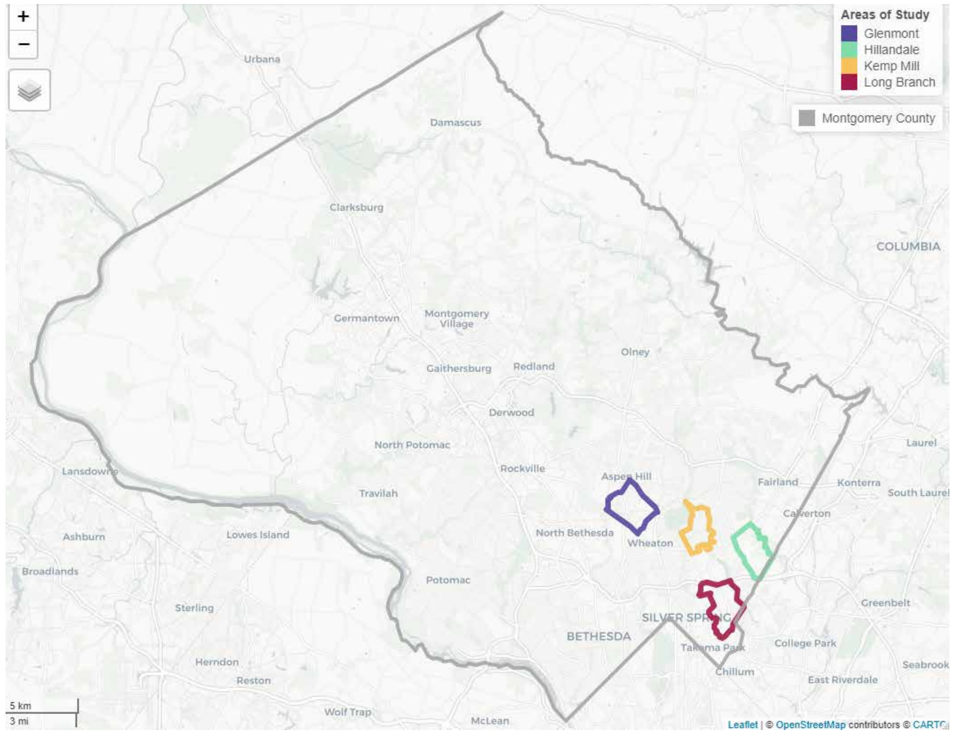



**Figure 3. Montgomery County candidate neighborhoods**

## APPROACH TWO
### Leading with qualitative data: Listening the community

As outlined in step 1, traffic data and information will likely be available for city-wide freeways and major arterials. However, more granular data is required to understand traffic patterns on local roads. In the absence of more specific data, and more importantly, to guide cities in identifying locations with higher traffic impacts, community input is essential. People's lived experiences offer a richness that numbers through surveys and traffic counts alone cannot convey. Listening to residents as part of ongoing planning and outreach efforts or through community organizations or institutions can be an efficient way to define the areas of study.

In fact, smaller cities or jurisdictions with established relationships and a history of work with local stakeholders might find this a more suitable approach to identify areas of potential conflict. Most of the time, cities and local stakeholders can leverage past or current common projects. This is the example of the City of Atlanta and the Tuskegee Airmen Global Academy (TAG), a public elementary school located in the city's Cascade neighborhood. The school community at TAG had been working on a Safe Routes to School program and identified increasing concerns of cut-through traffic in the neighborhood. The collaboration with TAG has been identified as a priority by the City of Atlanta since this is an equity priority zone exposed to gentrification in recent years.

## APPROACH THREE
### A combined approach: Blending numbers and stories

In many cases, communities might already have an idea of areas where cut-through traffic might be a problem based on community feedback or other outreach with residents but might want to prioritize selecting the study area based on traffic impact. This approach allows the cities to narrow down the technical analysis to those areas. In this project, the City of Orlando and Montgomery County were more aligned with this approach.

Montgomery County staff have heard from neighbors about cut-through traffic in the Glenmont, Hillandale, Kemp Hill, and Long Branch neighborhoods. Using this as a starting point allows focusing the data analysis in those areas. Data on Annual Average Daily Traffic and crashes highlighted Glenmont and Kemp Hill as more likely to be impacted by cut-through traffic, given its proximity to the I-270 corridor. The higher density of crashes in those neighborhoods is also an indicator of a higher traffic impact. The analysis also assessed the equity characteristics of these areas by using the Equity Focus Areas developed by the County. The equity focus areas are census tracts with concentrations of lower-income people of color, who may also speak English less than very well, as reported by the Census Bureau. This confirmed that Glenmont and Kemp Hill are composed mostly of census tracts in Equity Focus Areas.

## *STEP 4: ASSESS TRAFFIC CHANGE*

Measures of traffic can be as straightforward as traffic counts and annual average daily traffic. Nonetheless, dissecting traffic data to evaluate how much of it is local traffic versus cut-through traffic from app use is more complex. This is even more challenging because of the proprietary nature of routing apps' data. There are different ways to use available data and estimate the potential overflow of vehicle trips into local roads or to identify the order of magnitude that can be expected. The latter is handy if communities want to perform an initial assessment before more specific and field counts.

Traffic analysis can use different travel/trip data, which define the possibilities and best approach for the evaluation. As expected, more detailed data allows for a deeper understanding of traffic patterns. The key characteristics to consider in the data to assess cut-through traffic are:

- Street specific or aggregated. Some datasets have traffic flows (trips) associated with a specific road, while others have them aggregated at certain geography levels like traffic analysis zones or census tracts.
- Point specific or origin-destination. Some datasets provide traffic flows at a given specific point; for instance, annual average daily traffic gives the number of trips going through one particular point or section of the road at a given time. Other datasets provide the traffic flow between two specific locations, for instance, total vehicle trips between two census tracts.
- Time of the day. This dimension of the data is related to trips by the time of the day. Many datasets provide daily total average trips, but some will give those daily average by the time of the day.

Using these data dimensions, this analysis defines two types of data:

- **Direct data**. In terms of evaluating routing apps impact, the ideal data should contain trips at street level with origin and destination information and disaggregated by the time of day, at least for peak and non-peak travel periods. This level of specificity is likely only available for the routing apps themselves and or using proprietary data that relies on GPS, cellphone use, and other big data aggregation approaches.
- **Indirect data.** Most data available will fall under this category since it will likely have one or two dimensions but not all of them. For example, traffic counts provide helpful information on the traffic at a specific street, and they can be found at different times of the day. However, it is not possible to characterize the origin and destination of the traffic flows. Alternatively, regional travel demand models provide information on the travel flows within traffic analysis zones, but it does not provide information on the actual route (network link) to conduct that trip.

### Measuring traffic impact using direct data

After the existing condition analysis and defining the study areas, this step in the methodology to calculate cut-through traffic using direct data is straightforward:

- Select the streets within the neighborhood/study area, and calculate the total trips.
- For the streets defined above, identify all the trips from origin and destinations outside the study area. Compare these trips (with origin and destination out of the study area) with the total trips to obtain the proportion of cut-through trips.
- The process outlined above can be performed for different times of day to evaluate if cut-through traffic is more severe during peak periods.

### Measuring traffic impact using indirect data

Estimating the cut-through traffic using indirect data can differ depending on the specific data at hand. Nonetheless, the algorithm to conduct the assessment is very similar to what it would be using direct data.

*Estimate total trips in the study area (internal trips)*. The first piece of information needed is the amount of traffic flow within the study area. For instance, using traffic counts (AADT) select major streets or roads in the study area with the highest AADT. If zone-aggregated data is available like transportation analysis zones (TAZs) in the regional travel demand models, estimate the total trips starting and ending in the zones that more closely represent the area of study. The overall goal of this process is to obtain a magnitude of traffic flow in the study area.

*Estimate potential trips traveling through the study area.* Having trip activity within the study area is insufficient to assess how much is cut-through traffic. In this step, the goal is to estimate the number of trips that are likely to pass near the study area, particularly on freeways and major arterials. Regional travel demand models can be a helpful resource to estimate these flows or other third-party data with origin and destination matrixes (See Appendices). The approach in this step will rely on the city's knowledge, and the existing conditions step in this methodology to narrow down the origin-destination pairs likely to be routed close to the study area.

*Contrast trips flow within the study area with potential trips traveling nearby.* This step aims to assess the difference in magnitude between the trip activity in the study area and the surrounding road network. The comparison will not be an exact calculation given the limitation of the data; instead, the analysis can focus on streets within the study area that might be more vulnerable to traffic routing. The recommendation is to visually identify the specific streets within the study area with low trip flows but close major roads/freeways with high travel flows. Then cities can set thresholds and obtain a range of trips likely to be diverted into local roads: in other words, determine the number of trips diverted if the apps re-route 2%, 5%, 10%, etc., of the trips traveling in the near freeway or major road.

*Perform this evaluation at different times of the day.* If data by time of day is available, cities can compare trips within the study area and in nearby major roads in different periods. This is particularly important at non-peak and peak hours of the day, since this can provide insights to set the percent change thresholds.
The city case reports in the Appendices provide examples of the application of the methodology.

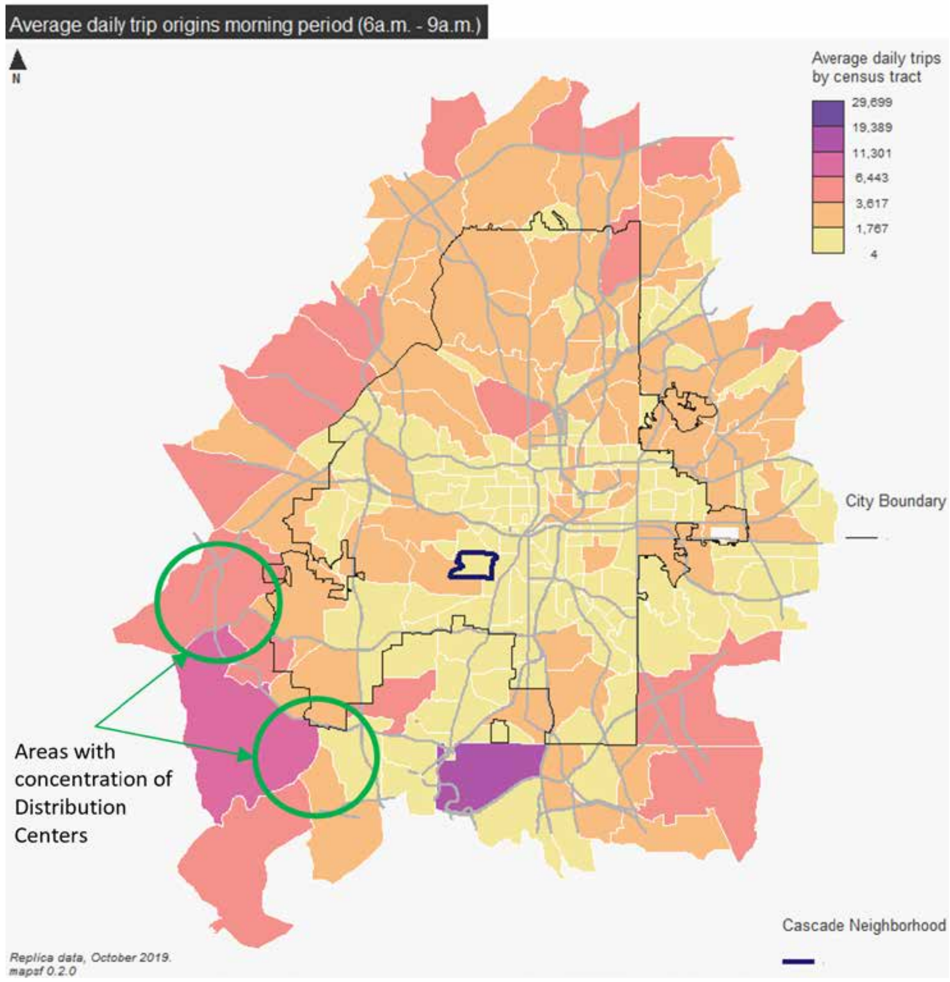



**Figure 4 Originated trips by census tract in the period morning in Atlanta**

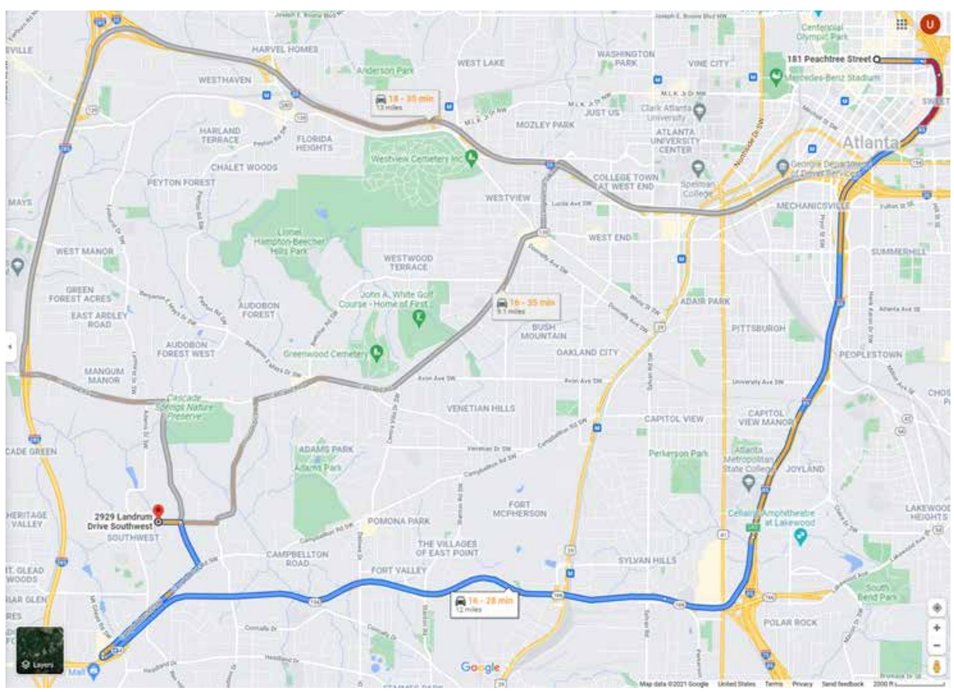


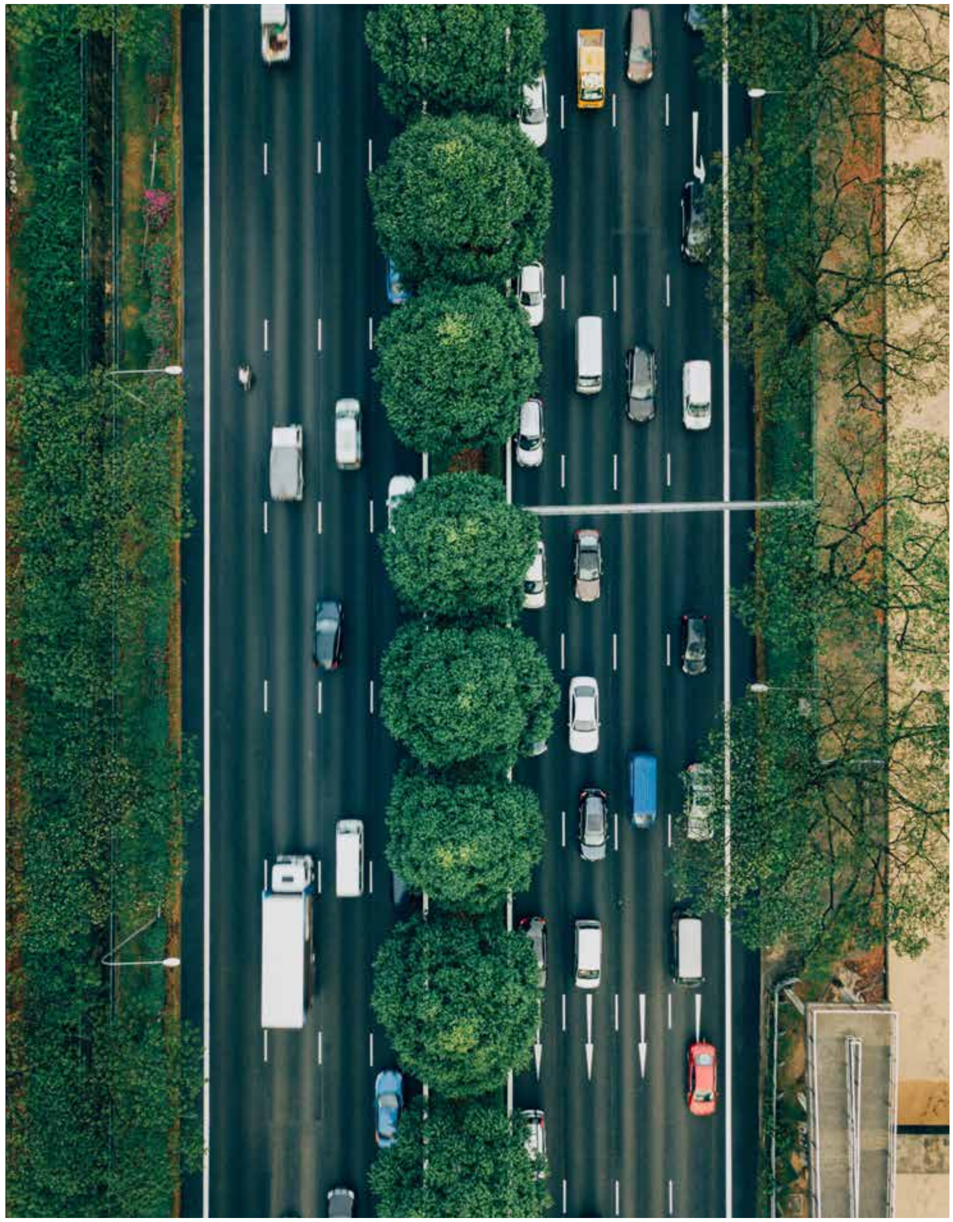
**Figure 5. Routing app screenshot of Cascade neighborhood in Atlanta**

### *Step 5: Communicate analysis results and alternative solutions*

As with prior steps in the analysis, it is important that results are shared with stakeholders and the community for purposes of ground truthing and discussion of alternative solutions. That discussion serves as a feedback loop on the analysis, so that it and the potential solutions that may arise from it reflect the experience and understanding of those living in the community.

Meetings were held with each of the communities participating in this project to discuss the methodology and the results of the analysis of traffic change. As discussed above, the meetings helped to confirm what was discovered in the data and provided insight into the complexity of some of the findings. For example, traffic peaks and flow patterns near the Cascade neighborhood of Atlanta that was the focus of the case study were occurring differently than expected if one looked at traditional commute patterns. Conversations with community stakeholders revealed that this was a reflection of the distribution centers in the area, afternoon and evening shift work and the increased hourly wages paid for working those shifts. Community stakeholders also discussed how deliveries from the distribution centers were more frequently happening in smaller commercial or personal vehicles as opposed to the standard UPS and FedEx delivery trucks seen in the past. This discussion led to more questions about data and policies than answers provided, but this is an important process for communities to go through to discover contextual solutions.

Figure 4 shows the originated trips by census tract in the period morning (6am – 9am) in Atlanta. As observed some high-originating tracts are in areas with high concentration of distribution centers, particularly at the west and southwest of the city. Potential trips coming out of these areas into downtown might be diverted into Cascade neighborhood, as suggested by the routing app in Figure 5.



### *Step 6: Thinking ahead*

This post-evaluation analysis/data stage should involve not just discussion and reflection on the findings, but also action towards solutions. That action will look different for each community; however, the analysis enables a group of stakeholders to come together and define what solutions may be, and propose an implementation plan.

A key element of any plan will be to measure and monitor. Data gaps were discussed throughout this report. The ability to determine the impact of navigation apps, and for communities to develop implementable, measurable solutions to address that impact is dependent on data—and the investment in both qualitative and quantitative data. It also requires partnerships within the community and jurisdiction, with other jurisdictions, and with private companies. The data relationships that jurisdictions develop with private technology companies is increasingly important, as the legal section of this report highlights. Establishing agreements outlining specifics around accessing and providing data can help an agency establish and maintain some control in a relationship that feel increasingly unbalanced.

# V An Exploration of Community Responses and Other Strategies

This section summarizes how local government agencies have tried to address challenges brought on by navigation systems to date. Information about different strategies was gathered through media coverage and conversations with local agency staff and the five case study communities worked with as part of this project. In addition, we explore and summarize strategies that have been suggested by others in the field but have not yet been deployed. Strategies are categorized into legal action, traffic calming measures, regulation, and collaboration.

## Legal Action Against Navigation Systems

Our research found that the potential for successful change through legal action against navigation systems is very limited. Legal claims against smartphone navigation apps and navigation systems usually fail. The Federal Trade Commission (FTC) has the broadest reach in regulating smartphone apps and related technologies and does so through Section 5 of the FTC Act, which prohibits "unfair or deceptive acts or practices in or affecting commerce." [56] The agency has the power to prosecute and investigate technology companies (among others) using either an administrative process or judicial process where there is reason to believe that a consumer protection or antitrust law has been violated. An act or practice is "unfair" if it "causes or is likely to cause substantial injury to consumers which is not reasonably avoidable by consumers themselves and not outweighed by countervailing benefits to consumers or to competition."[57] "Deceptive" practices are defined as involving a material representation, omission or practice that is likely to mislead a consumer acting reasonably in the circumstances.[58]

State laws targeting app developers or technology companies are largely fragmented across sectors: consumer protection,[59] data security,[60] antitrust,[61] and privacy[62] issues. These states have state Attorney General offices who are best positioned to scrutinize smartphone app developers (along with the Federal Trade Commission) through lawsuits, prosecutions, or investigation. Concomitantly, federal and state officials may bring enforcement actions against app owners and distribution platforms for the violation of federal and state regulations.

One claim cities and states are increasingly pursuing is nuisance. People sue for nuisance for special or egregious harms caused to the public or community.[63] For example, after San Francisco suspected that Uber was in violation of the state's nuisance law, Civil Code section 3479, the city opened an investigation into possible violations of the state and municipal law.[64] The San Francisco City Attorney's office had received numerous complaints from the San Francisco Municipal Transportation Agency regarding illegal parking, traffic congestion, and safety hazards caused by rideshare companies, including Uber.[65] The City Attorney also based its investigation upon a San Francisco police department study showing that ride shares accounted for nearly 65 percent of all moving violations for driving in transit lanes and bicycle lanes, obstructing bicycle lanes and traffic lanes, failure to yield to pedestrians, and illegal U turns in business districts.

Civil Code section 3479 defines a nuisance as "[a]nything which is . . . an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, or unlawfully obstructs the free passage or use, in the customary manner, or any. . .

public park, square, street, or highway." A public nuisance is "one which affects . . .any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal."

The elements required to file a public nuisance lawsuit varies across states given different nuisance state laws. It is typically easier to file a nuisance lawsuit as a government entity than as a private actor, namely because like in the San Francisco case, a government official can issue administrative subpoenas to investigate more about how the company's actions may cause the public harm.

For claims like negligence, fraud, false advertising, misrepresentation, or nuisance, it is also difficult for nongovernmental entities to prevail in lawsuits against smartphone apps or in-dash navigation companies for harm caused to consumers. Courts rarely find these companies liable for causing users' traffic violations, vehicle accidents, or other harms that might result from using their routing services. Most smartphone navigation apps sufficiently disclaim responsibility in their Terms of Service (which is a contractual agreement between an app developer and the end-user) for any routing errors or traffic violations that may occur from using the app. Complete blind reliance on an app could actually be considered misuse of the app or unreasonable use given different Terms of Service. Cases filed against smartphone navigation app developers for their actual routing operations, are far and few between. There is only some case law in which courts have held that a cell phone or phone app company could be held liable for injuries resulting from a crash purportedly caused by a driver's mere cell phone or app usage. However, nearly all the cases have resulted in favor of the app company, finding no liability.

Other cities, such as Davis, California have explored the path of legal action, but have not followed through because of the thinking that navigation apps present facts from an algorithm and legal action would not be effective.[66]

## Traffic Calming Measures

The most common strategy that local jurisdictions have used to curb the effects of navigation and routing systems is traffic calming. Traffic calming consists of physical design and other measures put in place on existing roads to reduce vehicle speeds and improve safety for pedestrians and cyclists.[75] Traffic calming can include vertical deflections (speed humps, speed tables, and raised intersections), horizontal shifts, roadway narrowing, and closures that obstruct traffic movements in one or more directions. Traffic calming measures can be implemented at a single intersection, street, neighborhood, or across an entire city or area. Traffic calming is often intended to address cut-through traffic, which is what many communities identify as the most troublesome result of navigation systems. Traffic calming measures are often a regular part of the transportation professional's "toolbox" when addressing local transportation concerns.

In addressing challenges resulting from navigation apps, traffic calming may achieve two objectives – it may make change the street design to make it more safe and comfortable for people walking and bicycling, and it may stymie navigation apps from directing drivers down the roads creating cut through traffic because the cars will be moving slower. Common types of traffic calming measures, and how cities in the US have tried them to combat the effects of navigation systems, are discussed below.

### Restricting Neighborhood Access/ Thru Traffic

The City of Leonia, New Jersey closed 60 streets to through traffic (those living or working in the area) during morning and afternoon commute hours because the streets were not designed to handle the volume of traffic being diverted to them by routing apps. The City issued yellow tags to cars that are permitted to drive in the borough, and implemented $200 fines for non-tagged drivers. Following implementation, a lawsuit was filed and the courts struck down the initial closure, not because of the actual strategy, but because the City had put it in place without state approval. The courts ruled that the State of New Jersey has ultimate authority over local roads.[76],[77] As a result, the City has a revised program in place with more limited road closures.

It should be noted that local jurisdictions have posted "No Thru Traffic" signs in to discourage drivers from cutting through neighborhoods on local streets, but have found that these signs can be deterrents but are not legally enforceable.[78]

### CASE STUDY: LOS ANGELES TAKES STEPS TO SOLIDIFY AGENCY CONTROL OVER TRAFFIC DIRECTION

*The City of Los Angeles, with its long history of traffic congestion and automobile-orientation, has been the first, if not the only, jurisdiction in the US to explore addressing navigation challenges by changing its local municipal code to specify its control over traffic in the digital realm. Los Angeles was once a partner with Waze, but the agreement expired in 2017. Following that expiration, the City proposed creating a pilot program to work with navigation providers to restrict traffic in certain areas in exchange for data sharing.[67] The City was looking to limit the streets that drivers are instructed to use in a given area, allowing traffic to be directed "away from school zones, neighborhood streets, and problem turning areas during peak hours."[68] Local elected officials raised concerns over the navigation apps currently directing drivers onto streets that were not designed for the volumes of traffic they are getting and creating safety concerns.[69],[70] While Apple Maps and TomTom expressed willingness to consider the pilot program, Waze and Google declined to participate.[71] Subsequently, the City Council challenged the navigation app providers as usurping the City's designated authority to exclusively direct traffic. Currently, the Los Angeles Municipal Code states that "no one, other than a Police Officer, a person deputized by the Chief of Police, a Traffic Officer, an off duty or retired police officer, or a member of the Fire Department shall direct traffic." The City Council made a motion in October 2019 to direct the City Attorney to prepare "an ordinance that would amend the Los Angeles Municipal Code to expressly prohibit the use of digital applications and digital infrastructure to re-route vehicular traffic that is inconsistent with official City street designations."[72] On the flip side, Waze Chief Executive Officer Noam Bardin made a statement that "It's important to note that Waze does not 'control' traffic but our maps do reflect public roads that federal and local authorities have identified and built for its citizens… If the city identifies a dangerous condition, it is their responsibility to legally reclassify a road, which will then be reflected on the Waze map." [73] Subsequent steps by the City of Los Angeles to amend its municipal code or take alternative actions have not been made public.*

***"The use of apps to save 90 seconds of travel time not only is destroying the quality of life in neighborhoods all over, but also endangering public safety." – Paul Krekorian, Councilmember, City of Los Angeles***

### Restricting Turns

A common response to try to reduce cut through traffic and cause navigation apps to direct drivers away from residential areas has been to implement turn restrictions, especially turn restrictions during peak commute hours. In Fremont, California, the City implemented turn restrictions at one intersection, coupled with delayed signal timing at another intersection (see below).[79] The City of Bellevue, Washington (one of our case study communities) has also implemented turn restrictions in certain neighborhoods during certain times of the day in order to essentially remove the option of navigation apps to direct drivers to cut through neighborhoods. Alexandria, Virginia created a residential permit program that restricts turns into or out of certain residential areas during rush hour.[80]

### Traffic Signal Timing

The City of Fremont delayed signal timing at the first major intersection for commuters exiting Interstate 680 (what the city saw as feeding the majority of traffic in the area).[81] This takes a different approach from restricting access or turns. Instead, the City is using the signal timing to delay drivers and make the routes less desirable because they are slower.

Other traffic calming devices that can be implemented include:

- Speed humps or speed tables
- Bulb-outs, bump-outs or curb extensions that narrow a street
- Traffic circles
- Painted narrowing lanes
- Road diets

More information about specific traffic calming devices can be found online. Notably, traffic calming measures are not fool-proof. One shortcoming of traffic calming is that certain devices can inhibit access or create obstacles for access to key public accommodations like hospitals if not done properly. If the barrier is excessive, it can lead to civil rights claims for unequal access to public accommodations or public streets[82] or be struck down as unconstitutional for other grounds.[83] Second, traffic calming measures can increase drivers' reliance on navigation apps because they can slow down drivers and further incentivize drivers to turn to navigation apps to find the quickest route. Finally, if traffic calming is done only in a reactive manner, meaning reacting to community complaints, traffic calming can result in upper income neighborhoods leveraging political power to exclude traffic. In order to be effective, communities should look at creating traffic calming plans and implementing solutions in a proactive manner.

## Proposed Federal Regulation

The National Highway Traffic Safety Administration (NHTSA) is a federal agency that is part of the U.S. Department of Transportation. NHTSA was established by the Highway Safety Act of 1970 to carry out needed safety research and development, as well as prescribe standards (Federal Motor Vehicle Safety Standards) for motor vehicles and motor vehicle equipment in interstate commerce. NHTSA exercises its regulatory authority by using regulatory tools: statutory interpretations, exemptions, notice-and-comment rulemaking, defects and enforcement authority through recalls. Under the statute, the definitions for "motor vehicle" and "motor vehicle equipment" are read to broadly define the NHTSA's scope of authority to include autonomous vehicles and technology accessories and equipment associated with vehicles. Less clear is whether the statutory scope includes authority over mobile navigation apps as it does for navigation systems that are embedded within motor vehicles.[84] In 2014, the U.S. House of Representatives proposed legislation that would give

NHTSA explicit authority to issue safety standards and conduct safety oversight over mobile routing maps.[85] The bill did not ultimately pass the House and was never introduced in the Senate, in large part due to stiff opposition from the technology industry. But, in 2016, NHTSA issued voluntary guidelines aimed at curbing driver distraction from cell phone apps. Although the NHTSA has not demonstrated interest in overseeing the actual routing optimization features of smartphone navigation apps or in-dash navigation systems, the guidelines have the potential to extend the department's reach. The guidelines were not mandatory but applied to app developers, such as Apple and Google, and recommended that companies design their portable devices to be paired with in-car systems.[86] Consumer technology groups insisted that NHTSA lacked oversight jurisdiction over apps and app developers.[87]

## Collaboration Between Agencies and Navigation System Providers

It should be noted that what we heard from our five communities, and what others more broadly have been saying, is not that anyone wants to get rid of navigation systems altogether. Instead, people do see the benefits that navigation systems could provide that would improve the transportation experience for all – drivers, walkers, cyclists, etc. No matter the strategies employed, communication and collaboration between the agencies that control the roads and the navigation system providers is crucial, and better collaboration has promise for furthering goals on both sides.

Navigation system providers do not have the local on-the-ground knowledge such as characteristics of road (steep hill, extremely narrow due to both sides of the street parking, passes by an elementary school, etc.) and could benefit from that local context and knowledge that a local agency could provide.[88] One expert says, "if [navigation system providers] share information with one another and with city governments, the rerouting algorithms could consider a far bigger picture, including information from the physical infrastructure, such as the timing schedule for traffic lights and meters and vehicle counts from static sensors, including cameras and inductive loops. This data sharing would make their apps better while simultaneously giving city traffic planners a helping hand."[89]

As mentioned above, traffic calming strategies are designed to make traffic slower in neighborhoods. But experts warn that without coordination between apps and public agencies, the problem of app induced cut-through traffic will worsen. They suggest that real-time app data be shared with transportation agencies so traffic resulting from these apps can be integrated into local traffic management systems.[90]

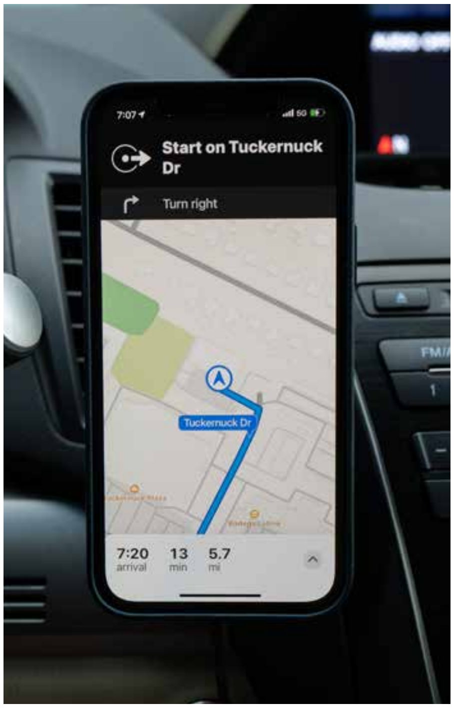
Some navigation system providers have already partnered with cities on a limited scale. Fremont, California partnered with Waze and used data from Waze to help identify their approaches.[91] Through the Waze for Cities Program (formerly the Connected Citizens Program) the company has data sharing agreements and shares things like crash or incident reports. The problem lies within what data is shared and what is not. Researchers have said this information is helpful, but not the most helpful for eliminating traffic. They argue that without the data to measure and understand the volume of drivers using navigation apps on city streets at a given time, it's hard to say for sure whether apps are helping reduce congestion or exacerbating it.[92]

Unfortunately, other agencies have had little success even getting the attention of the navigation companies, like in Breckenridge, Colorado where the state department of transportation has reached out to Google in hopes of trying to work out some of the kinks in its navigation software — like directing motorists over a closed mountain pass in the winter — but has had little luck so far.[93]

## Potential Collaboration to Influence Driver Behavior in a Positive Manner

Some researchers have identified potential ways to use navigation systems to create behavior change aligning with community goals and priorities such as mode shift.

Researchers from UC Berkeley found from a survey that multi-modal app users sometimes do change their travel behavior in response to information provided, and that may contribute to a reduction in vehicle use. There is potential to transfer this to navigation apps to create behavior change. For example, Waze uses competition and status seeking behaviors to encourage desired behavioral change – i.e. reporting roadway incidents gets points/status, encourages more info sharing/crowdsourcing. The researchers pose potential solutions to reduce "bad" user behavior, such as excessive speeds and cut through on neighborhood streets, through gamification and point reduction.




Google Maps is said to be rolling out air quality and climate layers that will account for lower impact modes of travel, if the user chooses to enable them.[94]

## Data from Navigation Systems Used for Research

Navigation systems have also provided researchers with new sources of data that have the potential to better inform local roadway studies. Traditionally, police crash reports have been the primary source of crash data in safety studies, but crowdsourced information about crashes that have do not get reported has the potential to help agencies understand dangerous hotspots. The U.S. DOT Volpe Center undertook an analysis of 2017 Waze data and police crash reports in Maryland. They found that "the Waze crash models appear to capture unreported crashes, including minor crashes which might not require a police presence, but can seriously impact congestion."[95] Researchers found that using crowd-sourced traffic data such as Waze could offer an early indicator of traffic crash risk. Similarly, in a study in North Texas, researchers found that Waze data was better able to predict safety risk of roadway segments than police-reported data. "While more high-risk road segments could be identified through Waze data (13 miles) compared to police data (8 miles), the most successful results were gleaned from a combination of both (14 miles)." The researchers noted a beneficial perspective toward gamification in Waze with users interacting with their mobile devices to report incidents for game points. Through cooperative data, safety risks can be identified in advance to prevent collision-related injuries from occurring.[96]

Other researchers have posed that data collected through GPS-navigation, smartphone apps, and other mobile device platforms is necessary to assess transportation's impact on climate and achieve reduction in transportation-related emissions. One researcher has presented a perspective highlighting the benefits of the data from navigation apps and how it may be applied toward reducing impacts from emissions.[97]

# VI Promising Directions

As discussed earlier, challenges with navigation systems are one piece of systemic issues related to transportation and land use that affect community livability, transportation safety, accessibility, and other local priorities. While communities continue to grapple with automobile reliance, insufficient transit access, and lack of multimodal options, through the project, we have identified a number of promising directions to address the effects of navigation systems that are exacerbating local challenges. These promising directions are categorized below in national scale, state scale, and local strategies.

## National scale strategies

- **Support federal policy interventions**

There are growing calls for the U.S. Department of Transportation to update the outdated federal motor vehicle regulatory framework that dates back to the 1970s with mandatory standards to address emerging technologies, namely AVs. Regulating AVs' route optimization features appears to have the greatest momentum and could likely serve as a foray into advancing regulations, programs, data collection efforts focused on the routing features of smartphone apps, ride shares, and in-dashboard navigation.

Given the debate on whether NHTSA has explicit statutory authority over smartphone navigation apps, a first step toward greater federal oversight would be to ensure NHTSA oversight. In keeping with existing law and practice, the federal government should be encouraged to prescribe regulations for the performance of both AVs and mobile apps. These federal policy interventions that can best lend itself to strong regulations for both routing apps and AVs:

- **Give NHTSA statutory authority to regulate and investigate safety concerns with mobile AI routing maps:**
    - NHTSA should be directed to review, investigate, and evaluate the impact of mobile routing maps on the road safety of non-arterial roads.

    - NHTSA should be directed to give local jurisdictions guidance on how to address the effects of mobile routing maps on non-arterial roads.
- **Require NHTSA to issue minimum performance standards for AVs.**
- **Support mandated standards for Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) technology that aim to reduce traffic congestion.** V2X is a vehicular communication system that incorporates V2I (vehicle-to-infrastructure), V2N (vehicle-to-network), V2V (vehicle-to-vehicle), V2P (vehicle-to-pedestrian), V2D (vehicle-to-device) and V2G (vehicle-to-grid). With standards that aim to ensure that these systems are used to reduce traffic congestion and not increase traffic congestion, these systems can mitigate the harms that AVs are likely to cause and provide cities and states with more information on road capacity.[98]
- **Propose that NHTSA issue new rules and regulations that reflect the following changes:**
    - Separate category under Federal Motor Vehicle Safety Standards designated for AI empowered AVs and routing apps
    - Expanded definition for AVs to include routing and navigation apps so that certain federal regulations that are in place for AVs can apply (to some degree) to navigation apps.
    - Minimum performance standards: standards to ensure that AVs detect bikers, small children, women, strollers and other children's equipment, people of color, (vision test).
    - National validation standards for AVs and mobile navigation apps: the validation process should be executed with community advocates and state road safety stakeholders and ensure testing methodologies that evaluate AV technologies' performance in mobile apps and AVs prescribe protocols and procedures that test for conformance with local road safety and interoperability, comparing AV and navigation systems to human performance
    - Comprehensive study to inform federal and local policymakers and the public about how AVs and routing maps will impact access to public accommodations, traffic congestion, pollution, and the environment and effective mitigation ways of problems identified.
    - Data collection and studies on how navigation apps and AVs affect traffic congestion and access to key public accommodations like schools.
    - Requirement for developers of routing maps and AV manufacturers to adjust algorithms in the event that local studies reveal adverse direct impact on road safety and access to public accommodations like schools, hospitals, etc.
    - Mandatory performance standards for vehicle-to-vehicle, vehicle-to-everything communication technologies.

## *State scale strategies:*

- **Increase public awareness by including discussion of the effects of navigation systems on community in driver's education, distracted driving campaigns, and other public awareness and education programs.** Currently, there is little to no discussion of navigation systems in driver education programs and safety campaigns. States that have hands-free laws may touch on safe interaction with a smartphone while driving, but there are opportunities to broaden awareness of how navigation systems work, how they can be used as a tool, but also how they should not detract from good driver behavior. This education can be integrated into driver's education curriculum developed by each state and in state-led or state-funded distracted driving and other safety campaigns. Regulations around education for commercial drivers should also include a discussion of navigation system use.
- **Establish partnerships and coordinate planning between state agencies and local agencies to undertake data analysis using the methodology described above to understand the real-word effects of navigation systems in areas with state-controlled roads.** This is especially important in areas where state-controlled roads bisect small towns or function as main streets.

## *Local scale strategies:*

- **Undertake data analysis using the methodology described above to understand the real-world effects of navigation systems on the local community. Utilize data and community input to make the case to prioritize and advance pedestrian and bicycle infrastructure improvements in areas and on corridors most likely to be affected by routing.** Specific improvements may include implementing traffic calming devices and ensuring adequate infrastructure exists for people walking and bicycling. Proactive undertaking of data analysis and implementing infrastructure changes is needed in order to address the effects of navigation systems on communities in an equitable way.
- **Adjust local policies and planning to recognize navigation systems as a potential contributor to adverse traffic impacts and incorporate data analysis into planning practices.** These policy and planning efforts may include comprehensive plans, transportation master plans, plans for new development or redevelopment, area master plans, or other local transportation and land use planning. Recognizing navigation systems as an influencer of traffic patterns is especially important when planning for intensification of land uses that are already likely to generate more automobile trips.
- **Utilize transportation demand management (TDM) strategies as a complement to infrastructure improvements to encourage walking, bicycling, transit usage, and telework as alternatives to driving for commuting.** Much of the influence that navigation systems have on traffic patterns results from underlying pressure on the roadway system during peak hours that correspond to drivers commuting. Information, encouragement, and incentives provided through TDM programs help people know about and use all their transportation options to optimize all modes in the system.[99]
- **Increase public awareness by including discussion of the effects of navigation systems on community in distracted driving campaigns and other public awareness and education programs.** Similar to at the state level, local agencies can include education around the effects of navigation systems in local distracted driving and other public awareness campaigns.
- **Make navigation system providers aware of local priorities whenever possible.** This can happen by exploring partnerships with navigation system providers for data sharing. Other avenues include exploring pilot programs with navigation system providers as they make public commitments to safety and to communities. Partnerships should include mechanisms for the provider to listen to and understand local concerns and priorities.

# VII Conclusion

The navigation and routing revolution over the past decade is creating a vast shift in traffic patterns and behaviors on streets around the country. Through this project, we were able to explore with five communities the effects that navigation systems are having on local level mobility, accessibility, and livability; develop a methodology to understand the effects of navigation systems on communities; and identify potential strategies to address the challenges to transportation safety, accessibility, and other local priorities created or exacerbated by navigation systems. A resounding theme heard from investigations by previous researchers and practitioners as well as local planners and transportation staff and community members who participated in this project is that challenges with navigation systems are but one piece of systemic issues related to transportation and land use.

Sections IV, V, and VI lay out a methodology for data analysis, a summary of strategies to address challenges posed by navigation systems, and promising directions for communities to use in moving forward in addressing challenges posed by navigation systems. There is much to be done to operationalize the promising strategies identified, evaluate the on-the-ground impact they have in different community types and dynamics, and continue to build more awareness among community members, policy makers, and navigation system providers about this important topic that is affecting efforts to support and improve local mobility, accessibility, and livability.

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78. the "NO THRU TRAFFIC" sign isn't in the California MUTCD, and as Rumford v. City of Berkeley, 31 Cal.3d 545 (Cal. Sup. Ct. 1982) makes clear, "[L]ocalities have no carte blanche and, absent express authority, may not determine which traffic shall and which shall not use streets."; https://www.al.com/breaking/2011/12/no_through_traffic_signs_in_ne.html

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82. See generally Rumford v. City of Berkeley , 31 Cal. 3d 545 (1982). " The streets of a city belong to the people of the state, and every citizen of the state has a right to the use thereof, subject to legislative control .... The right of control over street traffic is an exercise of a part of the sovereign power of the state .... localities have no carte blanche and, absent express authority, may not determine which traffic shall and which shall not use streets."

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84. § 30102 Definitions . . .
(6) "motor vehicle" means a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways, but does not include a vehicle operated only on a rail line.
(7) "motor vehicle equipment" means–
(A) any system, part, or component of a motor vehicle as originally manufactured;
(B) any similar part or component manufactured or sold for replacement or improvement of a system, part,or component, or as an accessory or addition to a motor vehicle; or
(C) any device or an article or apparel, including a motorcycle helmet and excluding medicine or eyeglasses prescribed by a licensed practitioner, that-

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