# How Would For-Hire Autonomous Vehicles Impact New York City?

## Lessons from California on Safety, VMT, and Parking


Sam Schwartz Transportation Research Program at Roosevelt House

HUNTER The City University of New York

OpenPlans

## ACKNOWLEDGMENTS

We would like to thank our reviewers for their time and input (in alphabetical order): Erich Arcement, Nicole Gelinas, Adrian Pietrzak, Deena Schwartz, Bob Scopatz, and Gerard Soffian. We would also like to thank the New York City Department of Transportation and Taxi and Limousine Commission for their generosity in providing us with the essential data needed to conduct our analyses.

## PUBLICATION TEAM

**Kelly McGuinness**
*Report Lead*
Director
Sam Schwartz Transportation Research Program
The Roosevelt House Public Policy Institute at Hunter College

**Michael Sutherland**
*Report Lead*
Senior Policy & Legislative Analyst
Open Plans

**Talya Schwartz**
Senior Strategist
Open Plans

**Sara Lind**
Co-Executive Director
Open Plans

Sam Schwartz TRANSPORTATION RESEARCH PROGRAM AT ROOSEVELT HOUSE | HUNTER The City University of New York

### About the Sam Schwartz Transportation Research Program at Roosevelt House Public Policy Institute

Launched in September 2025, the Sam Schwartz Transportation Research Program (SSTRP) at Roosevelt House at Hunter College is dedicated to advancing solutions for urban mobility and improving New York City's transportation systems.

OpenPlans

### About Open Plans

Open Plans' mission is to transform how people experience New York City's streets. Open Plans uses deep research, grassroots advocacy and policy change to reduce driving, reclaim space for people, and build connected neighborhoods. We promote a people-first street culture that prioritizes community, joy, and sustainable mobility.

# Contents

# How Would For-Hire Autonomous Vehicles Impact New York City?

## Lessons from California on Safety, Vehicle Miles Traveled, and Parking

### EXECUTIVE SUMMARY

Autonomous for-hire vehicles, better known as robotaxis, are operational in cities across the globe. In New York City, Waymo (one of the leading robotaxi companies and a subsidiary of Alphabet, Inc., the parent company of Google) received a permit to test their vehicles with a safety driver, which expired in March 2026. Robotaxi companies have spent millions of dollars in New York City and State lobbying for the legalization of robotaxis.

However, a core question remains unanswered: how might robotaxis impact our streetscape in comparison to the professional for-hire vehicle drivers of taxis, Ubers, and Lyfts? In this report, we explore this question through the lenses of safety, vehicle miles traveled, and parking. Waymo has the most prolific robotaxi fleet in the United States, and required public reporting in California gives us a unique look into their operations, which is why we choose to analyze Waymo data in this report. We compare the best currently available public data from Waymo's fleet operations in California, their self-published national safety data, and novel data on New York City's for-hire fleet from the city's Department of Transportation and Taxi and Limousine Commission and come to important conclusions.

1. **As it stands, replacing a high-volume for-hire vehicle in New York City with a robotaxi could increase vehicle miles traveled and congestion.** Waymo vehicles deadhead — drive empty, with no passenger in the car — more than New York City's high-volume for-hire vehicles (e.g., Uber and Lyft). For every mile with a passenger, a Waymo vehicle in California logs 14.8% more empty driving miles than a New York City Uber or Lyft.
2. **New York City's constrained parking supply, without enacting proactive curb management policies, would likely dramatically increase Waymo's deadheading if deployed in the city, leading to more traffic and wear on the streets.** We estimate that Waymo vehicles spend over half their waiting time parked in California. Our analysis finds that every 1% decrease in parked time would result in a 1.5% increase in deadheading; for example, if Waymo vehicles were only able to park 33% of the time while waiting for a ride in California, their deadheading would increase by 37%.
3. **Waymo's preliminary safety record in the cities where it currently operates compares favorably**

**to that of New York City for-hire vehicle drivers, though more miles in more conditions must be driven to constitute a sufficient sample and draw definitive conclusions.** Per mile traveled in the cities where they operate today, Waymo vehicles are involved in 62% fewer crashes resulting in an injury and 87% fewer crashes resulting in a serious injury or death when compared to New York City for-hire vehicles. In turn, New York City for-hire vehicles are involved in fewer crashes per mile resulting in injuries, serious injuries, or deaths than the average New York City driver.

With a grasp on these issues, we provide New York City (and other cities facing the issue of robotaxi legalization) with ways to prepare a more effective regulatory environment, including:

- Require robotaxi companies to compare their safety data to professional, for-hire vehicle drivers as a prerequisite to licensure to operate
- Require data transparency from robotaxi companies and cities to properly conduct critical analyses
- Prepare fees to adequately capture and reduce the impact of robotaxis on our streets
- Stop centering single-use vehicles and consider how automated public transit can fill holes in our transit system
- Consider limiting robotaxis' ability to travel within dense, transit-rich commercial areas
- Expand for-hire vehicle pick-up/drop-off zones
- Manage licensing and control deployment to prevent excessive robotaxi vehicle miles traveled growth

With this initial research, we hope to spur discussion about the potential impacts of robotaxis — safety, vehicle miles traveled, parking, and others not discussed in this paper like labor and privacy — to make our streets work for all users.

### Robotaxis drive more empty miles per trip

**+14.8%**

more empty (deadheading) miles per passenger mile than NYC's Uber and Lyft fleet

*Based on Waymo's California fleet operations data*

### Less parking means more empty driving

Waymo vehicles **spend over half their waiting time parked** in California

**+37%**

**more deadheading**

if parking availability fell to 33% — NYC's constrained supply makes this a real risk

*Every 1% drop in parked time raises deadheading by 1.5%*

### NYC's for-hire vehicles have fewer crashes than the average NYC driver

**20%** fewer crashes resulting in an injury

**25%** fewer crashes resulting in serious injury or death

*Based on crash rates per million miles driven*

### In the cities they operate, Waymo vehicles have fewer crashes than NYC's for-hire fleet

**62%** fewer crashes resulting in an injury

**87%** fewer crashes resulting in serious injury or death

*Based on crash rates per million miles driven by Waymo vehicles nationally (in the cities they operate)*

# Introduction

In the past decade, we have seen a significant proliferation of autonomous vehicle (AV) technology. Personal vehicles with semi-autonomous features have entered the market, and there has been heavy investment in technology for autonomous for-hire vehicles, also known as robotaxis. Robotaxis are operational in dozens of cities around the globe in a testing or commercial capacity, and they have been tested with a human safety operator on New York City streets.[1] The most prominent robotaxi companies include Waymo (owned by Google's parent company Alphabet, Inc.), Zoox (owned by Amazon), and Tesla; Uber is making initial moves to shift some operations to robotaxis.[2]

Waymo is a leader in early expansion efforts. While they're most prominent in the Bay Area of California in cities like San Francisco, they're fully operational in ten other cities, including Phoenix, Austin, and Miami. Substantial expansion efforts are ongoing, and as of June 2026, 21 cities are listed as "up next" on Waymo's website, including New York, London and Tokyo.[3] Waymo is the only company that has operated a pilot program in New York City (with a safety operator behind the wheel at all times, as fully driverless vehicles are not legal in New York State).

> ***There are a number of unanswered questions about how robotaxis would impact dense cities like New York City.***

There are a number of unanswered questions about how robotaxis would impact dense cities like New York City. Would they contribute to a safer street ecosystem? How would they impact vehicle miles traveled (VMT), an important metric to measure road use on city streets? What would be their effect on congestion, and how would they interact with the curb and parking management? What impact would they have on our streetscape?

A substantial portion of robotaxis' purported value is perceived safety benefits. Waymo claims that their vehicles are involved in 94% fewer crashes resulting in serious injuries or worse.[4] Experts have asserted that Waymo has not driven enough miles in all conditions, and that billions of miles would need to be driven to make definitive safety conclusions; as of June 2026, Waymo has driven roughly 220.6 million miles.[5] Waymo's comparisons are between Waymo vehicles and all drivers, and not solely between them and the

professional, for-hire drivers they would be replacing or supplementing who historically perform better than everyday drivers.[6] Additionally, multiple recalls and issues — cases where Waymo vehicles passed stopped school buses, drove through freeway work zones, and waded through a flooded road — raise questions about the potential for future issues.[7] These observations are not to say that Waymo's claims of safety are categorically untrue or without merit, but instead require scrutiny. Further, publicly available VMT data provided by Waymo (including data points like trips and waiting time) is geographically generalized and not granular enough to draw more specific conclusions. Driving patterns are different in rural, suburban, and urban areas, and localized VMT data allows researchers to make accurate comparisons (described further in the **Data Considerations** section).

The fact that robotaxis are autonomous results in new challenges to reducing VMT: the vehicles are not constrained by the limits of a human driver, just their battery, and therefore can circle for extended periods of time, be in service for longer hours, and take longer routes. VMT is an essential metric to understand the presence and impact of vehicles. It is a measure of how many miles are driven by vehicles in a given area, and it's important to monitor in the effort to reduce congestion and make public transit more efficient.[8] A recent independent meta-analysis found that robotaxis could increase VMT in a given city by 5.3%.[9] These impacts are compounded if there is no curb access; an analysis (funded in part by Waymo) found that if robotaxis did not have access to the curb for pick-up, drop-off, and downtime, the VMT of the study's theoretical fleet of 1,800 vehicles would increase by 60%.[10]

Most current research into the potential impacts of robotaxis employs theoretical robotaxi fleet models. But now that we have operational data from Waymo's fleet in California, and safety data from their deployments nationwide, we can investigate how that fleet actually performs and estimate how robotaxis may impact New York City. In this report, we attempt to investigate questions about safety, VMT impact, and curb management by asking: how would robotaxis fit into our larger transportation ecosystem? To do so, we compare key data from Waymo vehicles, both in California and nationally, and for-hire vehicles in New York City. With this research, we hope to contribute to the ongoing conversation around autonomous vehicles, robotaxis, and their impact on our city's streets.

# Data

For our analyses, we use VMT and crash data from the NYC Department of Transportation (DOT) and the NYC Taxi and Limousine Commission (TLC), obtained both through the NYC Open Data portal and provided directly to our research team. Waymo did not respond to our multiple requests for additional data.[11] We also use publicly accessible VMT and crash data provided by Waymo via its website, as well as data from the California Public Utilities Commission (CPUC). While the comparison between New York City and San Francisco is not apples-to-apples, out of all the environments that Waymo is currently deployed in, San Francisco is the closest to New York City with respect to population and demand density, pedestrian and cyclist activity, and street orientation. More details on the data used can be found in **Appendix A1**.

# VMT Analysis

California's Waymo robotaxi fleet generates unique and detailed operational data due to public reporting requirements to the California Public Utilities Commission (CPUC). This data set provides us with a rare empirical window into how robotaxis actually behave on public streets. It also allows us to create hypothetical robotaxi deployment scenarios in New York City and estimate potential VMT impact. Additionally, by comparing this data provided to the CPUC and data on New York City's HV-FHV fleet (e.g. Uber and Lyft) VMT provided by the Department of Transportation, we can make comparisons on how autonomous and human for-hire fleets impact VMT.

### KEY FINDINGS

1. Replacing human-driven FHVs with robotaxis could increase total VMT. Waymo's deadheading rate (the amount of time a vehicle drives empty) exceeds New York City's existing high-volume for-hire fleet. **Waymo vehicles drive empty 41.6% of the time as compared to 33% for the city's human for-hire fleet.**
2. Waymo's VMT multiplier (total miles driven empty per passenger mile served) is 1.71, compared to 1.49 for New York City's existing HV-FHV fleet. This means that for every mile a passenger is onboard, Waymo vehicles drive .71 miles with no one in the car as opposed to .49 miles for HV-FHVs. **The 14.8% gap means that, at current rates, replacing HV-FHV trips with robotaxi trips could increase, not decrease, total VMT on city streets.**

## VMT Data from California

In March 2026, Waymo completed 1,363,067 trips across its California fleet. Under California law, Waymo is required to report its VMT to the CPUC,[12] broken down into three operating phases:

- P1: Idle/Waiting for a Trip
- P2: En-route to Pick-up
- P3: Passenger Onboard

This phase breakdown allows us to better understand what Waymo vehicles are doing when they are doing it. For example, we can determine their "deadheading," or time spent without a passenger in the vehicle, by adding P1 and P2. Deadheading is the primary mechanism by which HV-FHVs add net VMT to city streets without moving people. **Table 1** contains travel classifications and statistics for Waymo vehicles in March 2026.

Deadheading is particularly impactful in urban areas. While an empty mile and an occupied mile impose similar per-mile costs on roadway congestion and safety, deadheading represents VMT added without any corresponding transportation benefit. Each empty mile driven is a mile of congestion, emissions, and crash exposure without a trip served. Robotaxis may also be prone to higher rates of deadheading simply because there is no human driver. Without a driver, there are no human constraints on operational hours like sleep, hunger, or bathroom breaks. In theory, robotaxis can operate for as long as their battery is charged.

*Table 1: Waymo VMT Travel Classifications and Summary*

## Waymo VMT Travel Classifications and Summary

| Travel Classification | Description | Miles Traveled by Waymo (% of their total VMT) |
|---|---|---|
| Idle / Waiting for Trip (P1) | Vehicle travel after completing a trip, before accepting the next one | 2,434,465.45 (26.7%) |
| En Route to Pick-up (P2) | Vehicle travel from last drop off to next passenger | 1,353,238.74 (14.9%) |
| Passenger Onboard (P3) | Vehicle travel with active trip & passenger on board | 5,317,404.10 (58.4%) |
| Total VMT (P1 + P2 + P3) | Sum of all vehicle travel | 9,105,108.29 |
| Deadheading (P1 + P2) | Time spent driving without a passenger | 3,787,704.19 (41.6%) |
| VMT Multiplier (Total VMT ÷ P3) | Total miles driven per passenger-carrying mile | 1.71 *(i.e. for every mile driven with a passenger, 0.71 miles are driven empty)* |

***Sources:*** *Waymo via California Public Utilities Commission, VMT data for March 2026 (see **Appendix A1** for further data and methodology details).*

### Translating to Per-Vehicle Behavior

To better understand the impact of a hypothetical fleet, we need to understand the impact of individual vehicles. Waymo does not directly report vehicle counts to the CPUC, or elsewhere. Therefore, we used a December 2025 report of 1,955 registered vehicles in California,[13] which we rounded up to 2,000, to estimate a per-vehicle daily performance (**Table 2**) for March 2026, which informs our hypothetical New York City scenarios.

*Table 2: Waymo VMT Impact Per-Vehicle Per-Day in California, Assuming 2,000 Fleet Vehicles*

| Metric | Result[14] |
|---|---|
| Trips per vehicle per day | 22.0 |
| Total VMT per vehicle per day | 146.9 |
| Passenger (P3) VMT per vehicle per day | 85.8 |
| Deadhead VMT per vehicle per day | 61.1 |

*See **Appendix A1** for calculations.*

## New York City Fleet Scenarios

To understand the potential impacts on New York City's streets, we model two scenarios:

- **SCENARIO 1:** Robotaxis only add to New York City's HV-FHV trips, and do not displace any existing trips
- **SCENARIO 2:** Robotaxis displace and replace existing HV:FHVs 1:1

Further details on our methodology and sources are expanded on in this section, and in **Appendix (A1)**. We chose to conduct this section of our analysis using HV-FHVs only, instead of combining with taxis. This decision is expanded on in **Appendix (A2)**.

### SCENARIO 1 Robotaxis Only Add to HV-FHV Trips

If Waymo robotaxis entered the New York City market without displacing any existing HV-FHV trips, the VMT impact would be straightforward: every robotaxi trip adds vehicle miles that did not previously exist (**Table 3**). Approximately 42% of those total miles would be empty.

*Table 3: Incremental Trips and VMT from Robotaxis, Assuming No HV-FHV Displacement (Scenario 1)*

**Incremental Trips and VMT from Robotaxis, Assuming No HV-FHV Displacement (Scenario 1)**

| New York City Robotaxi Fleet Size | Trips/day (*veh count * 22.0*) | Added Total VMT/day (*veh count * 146.9*) | Added Empty VMT/day (*veh count * 61.1*) |
|---|---|---|---|
| 500 vehicles | 11,000 | 73,450 | 30,550 |
| 1,000 vehicles | 22,000 | 146,900 | 61,100 |
| 2,000 vehicles | 44,000 | 293,800 | 122,200 |

While the likelihood of Scenario 1 persisting in the long term is low, we believe it serves as a useful lens. Due to the novelty of robotaxis, we believe that a robotaxi company's launch would result in a net increase in total rides; riders would be interested to try a new technology, and may substitute other means of travel (biking, walking, public transportation) to try it out, thereby adding robotaxi trips. Further, in an earnings report, Uber explicitly says that they believe that robotaxi growth will result in "incremental growth for the entire category."[15]

More than anything, Scenario 1 creates an upper bound on VMT impact, and illustrates that even a modestly sized robotaxi fleet generates substantial empty driving. **A fleet of just 500 vehicles would add over 73,000 vehicle miles per day to city streets — including over 30,000 empty miles, the equivalent to 938 trips around Manhattan a day.**

## SCENARIO 2 Robotaxis Replace Existing HV-FHV Trips 1:1

Our second scenario takes into account the potential share of the market that Waymo would take from HV-FHVs, which are on-demand ride services (e.g. Uber, Lyft) that serve essentially the same function as Waymo. The critical question we address is whether robotaxi trips generate more or less VMT than the HV-FHV trips they replace. In this analysis, we assume Waymo vehicles would replace HV-FHVs 1:1. Like Scenario 1, we do not believe that demand replacement will be exactly 1:1. However, it is a helpful way to analyze potential replacement impacts.

**VMT Multiplier**

*The VMT multiplier is the number of total vehicle miles traveled for every passenger-carrying mile, capturing the deadhead miles driven between fares.*

**Table 4** compares VMT metrics for both city HV-FHV and Waymo vehicles. New York City Department of Transportation data from 2025 shows that the human-driven HV-FHV fleet had a citywide utilization rate of 67%, implying a deadheading share of 33% — meaningfully lower than Waymo's 41.6% deadheading rate for March 2026. With this, we can compare the two fleets on multiplier terms:

*Table 4: Empty VMT Comparisons, New York City High-Volume For-Hire Vehicles vs. Waymo (Inputs for Scenario 2)*

### Empty VMT Comparisons, New York City High-Volume For-Hire Vehicles vs. Waymo (Inputs for Scenario 2)

| Metric | New York City High-Volume For-hire Vehicles (Citywide, 2025) | Waymo (California March 2026) | Difference |
|---|---|---|---|
| Empty Share of Total VMT | 33.0% | 41.6% | +8.6 percentage points |
| VMT Multiplier | 1.49 | 1.71 | +0.22 (+14.8%) |
| Empty Miles Per Passenger Mile | 0.49 | 0.71 | +0.22 (+14.8%) |

***Sources:*** *Waymo via California Public Utilities Commission, VMT data for March 2026; NYC Department of Transportation VMT data (2025) (see* ***Appendix A1*** *for further data and methodology details).*

The 0.22 gap in multipliers is critical: for every passenger mile shifted from an existing city HV-FHV to a Waymo vehicle, approximately 0.22 additional vehicle miles would be driven — an increase of almost 15% in total VMT per passenger mile served. This holds regardless of whether New York City trips are longer or shorter than Waymo's California average. **If the Waymo multiplier remains above the city's HV-FHV multiplier, there will be an increase in total VMT per passenger mile served.**

As it stands, replacing a HV-FHV with a robotaxi could increase VMT and congestion.

# Parking & Curb Analysis

A crucial matter often overlooked when discussing robotaxis is their potential impact on the curb. In California, Waymo reports data on miles driven but not on time spent parked. However, using a formula devised by Dr. Matthew Raifman, a UC Berkeley transportation researcher, we can estimate how long Waymo vehicles spend parked waiting for their next ride. By doing this, we can better understand potential impacts on the curb, parking, and congestion.

**KEY FINDINGS**

1. **New York City's constrained parking supply, without enacting proactive curb management policies, would likely dramatically increase Waymo's deadheading if deployed in the city, leading to more traffic and wear on the streets.** We estimate that Waymo vehicles spend over half their waiting time parked in California. Our analysis finds that every 1% decrease in parked time would result in a 1.5% increase in deadheading; for example, if Waymo vehicles were only able to park 33% of the time while waiting for a ride in California (instead of the approximated 58% they spend parked today), their deadheading would increase by 37%.
    a. This increase in P1 mileage means that overall deadhead miles (travel without a passenger, either idle or en-route to a pickup) would increase by 1.5% for every 1% decrease in parked time.
2. In California, Waymo vehicles spend an estimated 57.7% of their waiting time parked: about 10.4 minutes per trip according to our calculations. **This means that each vehicle in the fleet needs to be parked on-street while waiting between rides for about four hours a day.**

## Waymo Parked Time in California

Data reported by Waymo to the CPUC — miles traveled waiting for a ride (P1) and time waiting in between rides — allows us to estimate how much time Waymo's fleet spends parked waiting for a ride. Dr. Raifman determined that by dividing Waymo's P1 VMT share (their time spent waiting before or after a ride) and an assumed miles per hour driven (14 mph), we can calculate the hours of P1 that vehicles spend moving.[16] Then, by subtracting Waymo's total waiting time and their P1 moving time, we can estimate their parked time. Deriving parked time by this method is necessary because Waymo does not provide public data about their parking habits. Further details on our methodology and sources are included in **Appendix (A1)**.

Dr. Raifman estimated that the average Waymo vehicle spent approximately 53.3% of its waiting time (P1) in September 2025 parked rather than moving. Applying the same methodology to the March 2026 data yields an even higher share of parked time, as shown in **Table 5**:

*Table 5: Estimated Waymo Parked Share in California*

### Estimated Waymo Parked Share in California

| Metric | March 2026 |
| --- | --- |
| Parked Share (Share of P1 time spent parked) | 57.7% |
| Estimated parking time per trip | 10.4 min |

*See **Appendix A1** for calculations.*

Waymo vehicles spend more than half of their between-trip time standing still, presumably parked.

*Table 6: Estimated Waymo Fleet Parking Behavior*

### Estimated Waymo Fleet Parking Behavior

| New York City Robotaxi Fleet Size | Trips/Day (*veh count * 22.0*) | Hours/Parking (*Trips * 10.4 minutes*) |
|---|---|---|
| 500 vehicles | 11,000 | 1,907 |
| 1,000 vehicles | 22,000 | 3,813 |
| 2,000 vehicles | 44,000 | 7,627 |

## Implications for New York City

Using this estimate, we can understand two key metrics: the parking needs of different sized fleets and the impact on VMT if parking is unavailable.

If a hypothetical New York City Waymo fleet maintained the same parked-time behavior observed in California, the curb space demand would be substantial, requiring each vehicle to be parked for about four hours a day (**Table 6**).

However, we are doubtful that parked share in New York City would be similar to California's parked share (57.7%). Parking availability, especially in the most dense, high-demand areas for FHVs (like the Central Business District in Manhattan), is extremely constrained. Therefore, it's important for us to look at the potential VMT impacts of a lower parked share during P1 (idle time), which would result in more deadheading VMT.

**Table 7** estimates how both idle time and overall deadheading would change if Waymo's parked share of waiting time fell below its California baseline of 57.7%. By reversing the tactic used to devise parked share, we can estimate the following:

*Table 7: Reduced Park Share Deadheading Scenarios*

### Reduced Park Share Deadheading Scenarios

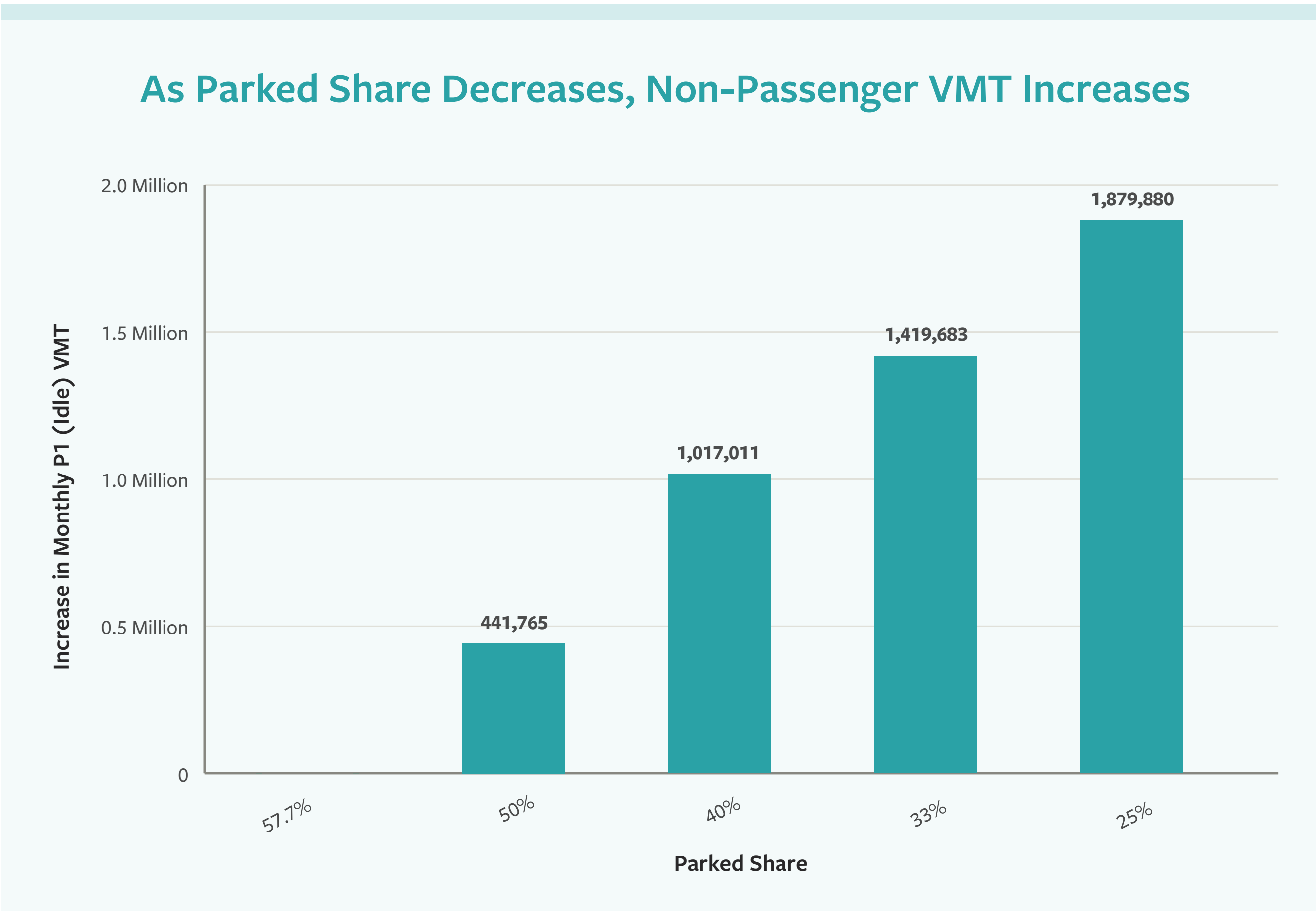
| Parked Share | Waiting Hours Parked | Increase in Monthly P1 (Idle) VMT | Increase in P1 (Idle) VMT (%) | Increase in Deadhead VMT (%) |
|---|---|---|---|---|
| California Baseline (57.7%) | 237,000 | — | — | — |
| 50% | 205,445 | 441,765 | 18% | 12% |
| 40% | 164,356 | 1,017,011 | 42% | 27% |
| 33% | 135,594 | 1,419,683 | 58% | 37% |
| 25% | 102,723 | 1,879,880 | 77% | 50% |

***Sources:*** *Estimated from Waymo data via California Public Utilities Commission, Wait Time and VMT data for March 2026 (see* ***Appendix A1*** *for further data and methodology details).*

**Figure 1** plots this relationship, showing that as vehicles spend less time parked and more time circulating while waiting for a dispatch, idle VMT rises.

If parked share decreases, deadheading VMT would increase sharply. For every 1% decrease in parked share, there is roughly a 2.4% increase in P1 VMT and a 1.5% increase in deadheading, assuming all else remains the same. Our findings are in line with other research that found that banning robotaxis from staging at the curb would result in significant VMT increases.[17] Both scenarios — banning robotaxis from the curb and allowing them to freely use the curb — would create complex issues at the curb. Robotaxis leave a significant footprint on a city's streets and curbs.

*Figure 1: Relationship between Parked Share of Waiting Time and Increases in Monthly P1 (Idle VMT)*




*Baseline waiting hours parked = 237,000. VMT increase calculated relative to baseline.*

# Safety Analysis

***This safety analysis was updated on August 21, 2026. Please see Appendix A4 for more information.***

Waymo benchmarks its driverless vehicle safety record against the average human driver. The company reports 94% fewer crashes (per mile driven) resulting in a serious injury or death, and 82% fewer crashes (per mile driven) involving any injuries compared to human drivers.[18] But robotaxis won't replace the average driver. In New York City and beyond, they would replace for-hire drivers, who have better safety records than the general public.[19] **The best comparison isn't robotaxis versus everyone, it's robotaxis versus the for-hire fleet they would replace.**

To approximate that benchmark, we compare New York City's for-hire vehicles (FHVs) — yellow taxis and high-volume for-hire vehicles (HV-FHV, e.g., Lyft and Uber) — against Waymo's driverless fleet. Both are measured in the same way: the numbers of vehicles involved in crashes for every million miles driven. We use two Waymo benchmarks, its record across all deployed locations nationally and its record in the San Francisco Bay Area, the current deployment environment that most closely resembles New York City and is considered the most favorable to AV deployment in the United States.[20] We look at two levels of crash outcome severity:

- **Injury-Causing Crash**: a crash with at least one injury reported, including minor, moderate, and serious injuries, as well as deaths. This includes the K, A, B, and C levels of the KABCO scale, a federal standardized injury classification for crash reports.[21]
- **Serious-Injury or Worse Crash (known as killed or seriously injured, or KSI):** a crash with at least one serious injury or fatality. KSI crashes are a subset of injury-causing crashes, and align with the "K" and "A" portions of the KABCO scale.

By comparing a New York City record to Waymo's record in other cities, we acknowledge this isn't an apples-to-apples comparison. Waymo has only ever held a testing permit in New York City, not a fully driverless fleet. By providing two comparison points (Waymo's national safety record, and San Francisco-only Waymo safety record) we hope to bracket the estimates of safety performance using general and "current environment most favorable to AVs" as the basis for estimating a potential range of safety-related outcomes for full deployment of Waymo's AVs.[22] We also recognize that safety is not limited to crashes, and can also include metrics such as remote operator interventions, interactions with emergency response vehicles, and near-misses, of which there is little publicly available data. **We include this analysis to identify what a safety benchmark for New York City could look like, and what should be evaluated, before a fleet is deployed.**

In our analysis, we adjusted for three things: vehicle type (active TLC vehicles, defined by their status in the month of the crash; and the vehicle classes covered by citywide VMT reporting), in-transport vehicles only (i.e., not parked at the time of the crash), and injury-severity on the KABCO scale. We did not adjust for highway versus surface-street travel, or weather and roadway conditions, which could impact a comparison between New York City and other locations (discussed further below). We included crashes for each vehicle class, regardless for the party at fault and aligning with how Waymo conducts their safety impact assessments. Further research could expand upon and aim to improve these areas of the study.

Given these constraints, the figures below should be read as a benchmark New York City should hold a driverless fleet to, not a direct measurement of how they would perform here. A more complete comparison would require Waymo to be operating driverless in New York City, TLC and Waymo to report injuries on a shared severity standard, and both datasets to capture VMT using comparable methodology. However, the data isn't available to make this comparison, and therefore what follows is our best approximation of an appropriate benchmark using the data currently available.

**KEY FINDINGS:**

1. Waymo measures their safety performance to the average human driver. **But per mile driven, New York City's FHV drivers are in 25% fewer KSI crashes and 20% fewer crashes resulting in any injury as compared to the average New York City driver**, which makes them a more relevant benchmark.
2. Based on the performance in cities where they operate today, per million miles, **Waymo vehicles have been involved in 62% fewer crashes resulting in an injury and 87% fewer KSI crashes than New York City FHVs.** The subset of Waymo vehicles in the San Francisco Bay Area are involved in 63% fewer injury crashes and 73% fewer KSI crashes per million miles than New York City FHVs.
3. These results are promising, but not yet a conclusion for New York City. **Further aggregated data in conditions similar to New York City (i.e. traffic, street density, and weather), and more miles in all conditions, are necessary to draw more definitive conclusions.**

## Determining Crash Rates

Each crash rate is calculated as the number of vehicles involved in a crash of a given severity divided by the miles those vehicles drove, expressed "per million miles" (PMM). A fleet that drives ten times as many miles will (all else equal) have roughly ten times as many crashes — not because it is more dangerous, but because it is on the road more. Taxis and HV-FHVs drove almost eight times more in just 2025 than all of Waymo's driverless miles between its launch in 2020 to March 2026. Calculating rates normalizes for fleets of different sizes and different utilization.

A 95% confidence interval indicates the range within which the true crash rate is likely to fall, given the observed data. 95% confidence intervals for crash rates are calculated using the exact Poisson (Garwood) method, which is standard for rare-event rate estimation and does not require large samples.[23] Intervals are computed based on observed crashed-vehicle counts and VMT for each vehicle category, then expressed as crashed vehicles per million miles.

The datasets cover different years: 2025 for New York City for-hire vehicles, 2024 for all New York City vehicles, and September 2020 through March 2026 for Waymo, cumulative since launch. This difference in time periods does not undermine the validity of the per-mile rates themselves, since each rate is normalized by that category's own exposure (miles driven). It does assume that risk per mile is reasonably stable over time.[24] This difference in time periods mirrors what Waymo produces for their safety benchmarks, which examines their driverless vehicle performance since launch compared to one full year of all drivers.[25]

Further details on our methodology and data sources for this section can be found in the **Appendix (A1)**.

## The Importance of Human FHV Benchmarks

Waymo compares its safety data to all drivers rather than to human FHV drivers specifically. Our analysis shows the flaws in that approach. Citywide, the gap between all drivers and FHV drivers is significant: New York City FHVs are involved in 20% fewer injury-causing crashes and 25% fewer KSI crashes than the average vehicle (**Table 8, Table 9**). **Comparing Waymo vehicles only to all drivers does not take into account the safety gap between the everyday driver and FHV drivers.** The best comparison isn't robotaxis versus all drivers: it's robotaxis versus the for-hire fleet they would replace.

## The Importance of Roadway Conditions

An important limit on this comparison is which miles Waymo has driven. New York City for-hire drivers work in every condition, on every day of the year and operate through snow, slush, ice, floods, and more. These drivers are expected on the roads in some of the worst conditions, and may even see surge demand in the worst weather.

In contrast, Waymo vehicles have operated in mild-weather cities. San Francisco is the closest match to New York City on density (though still has less population density than New York City) and street design in Waymo's published data, but it is not a match on weather. At this time, it is challenging to determine how much of Waymo's safety advantage comes from the driving system and how much comes from a more forgiving mix of conditions.

## Killed or Seriously Injured (KSI) Crashes

**Table 8** shows that for crashes with deaths or serious injuries — the most crucial Vision Zero data point — New York City FHVs were involved in 0.109 KSI crashes per million miles, while all vehicles in the city were involved in 0.146 KSI crashes PMM. Waymo reports 0.014 KSI crashes PMM nationally, and 0.030 KSI crashes PMM in the Bay Area. That is 87% fewer KSI crashes per mile than New York City FHVs on the national scale, and 72% fewer on the Bay Area scale.

**Figure 2** illustrates the 95% confidence intervals underlying these estimates. New York City's FHVs have an interval of 0.094 to 0.125, reflecting 190 crashes over 1.75 billion miles. Waymo's national interval, 0.003 to 0.040, is similar in absolute width but is based on just 3 crashed vehicles over 220 million miles. What the national figure cannot tell us is whether the same record would hold on New York City streets.

In the San Francisco Bay Area, the 95% confidence interval ranges from 0.004 to 0.108. This estimate is based on just two vehicles, and at this sample size, a single additional crash could shift the estimate substantially. The Bay Area interval overlaps with the New York City FHVs range of 0.094–0.125, meaning the data cannot rule out a KSI rate for Waymo comparable to professional FHV drivers. Experts believe that it would take billions of miles driven before conclusive, definitive statements could be made.[26] Additional driverless mileage accumulated in conditions similar to those in New York City could continue to move this comparison forward.

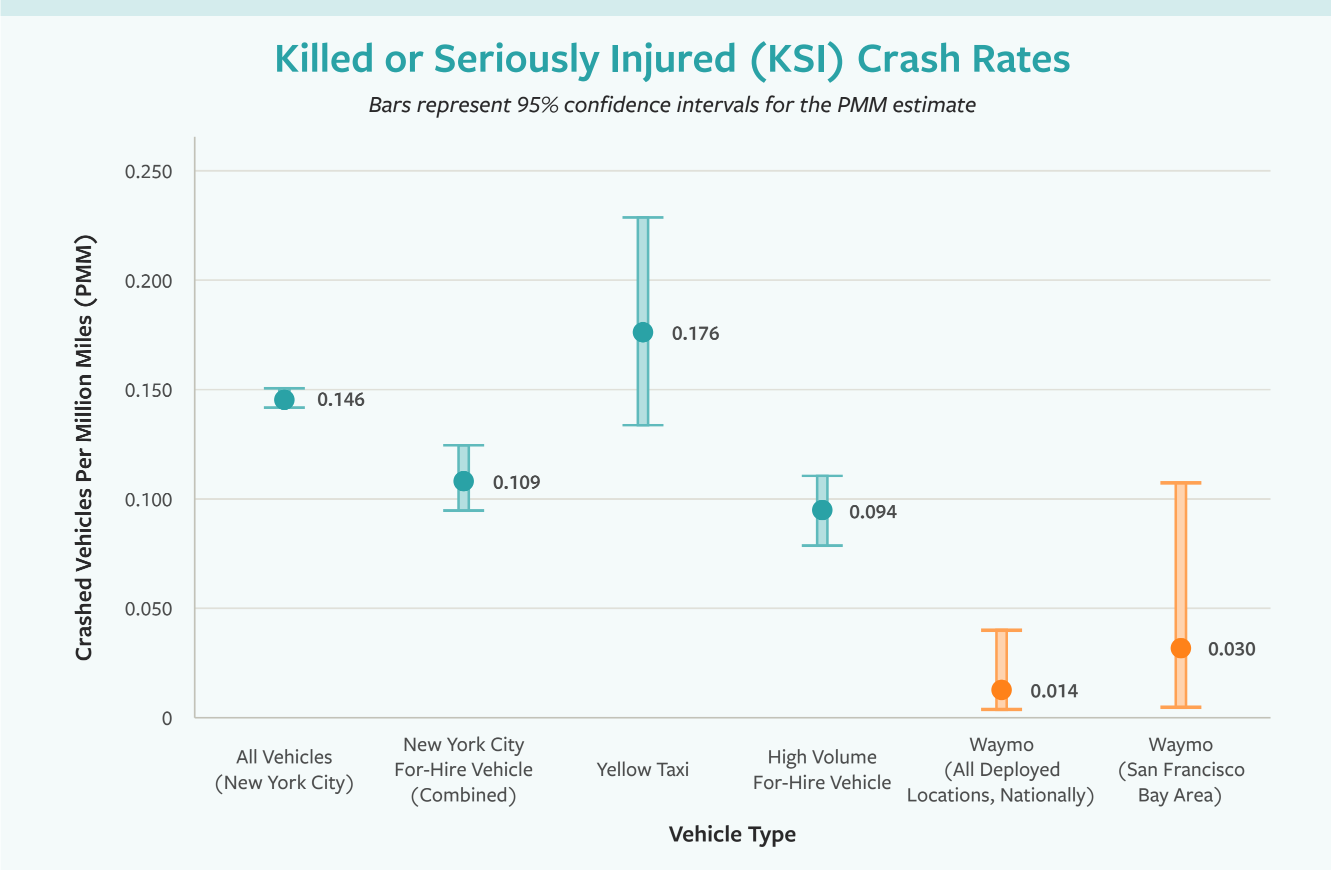
*Table 8: Killed or Seriously Injured (KSI) Crash Rates*

### Killed or Seriously Injured (KSI) Crash Rates

| Vehicle Type | Vehicle Miles Traveled | Vehicles Involved in KSI Crashes | Crashed Vehicles Per Million Miles (PMM) | 95% Confidence Intervals |
|---|---|---|---|---|
| **All Vehicles (New York City)** | **24,462,691,033** | **3,564** | **0.146** | **0.141 – 0.151** |
| **New York City For-Hire Vehicles (Combined)** | **1,750,149,509** | **190** | **0.109** | **0.094 – 0.125** |
| Yellow Taxis | 317,877,185 | 56 | 0.176 | 0.133 – 0.229 |
| High-Volume For-Hire Vehicles | 1,432,272,323 | 134 | 0.094 | 0.078 – 0.111 |
| **Waymo (All Deployed Locations, Nationally)** | **220,613,000** | **3** | **0.014** | **0.003 – 0.040** |
| Waymo (San Francisco Bay Area) | 67,078,000 | 2 | 0.030 | 0.004 – 0.108 |

***Sources:*** *NYC Taxi & Limousine Commission and NYC Department of Transportation crash data (2024 & 2025); NYC Department of Transportation VMT data (2025); Mayor's Office of Climate and Environmental Justice VMT data (2024); Waymo crash and VMT data September 2020 through March 2026 (see* ***Appendix A1*** *for further data and methodology details).*

*Figure 2. Killed or Seriously Injured (KSI) Crash Rates*




***Sources:*** *NYC Taxi & Limousine Commission and NYC Department of Transportation crash data (2024 & 2025); NYC Department of Transportation VMT data (2025); Mayor's Office of Climate and Environmental Justice VMT data (2024); Waymo crash and VMT data September 2020 through March 2026 (see* ***Appendix A1*** *for further data and methodology details).*

## Injury-Causing Crashes

**Table 9** shows New York City FHVs were involved in 1.871 injury crashes PMM, while all New York City vehicles were involved in 2.343 injury crashes PMM. This rate is 0.712 injury crashes PMM for Waymo nationally and 0.701 injury crashes PMM in the Bay Area. This means that Waymo vehicles both nationally and in the Bay Area have roughly 62% fewer injury-causing crashes PMM when compared to New York City FHVs.

> ***Waymo vehicles appear to perform well on the streets and conditions they are currently deployed. It is not yet determined how these vehicles will perform in the roadway conditions of New York City.***

Unlike the KSI analysis discussed above, this comparison includes a larger number of events for both the human and robotaxi fleets. **Figure 3** illustrates the relationships between confidence intervals for injury-causing crashes, showing that the intervals are much smaller for both Waymo and New York City FHVs. This, coupled with the difference in magnitude, gives us more confidence in preliminary numbers that Waymo's record for injury-causing crashes is better than a professional human fleet. However, the injury comparison still remains a geographic question. Waymo vehicles appear to perform well on the streets and conditions they are currently deployed. **It is not yet determined how these vehicles will perform in the roadway conditions of New York City.**

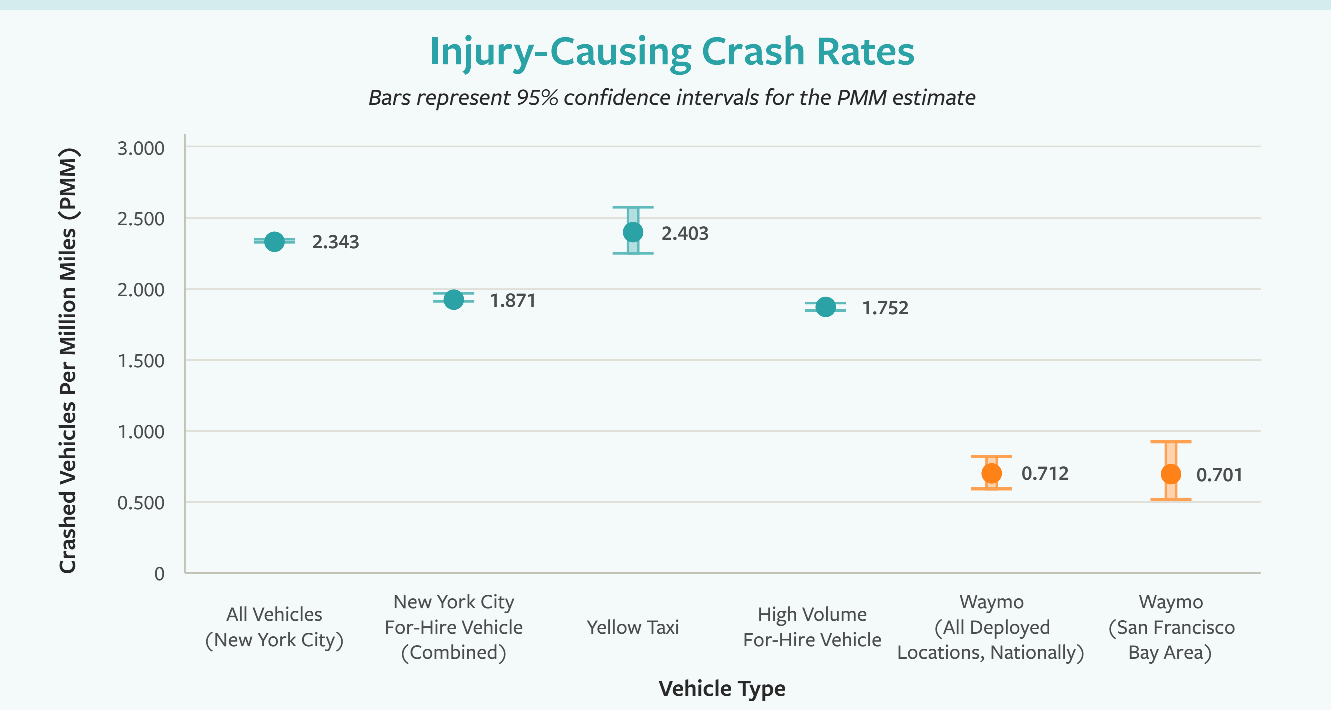
*Table 9: Injury-Causing Crash Rates*

**Injury-Causing Crash Rates**

| Vehicle Type | Vehicle Miles Traveled | Vehicles Involved in Injury-Causing Crashes | Crashed Vehicles Per Million Miles (PMM) | 95% Confidence Intervals |
|---|---|---|---|---|
| **All Vehicles (New York City)** | **24,462,691,033** | **57,305** | **2.343** | **2.323 – 2.362** |
| **New York City For-Hire Vehicles (Combined)** | **1,750,149,509** | **3,274** | **1.871** | **1.807 – 1.936** |
| Yellow Taxis | 317,877,185 | 764 | 2.403 | 2.236 – 2.580 |
| High-Volume For-Hire Vehicles | 1,432,272,323 | 2,510 | 1.752 | 1.685 – 1.822 |
| **Waymo (All Deployed Locations, Nationally)** | **220,613,000** | **157** | **0.712** | **0.605 – 0.832** |
| Waymo (San Francisco Bay Area) | 67,078,000 | 47 | 0.701 | 0.515 – 0.932 |

***Sources:*** *NYC Taxi & Limousine Commission and NYC Department of Transportation crash data (2024 & 2025); NYC Department of Transportation VMT data (2025); Mayor's Office of Climate and Environmental Justice VMT data (2024); Waymo crash and VMT data September 2020 through March 2026 (see* ***Appendix A1*** *for further data and methodology details).*

*Figure 3. Injury-Causing Crash Rates*




***Sources:*** *NYC Taxi & Limousine Commission and NYC Department of Transportation crash data (2024 & 2025); NYC Department of Transportation VMT data (2025); Mayor's Office of Climate and Environmental Justice VMT data (2024); Waymo crash and VMT data September 2020 through March 2026 (see* ***Appendix A1*** *for further data and methodology details).*

# Data Considerations

The calculations done in this paper are assembled with publicly available data and data that has been obtained from the NYC DOT and the NYC TLC. Waymo did not respond to our multiple requests for additional data.[27] We chose to use Waymo data for our analysis because they have the most robust publicly available data due to California requirements and the size of their fleet. Though Waymo does provide some data that is not required by any governmental authority, key data points are still missing. As a result of these gaps in the data, the scope of this study is limited to the questions addressed. With additional data, we (and other researchers) could conduct further in-depth research. Some of the data gaps include:

- **A lack of localized, aggregated VMT data.** If aggregated VMT data were available at the city level (i.e. San Francisco), it would allow a closer apples-to-apples comparison of citywide VMT. Instead, we have to rely on state-wide data mandated by the California Public Utilities Commission (CPUC). Additionally, as robotaxi operations expand across a wider range of roadway types, VMT reporting requirements should be extended to include a breakdown by roadway type (e.g., highway, freeway, surface street).
- **A definitive total number of Waymo vehicles operating in a given city or state.** Access is limited to numbers periodically shared with Waymo shareholders or reported in the press. Fleet size is directly tied to any assessment of operational efficiency.
- **The amount of time Waymo vehicles spent parked, double parked, or otherwise parked in violation of parking regulations.** We can only estimate parked time. Quantified parked time matters for understanding potential impacts on curb management.
- **The number of daily hours Waymo vehicles operate, individually or fleet wide.** Without precise numbers, it is challenging to fully understand VMT impacts.

Some of these data gaps are not strictly related to Waymo; there are also gaps in the New York City FHV data. For our analysis, the important gap is how long FHVs in the city are parked. And for localities outside of New York City (including San Francisco), there is limited data on FHV behavior in order to make a comparison to other for-hire fleets.[28] However, as a result of robotaxis being a fully autonomous fleet, the capture and dissemination of such data is significantly easier than for other kinds of FHVs.

These gaps notwithstanding, with robotaxis launching in cities around the country and the globe, it is essential we use the data that we do have in order to spur analysis, thought, and debate.

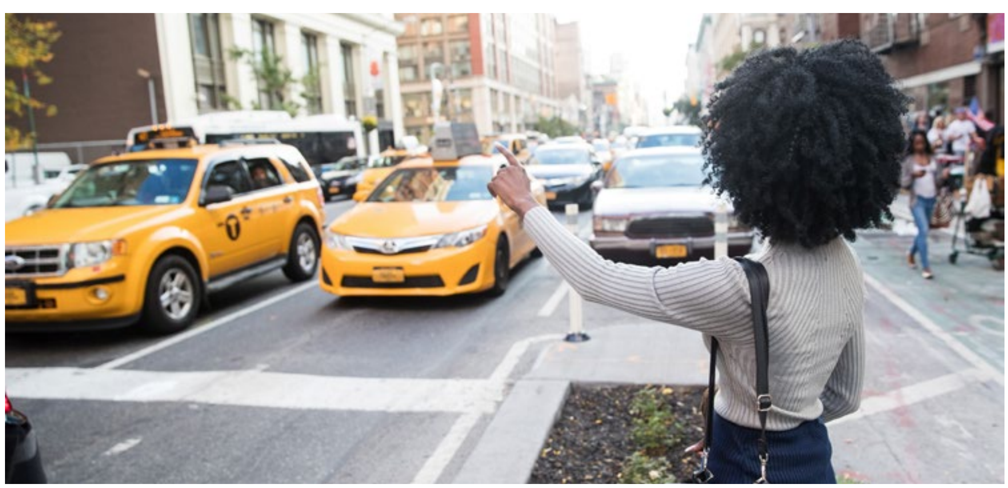
# Policy Implications

Our research raises important questions for policymakers. These results further complicate if and when New York City — or any dense, urban environment — should allow robotaxis. Below, we name further considerations informed by our analyses.

## 1 There will be additional impacts on VMT and congestion.

While we touch on a number of potential impacts on VMT in our analysis, there are also others that require further investigation and research.

- **Where would robotaxi depots be placed, and how often are Waymo vehicles going to and from the depots for charging, cleaning, and maintenance?** In the current VMT data, mileage for returns to depots are not included; these would be additional deadheading miles, and potentially some of the most negatively impactful miles. If robotaxi depots are placed in New Jersey or in the outer boroughs, the added congestion on bridges and tunnels could diminish the positive impact of congestion pricing. Further, depot placement could have negative impacts on those near the depot including added congestion and noise.
- **How would robotaxis' parking behavior impact our streets and curbs?** How would frequent pulling in and out of parking spaces impact congestion on our streets? Would buses be delayed by Waymo vehicles leaving or entering parking spots? If we allow robotaxis in loading zones (like Neighborhood Loading Zones), would that reduce the effectiveness of the loading zones? How would cyclists be impacted? While many of these same questions exist for vehicles of all types, it is a meaningfully different question; robotaxis' parking behavior is entirely determined by policy and programming.
- **How would induced demand impact VMT?** In practice, lower fares and service proliferation may grow the total ride-hail market, attracting riders who currently walk, bike, or take transit. This could also impact road-user safety. Public transit is currently safer than any FHVs or robotaxi, so pulling riders from transit to robotaxis would have an overall negative impact on safety.




## 2 We already have technology and infrastructure that make cars and streets safer.

We have existing technologies and street design techniques that increase safety without the host of questions robotaxis introduce. With respect to vehicle safety technology, advanced driver assist systems have proven to reduce crashes of all types: forward collision warning and automatic braking cuts rear-end crashes in half, automatic braking for pedestrians cuts crashes by 27%, and blind spot detection reduces lane-change crashes by 14%.[29] Some of these technologies are required by the National Highway Traffic Safety Administration (NHTSA) in new vehicles, but not all.

**The best way to improve safety on our streets is by designing them for safety.** By designing streets to reduce and prevent speeding, putting in place bus and bike lanes to encourage transit and bike use, and implementing other interventions like curb extensions, hardened daylighting, and road diets, we can make our streets safer with tools we already have in our toolbox.

## 3 The benefits of fleet operations are contingent on corporate monopoly or good regulation.

Aside from purported and potential safety benefits of robotaxis, a factor that proponents often cite is the benefit of having a fleet of vehicles that "talk" to each other, especially for safety reasons. For example, if there's an emergency and an area is blocked off, the entire fleet can be immediately notified and avoid that area. Robotaxis can also communicate with each other to synchronize pick ups and drop offs.

However, that is only true in two circumstances: if a single company holds a monopoly and operates all robotaxis in a city (which may have harmful impacts on consumer choice), or if State and City regulators require companies to share fleet data, creating a truly unified network. **Without regulations mandating this kind of data sharing, we could end up with a fragmented system where operators only coordinate their own vehicles.** Each company would optimize its own fleet in isolation, with no visibility into what competitors are doing at the same curb, intersection, or block. The result is a patchwork of siloed fleets behaving less like a coordinated network, with more competition for the same limited street space – arguably no better than the coordination problems with our existing for-hire fleet, despite the technology's potential to improve information sharing.

# Policy Recommendations

**It is still unclear whether robotaxis will be a net benefit to New York City; this research introduces further questions.** However, it's important that our city is prepared to consider their adoption and to mitigate their potential negative effects. Based on our analyses, we present several recommendations for New York City (and other governments) to take into account and implement.

## 1 Require robotaxi companies to compare their safety data to professional, FHV drivers as a prerequisite to licensure to operate

Everyday drivers will not be directly replaced by robotaxis — professional, FHV drivers (e.g., drivers of taxis, Ubers, and Lyfts) will. It is critical that DOT, through partnership with TLC, require robotaxi companies to compare their purported safety benefits to our city's FHV drivers as a prerequisite to receive operating licenses. They should be significantly safer than these drivers in all conditions. Those studies should be peer-reviewed by recognized, independent bodies in the traffic safety field.

## 2 Require data transparency from robotaxi companies and cities to properly conduct critical analyses

Due to the fleet-based nature of robotaxis, companies are able to collect data at an unprecedented scale and granularity. In our **Data Considerations** section, we identify gaps in publicly available data that limited the scope of our analysis. There are also gaps, both with the data collection and public reporting, on the city-level that should be standardized so that ongoing, consistent monitoring of any future robotaxi deployment can be measured. New York City (and other governments) should require robotaxi companies to provide the following information for analysis, to close existing data gaps:

- Localized VMT data, especially for dense, urban areas like San Francisco
- VMT data for non-service phases, such as mileage spent returning to depots or offline
- Depot location and time spent at depots charging, parked, or receiving service
- The total number of robotaxi vehicles operating in their fleet nationally, and in each state, locality, and operating area
- The amount of time each vehicle in their fleet spends parked: legally and illegally (including whether it is double parking, parking at the curb in an illegal space, or in a bike or bus lane). This information should also be required from citywide for-hire TLC fleets.
- The number of daily hours each vehicle in their fleet operates
- Non-crash safety metrics for their vehicles, including the number and type of remote operator interventions, interference with emergency response, and near-misses.[30]

The City should set uniform reporting requirements for agencies and non-agency partners covering:

- Tracking and assessing crash rates for the FHV industry on crash severity scale, aligning with state and federal KABCO definitions
- Monitoring VMT by roadway types in a consistent and matching way to driverless vehicles

If deployment is eventually approved, data should be continuously shared so that the State and City can properly monitor and assess impacts over time. This should include, but is not limited to: regular, standardized reporting on crash and non-crash safety-related incidents, real-time or periodic VMT and deadheading figures, curb and parking violation data, and the geographic distribution of trips and vehicle activity across neighborhoods, to track whether impacts are concentrated in specific areas over time.

## 3 Prepare fees to adequately capture and reduce the impact of robotaxis on our streets

In our VMT and parking analyses, we found that the potential traffic impact of robotaxi fleets is significant. To adequately put a price to these externalities, New York City should consider one or a combination of all of the following:

1. **A vehicle miles traveled fee**, which would be levied for every mile a robotaxi drives. New York City should determine the fee that would best discourage excess miles, and a higher fee for miles that are spent deadheading. Such a policy is not unprecedented; the District of Columbia Council, for example, recently introduced a bill which included a VMT fee for robotaxis.[31]
2. **A vehicle hours fee**, which would charge robotaxi operators based on the total time a vehicle occupies a given highly congested zone (like the Central Business District), whether it is moving, idling, or parked illegally. By pricing total time in the zone rather than distance traveled, the fee would create a direct financial incentive for operators to minimize dwell time within the congested areas, including repositioning to lower-demand areas outside the zone. A vehicle hours fee would be levied in place of a VMT fee in applicable areas; they would not double up. Time-based charges are already deployed in some capacity by the TLC for driver-pay formulas.[32]
3. **Parking and curb use fees**, which would properly price robotaxis' potential impact on our curbs. At the very least, it's important for New York City to identify how to charge robotaxi companies for use of metered spots. After a more thorough analysis, the City should also determine whether robotaxi companies should be charged for all uses of the curb, whether they occupy a paid or "free" spot. Companies are already integrating robotaxi metered parking payment, and organizations like the Open Mobility Foundation are developing digital tools to assist cities in a robotaxi launch.[33]

## 4 Stop centering single-use vehicles and consider how automated public transit can fill holes in our transit system

We cannot fall into the trap of only centering single-use vehicles, as so many transportation planners and experts have for decades. While debate about the merits of robotaxis is important, it's perhaps more important to discuss and consider how this generation-defining automated technology can be used for the public's benefit, and not just for corporate benefit.

Automated public transportation is already being used across the country and globe. Atlanta, Georgia is running an automated shuttle pilot, and closer to home, the Port Authority of New York and New Jersey is piloting automated airport shuttles.[34] Early research suggests it is possible to benefit from this technology without losing jobs.[35] It is important to consider how New York City can leverage this technology to increase service and close gaps in our transportation system.

## 5 Consider limiting robotaxis' ability to travel within dense, transit-rich commercial areas

Robotaxis stand to add millions of miles annually to our streets. We do not need more vehicles entering highly dense, transit-rich commercial areas like Midtown Manhattan, the Financial District, or Downtown Brooklyn. This is particularly true for areas in the Central Business District, where massive gains have been made in reducing congestion due to congestion pricing. The City should consider whether robotaxi travel should be limited (also known as geofencing) within certain commercial areas, similar to the limited geographic scope of green cabs, to prevent congestion. Geofencing could also encourage robotaxis to fill transit gaps, by directing service towards areas with poor transit access.

## 6 Expand FHV pick-up/drop-off zones

Robotaxis have the potential to greatly disrupt our already-chaotic curb landscape. New York City should implement more dedicated FHV pick-up and drop-off zones, regardless of whether robotaxis deploy in our city, to avoid illegal and double parking. If they do, the NYC Department of Transportation should consider how robotaxis would interact with these and other loading zones. Would they need dedicated, robotaxi pick-up/drop-off zones or parking? Would they be permitted to use Neighborhood Loading Zones like human FHV drivers are today? How would robotaxis be fined if they violate parking laws? These are important questions that will shape our curbs in the decades to come, but the answer begins with more pick-up/drop-off zones.

## 7 Manage licensing and control deployment to prevent excessive robotaxi VMT growth

We find that robotaxis carry a higher VMT multiplier than New York City FHVs, with more deadheading without a passenger. Without a driver, there are no human constraints on operational hours like sleep, hunger, or bathroom breaks. In theory, robotaxis can operate for as long as their battery is charged. Without a mechanism to manage growth, robotaxi deployment risks adding net VMT and congestion to city streets. If deployed in New York City, the City should study the actual net VMT impact of robotaxi deployment relative to existing FHV activity on our streets and manage licenses, including a potential fleet cap, to prevent an increase in VMT.

## APPENDIX A1

# Further Details on Methodology & Data Sources

## VMT Analysis

**VMT:**

- **NYC Taxis & High-Volume For-Hire Vehicles:** 2025 Citywide FHV VMT provided by the New York City Department of Transportation. This data is derived from an analysis of New York City Taxi and Limousine Commission Taxicab Passenger Enhancement Program (TPEP) for Yellow Taxis and HV-FHV (Uber, Lyft) breadcrumb data, which are sequential GPS pings. This data set was provided to the Sam Schwartz Transportation Research Program directly.
- **Waymo:** Under California law, Waymo is required to report vehicle miles traveled to the California Public Utilities Commission (CPUC) as part of Deployment Program Quarterly Reports. This data is available publicly on the CPUC website.[36] For our analysis, we used the most-recent available month (March 2026) of the latest quarterly report at the time of publication, 2026 Q1 (Reporting Period: January 1, 2026 – March 31, 2026).

  While the names of the files can vary between reporting periods, VMT data for this report was found in the file named 'PSG0038152_2026_05_AV_Month_Parto-Deployment.csv'.

**Calculations:**

Multiplier = Total VMT ÷ P3 (On-Trip) VMT

Trips per vehicle per day = Total Trips per Month ÷ Total Vehicles ÷ Days per Month

Total VMT per vehicle per day = Total VMT per Month ÷ Total Vehicles ÷ Days per Month

Passenger (P3) VMT per vehicle per day = Total P3 VMT per Month ÷ Total Vehicles ÷ Days per Month

Deadhead VMT per vehicle per day = (P1 + P2) VMT per Month ÷ Total Vehicles ÷ Days per Month

## Parking Analysis

"Parked share" is an estimate based on an analysis method developed by Dr. Matthew Raifman, a UC Berkeley transportation researcher studying how automated vehicle systems affect safety, sustainability, and urban mobility. His original description of his methodology is available online.[37]

**VMT:**

- **Waymo:** same VMT source as the VMT Analysis. The quarterly reporting required by CPUC also requires Waymo to submit information on Total Waiting Time, or the total amount of time vehicles waited between ending one passenger trip and initiating the next passenger trip, expressed as a monthly total in hours, in the same CSV as the other VMT data.

**Calculations:**

P1 Waiting Time Moving (Hours) = P1 VMT ÷ Assumed Miles per Hour

P1 Waiting Time Parked (Hours) = Total Waiting Time (Hours) - P1 Waiting Time Moving (Hours)

Share Time Parked = P1 Waiting Time Parked (Hours) ÷ Total Waiting Time

Time Parked Per Trip (Minutes) = (Total Trips ÷ P1 Waiting Time Parked (Hours))*60

## Safety Analysis

For each fleet, the numerator (count of vehicles involved in crash incidents) and denominator (VMT) come from the same reporting period, so each individual rate is internally consistent. Comparing rates across different reporting windows doesn't undermine the validity of the per-mile rates themselves, since each rate is normalized by that category's own exposure (miles driven). However, the sources for each base statistic vary:

**VMT:**

- **NYC Taxis & High-Volume For-Hire Vehicles:** 2025 Citywide FHV VMT provided by the New York City Department of Transportation. This data is derived from an analysis of New York City Taxi and Limousine Commission Taxicab Passenger Enhancement Program (TPEP) for Yellow Taxi and HV-FHV (Uber, Lyft) breadcrumb data, which are sequential GPS location pings. This VMT covers all areas of NYC on any roadway type. This data set was provided to the Sam Schwartz Transportation Research Program directly.
- **Waymo:** Provided by Waymo, capturing all driverless miles driven (which Waymo refers to as 'rider-only,' meaning there is no driver in the car) since service launch in September 2020 through March 2026. Available publicly.[38]
- **All New York City Vehicles:** VMT provided by the New York City Mayor's Office of Climate and Environmental Justice (MOCEJ) for 2024. Sum of VMT for all vehicles (buses, school buses, trucks, passenger cars). Available publicly.[39]

**Crash Incidents:**

- **NYC Taxis & High-Volume For-Hire Vehicles:** 2025 citywide counts of TLC-licensed vehicles involved in crashes, by TLC vehicle type and KABCO severity, covering all areas of NYC and all roadway types. TLC and DOT provided this data. Because TLC-licensed vehicles can serve the traditional FHV industry, the high-volume (Uber/Lyft) industry, or both, TLC built this figure from raw NYPD crash records, matching each crash record's vehicle plate to its internal vehicle and trip records and assigning the crash to whichever industry the vehicle had completed a trip for in that month. This data is representative of in-transport TLC vehicles, (e.g., not parked), aligning with the data from Waymo. DOT provided the KABCO score designation, a standardized police crash injury coding system.

  This data set was provided to the Sam Schwartz Transportation Research Program & Open Plans directly.

- **All Injuries:** fatal and all injuries (KABC); including crashes with injuries with unknown severity.
- **KSI:** fatal and serious injuries (KA).
  - Serious injuries are defined based on the New York City Department of Transportation's categorization, which follows New York State law. This aligns the NYPD data form to the NYS DMV definition of Severe Injury, to the extent that the necessary fields are complete and accurate in NYPD data. The formula captures: Injuries resulting in emotional state: 'Unconscious', 'Semiconscious', 'Incoherent', and injuries resulting in complaint: 'Amputation', 'Concussion', 'Internal',' Severe Bleeding', 'Moderate Burn', 'Severe Burn', 'Fracture - Dislocation', 'Fracture - Distorted - Dislocation', 'Crush Injuries', 'Paralysis', 'Severe Lacerations'.
  - "Fatal-related" cases are excluded from this data: Off-street (e.g. parking lots, driveways, property not accessible to the public); Not transportation related (e.g. death from disease, heart attack, police pursuit, suicide, deliberate homicide, hurricane)
- **Waymo:** All crash incidents from Waymo's publicly supplied data, capturing every reported incident for in-transport vehicles (e.g., not parked) during driverless operations since launch in September 2020. The latest update at the time of this report included data through March 2026. This data is based on reporting required by the National Highway Traffic Safety Administration (NHTSA) Standing General Order (SGO), but is adjusted by Waymo for alignment with the KABCO score. NHTSA acknowledges that SGO reports may be incomplete or unverified, and traffic safety experts have recommended recoding its severity categories to KABCO so they align with police-reported crash databases.[40]
- **All New York City Vehicles:** 2024 citywide counts of all motor vehicles (buses, trucks, cars, SUVs) involved in a crash, by KABCO definitions. This data is representative of in-transport vehicles, (e.g., not parked), aligning with the data from Waymo. To align with the citywide VMT we have from MOCEJ, which includes VMT from buses, school buses,

trucks, and cars for 2024, this metric includes only these vehicles involved in crashes in 2024.

This data set was provided to the Sam Schwartz Transportation Research Program & Open Plans directly.

- **All Injuries:** fatal and all injuries (KABC); including crashes with injuries with unknown severity.
- **KSI:** fatal and serious injuries (KA).
  - Serious injuries are defined based on the New York City Department of Transportation's categorization, which follows New York State law. This aligns the NYPD data form to the NYS DMV definition of Severe Injury, to the extent that the necessary fields are complete and accurate in NYPD data. The formula captures: Injuries resulting in emotional state: 'Unconscious', 'Semiconscious', 'Incoherent', and injuries resulting in complaint: 'Amputation', 'Concussion', 'Internal',' Severe Bleeding', 'Moderate Burn', 'Severe Burn', 'Fracture - Dislocation', 'Fracture - Distorted - Dislocation', 'Crush Injuries', 'Paralysis', 'Severe Lacerations'.
  - "Fatal-related" cases are excluded from this data: Off-street (e.g. parking lots, driveways, property not accessible to the public); Not transportation related (e.g. death from disease, heart attack, police pursuit, suicide, deliberate homicide, hurricane)

**Calculations:**

Crashes Per Million Miles (PMM) = (Crashed Vehicles / VMT) * 1,000,000

**Exact (Garwood) Poisson Confidence Intervals**

Bounds were calculated in Excel using the chi-square distribution, at the 95% confidence level, where x is the observed count of crashes. The resulting bounds represent the 95% confidence interval for the expected count and are then divided by the relevant exposure measure (vehicle miles traveled) to produce the rate confidence interval reported in the study.

Upper bound (per million VMT): =0.5*CHISQ.INV(0.975, 2× x+2)/(VMT/1,000,000)

Lower bound (per million VMT): =0.5*CHISQ.INV(0.025, 2× x)/(VMT/1,000,000)

## APPENDIX A2

# Omitting Taxis from VMT & Parking Analyses

We chose to omit taxi data from our VMT and parking analyses and include it in the safety analysis. This is due to a number of reasons.

**With respect to our VMT and parking analysis:**

Taxis have dissimilar driving patterns to HV-FHVs, and therefore, to robotaxis. Taxis get a significant amount of their fares and passengers by scouting the streets, resulting in a disproportionate amount of deadheading. HV-FHVs are solely dispatched to passengers through an app, like robotaxis are, and therefore do not have the intrinsic share of deadheading that taxis have. Therefore, we believe it would be inaccurate to compare the VMT impacts of taxis to Waymo vehicles or other robotaxis for the purposes of our analysis.

We believe that the type of FHV that will be most displaced by robotaxis will be HV-FHVs. This is because, due to the above reasons, they are much more similar to each other than taxis are to robotaxis. They serve a different (though sometimes overlapping) purpose as compared to HV-FHVs. However, we would be remiss to note that it is possible that robotaxis could more directly displace taxis through the purchase of taxi medallions, either from drivers themselves or the corporate entities that now own many licenses. However, whether this option would be pursued by legislators or companies is difficult to say.

Nevertheless, for the sake of transparency, we have included below the basic statistics (**Table 10**) of taxis as it relates to our VMT analysis.

**With respect to our safety analysis:**

Our goal with the safety analysis is to compare the safety records of Waymo vehicles in California and professional, for-hire drivers in New York City. For this purpose, their deadheading and methods through which they pick up passengers isn't important. The important factor is that they are professionals, driving for a living, licensed by the TLC.

*Table 10: Taxis & Waymo VMT Multiplier*

### Taxis & Waymo VMT Multiplier

| Metric | NYC Yellow Taxi | Waymo (California March 2026) | Difference |
|---|---|---|---|
| Empty Share of Total VMT | 58.8% | 41.6% | -17.2% |
| VMT Multiplier | 2.43 | 1.71 | -0.72 (-29.5%) |
| Empty Miles Per Passenger Mile | 1.43 | 0.71 | -0.72 (-29.5%) |

***Sources:*** *Waymo via California Public Utilities Commission, VMT data for March 2026; NYC Department of Transportation VMT data (2025). (see* Appendix A1 *for further data and methodology details).*

## APPENDIX A3

# Waymo & New York City For-Hire Vehicle Fatalities

Because our serious-outcome (KSI) analysis is inclusive of fatalities, we did not include isolated fatalities within the analysis itself. We are providing the statistics below in **Table 11** for transparency:

### Fatalities

*Table 11: Fatal Crash Rate, Including Taxis*

**Fatal Crash Rate, Including Taxis**

| Vehicle Type | VMT | Vehicles Involved in Fatal Crashes | Crashed Vehicles Per Million Miles (PMM) | 95% Confidence Intervals |
|---|---|---|---|---|
| **All New York City Vehicles** | **24,462,691,033** | **278** | **0.011** | **0.010 - 0.013** |
| **New York City For-Hire Vehicle (Combined)** | **1,750,149,509** | **9** | **0.005** | **0.002 - 0.010** |
| Yellow Taxi | 317,877,185 | 2 | 0.006 | 0.001 - 0.023 |
| High-Volume For-Hire Vehicle | 1,432,272,323 | 7 | 0.005 | 0.002 - 0.010 |
| **Waymo (All Deployed Locations, Nationally)** | **220,613,000** | **2** | **0.009** | **0.001 - 0.033** |
| Waymo (San Francisco Bay Area) | 67,078,000 | 1 | 0.015 | 0.000 - 0.083 |

***Sources:*** *NYC Taxi & Limousine Commission and NYC Department of Transportation crash data (2024 & 2025); NYC Department of Transportation VMT data (2025); Mayor's Office of Climate and Environmental Justice VMT data (2024); Waymo crash and VMT data September 2020 through March 2026 (see* ***Appendix A1*** *for further data and methodology details).*

**APPENDIX A4**

# On Our Safety Analysis Revisions

After the release of this report on July 20, 2026, we were made aware of a potential discrepancy in the definition of injuries in the City data used in our analysis and the definition used by Waymo. Prior to our analysis, our research team requested crash injury data for for-hire vehicles disaggregated by injury type, including by serious injury. After publication, we consulted with the original data sources and with the providers of those data sources, and discovered that TLC was not using KABCO standards and instead follows Local Law 31 of 2014, which requires TLC to collect and report critical injuries and fatalities, not serious injuries. Once we learned this, we temporarily removed our safety section from our report and worked with TLC and DOT to isolate serious injuries, in-line with KABCO standards used by Waymo. We also further refined crash counts to reflect involved, in-transport vehicles. As a result, the numbers in this update are different from the originally issued report. We regret any confusion caused by the initial analysis' findings.

## ENDNOTES

1 Office of the Mayor of New York City, "Mayor Adams, DOT Announce Approval of First Application to Test Autonomous Vehicles in New York City With Trained Safety Specialist Behind Steering Wheel," August 22, 2025, https://www.nyc.gov/mayors-office/news/2025/08/mayor-adams--dot-announce-approval-of-first-application-to-test-.

2 Sean O'Kane and Kirsten Korosec, "Uber Taps Rivian to Build Robotaxis in Deal Worth up to $1.25B," *TechCrunch*, March 19, 2026, https://techcrunch.com/2026/03/19/uber-taps-rivian-to-build-robotaxis-in-deal-worth-up-to-1-25b/.

3 Waymo, "Where Waymo Is Driving," https://waymo.com/rides/.

4 Waymo, "Safety," https://waymo.com/safety/.

5 David Zipper, "We Still Don't Know If Robotaxis Are Safer Than Human Drivers," *Bloomberg*, January 6, 2026, https://www.bloomberg.com/news/features/2026-01-06/are-autonomous-vehicles-safer-than-human-drivers-we-don-t-know-yet; Waymo, "Safety Impact," https://waymo.com/safety/impact/.

6 Schaller Consulting, *Taxicab and Livery Crashes in New York City 2004* (2006), https://www.schallerconsult.com/taxi/crash06.pdf.

7 Natalie Lung, "Waymo Recalls Robotaxis After Vehicle Drove on a Flooded Road," *Bloomberg*, May 12, 2026, https://www.bloomberg.com/news/articles/2026-05-12/waymo-recalls-robotaxis-after-vehicle-drove-on-a-flooded-road; Jeff Brady, "Waymo Will Recall Software after Its Self-Driving Cars Passed Stopped School Buses," Technology, *NPR*, December 6, 2025, https://www.npr.org/2025/12/06/nx-s1-5635614/waymo-school-buses-recall; Lora Kolodny, "Waymo Recalls about 3,900 Robotaxis after Some Drove into 'Freeway Construction Zones,'" Technology, *CNBC*, June 18, 2026, https://www.cnbc.com/2026/06/18/waymo-nhtsa-voluntary-recall-robotaxis-entered-freeway-construction-zones.html.

8 Open Plans, *Hit the Brakes: Understanding and Reducing Vehicle Miles Traveled in NYC* (2025), https://drive.google.com/file/d/1brr-074jmtQQ6b8kwn-kD2j3GQqTsV2j/preview.

9 Farah Naz and Stephen P. Mattingly, "Assessing Automated Vehicle-Induced VMT: Meta-Analysis of Current Research," *Travel Behaviour and Society* 44 (July 2026): 101268, https://doi.org/10.1016/j.tbs.2026.101268.

10 Younghun Bahk et al., "Curb Staging: Understanding the Impacts of Automated Vehicle Ridehail Fleet Operations Under Different Parking Policies," SSRN Scholarly Paper no. 5526419 (Social Science Research Network, September 24, 2025), https://doi.org/10.2139/ssrn.5526419.

11 From Waymo, we requested information about their fleet size in California and in California localities, a breakdown of VMT in San Francisco, further information on their reported VMT data related to vehicles taken offline, total parked time while in service in California, and how long vehicles stay in service before being taken out of service.

12 California Public Utilities Commission, "Quarterly Reporting," https://www.cpuc.ca.gov/regulatory-services/licensing/transportation-licensing-and-analysis-branch/autonomous-vehicle-programs/quarterly-reporting.

13 Grace Kay, "Tesla Has Registered More than 1,000 New Vehicles for Its 'Robotaxi' Fleet in California in Just a Few Months," *Business Insider*, December 21, 2025, https://www.businessinsider.com/tesla-california-robotaxi-registered-vehicles-drivers-2025-12.

14 If the active fleet is smaller than 2,000, the per-vehicle figures would be higher, and if the fleet is larger, the per vehicle figures will be lower.

15 Uber, Uber Technologies, Inc. Q4 2025 Earnings Autonomous Vehicles Spotlight (2026), https://s23.q4cdn.com/407969754/files/doc_events/2026/Feb/04/Uber-Q4-25-Earnings-AV-Spotlight.pdf.

16 Matthew Raifman, "How Waymo Spends Its Time Between Trips," Substack, *How Waymo Spends Its Time Between Trips*, December 10, 2025, https://www.thedriverlessdigest.com/p/how-waymo-spends-its-time-between.

17 Bahk et al., "Curb Staging."

18 Waymo, "Safety Impact."

19 Schaller Consulting, Taxicab and Livery Crashes in New York City 2004 (2006), https://www.schallerconsult.com/taxi/crash06.pdf.; Masami Aga et al., "Comparison between Taxi Drivers and Ordinary Drivers by Analyzing Traffic Accident Statistics and Drive Recorder Data" (paper presented at the 8th International Symposium on Future Active Safety Technology toward Zero Traffic Accidents (FAST-zero'25), Arles, France, September 23–26, 2025). In a study of Japanese taxi drivers, the authors found that taxi drivers were involved in fewer crashes per unit of driving exposure than ordinary drivers despite spending substantially more time on the road.

20 Uber, Uber Technologies, Inc. *Q4 2025 Earnings Autonomous Vehicles Spotlight*.

21 United States Department of Transportation, "KABCO Injury Classification Scale and Definitions," https://highways.dot.gov/media/20141.

22 Uber, Uber Technologies, Inc. *Q4 2025 Earnings Autonomous Vehicles Spotlight*.

23 F. GARWOOD, "(I) Fiducial Limits for the Poisson Distribution," *Biometrika* 28, nos. 3–4 (1936): 437–42, https://doi.org/10.1093/biomet/28.3-4.437.

24 Our analysis uses the most recent complete data available at the time of writing: 2025 for for-hire vehicle crash rates and 2024 for all New York City vehicles. Our examination of crash rate stability over time indicated that for-hire crash rates were stable across 2024 - 2025, the two years of data available to us. All-vehicle crash rates were stable across 2022-2024, the period after COVID-19 pandemic disruptions.

25 Kristofer D. Kusano et al., "Comparison of Waymo Rider-Only Crash Rates by Crash Type to Human Benchmarks at 56.7 Million Miles," *Traffic Injury Prevention* 26, no. sup1 (2025): S8–20, https://doi.org/10.1080/15389588.2025.2499887.

26 Zipper, "We Still Don't Know If Robotaxis Are Safer Than Human Drivers."

27 From Waymo, we requested information about their fleet size in California and in California localities, a breakdown of VMT in San Francisco, further information on their reported VMT data related to vehicles taken offline, total parked time while in service in California, and how long vehicles stay in service before being taken out of service.

28 As of 2021, there is a moratorium on publicly disclosed FHV data in California. This does not allow for comparative analysis between San Francisco FHVs and Waymo, which is one of the reasons we did not include this analysis in our paper. Further, past data disclosed by CPUC did not disaggregate between the types of injury or property damage, discussed further in a paper by Chen & Shladover. You can read more about this moratorium on CPUC's website.

29 Alexandra Mueller, "Advanced Driver Assistance," IIHS-HLDI, July 2025, https://www.iihs.org/research-areas/advanced-driver-assistance.

30 SB 1417, Arizona State Senate Fifty-seventh Legislature, Second Regular Session (2026), https://www.azleg.gov/legtext/57leg/2R/bills/SB1417P.pdf.

31 Autonomous Vehicle Deployment Authorization Amendment Act of 2026, B26-0684, Council of the District of Columbia, accessed July 7, 2026, https://lims.dccouncil.gov/Legislation/B26-0684.

32 Yellow (and green) taxi meters have a built-in traffic-time charge. Per TLC's official rate structure, the meter switches between distance-based and time-based charges depending on congestion levels, charging 70 cents per 1/5 mile when traveling above 12mph, or the same 70 cents per 60 seconds in slow traffic or when the vehicle is stopped. TLC also sets a wage floor for Uber/Lyft drivers using a formula that pays a fixed rate per mile plus a fixed rate per minute of each trip, so drivers are effectively compensated for dead time between fares, not just paid-passenger minutes.

33 Open Mobility Foundation, "About CDS," 2026, https://www.openmobilityfoundation.org/about-cds/; Ryan Deto, "Pittsburgh Firm Targets Driverless Parking Gap," *Axios*, June 2, 2026, https://www.axios.com/local/pittsburgh/2026/06/02/driverless-cars-parking-fees-revenue-loss.

34 Port Authority of NY & NJ, "PORT AUTHORITY TO TEST SELF-DRIVING SHUTTLE BUSES AT NEWARK LIBERTY INTERNATIONAL AIRPORT THIS SPRING," February 25, 2026, https://www.portauthoritybuilds.com/content/redevelopment/us/en/ewr/news/port-authority-to-test-self-driving-shuttle-buses-at-newark-libe.html; Atlanta Beltline, "ATL Spoke Launches as Atlanta's First Autonomous Public Transit Service Pilot," May 28, 2026, https://beltline.org/blog/atl-spoke-launches-as-atlanta-s-first-autonomous-public-transit-service/.

35 NYU Rudin Center for Transportation, *The Future of the Bus* (2026), https://wagner.nyu.edu/files/faculty/publications/FINAL-The-Future-of-the-Bus-May-2026.pdf.

36 California Public Utilities Commission, "Quarterly Reporting."

37 Matthew Raifman, "How Waymo Spends Its Time Between Trips."

38 Waymo, "Safety Impact."

39 NYC Open Data, "NYC Greenhouse Gas Emissions Inventory," April 2026, https://data.cityofnewyork.us/Environment/NYC-Greenhouse-Gas-Emissions-Inventory/wq7q-htne/about_data.

40 Eric R. Teoh, David G. Kidd, and Luke E. Riexinger, "Rise of the Machines: Crash Experiences of Highly Automated Vehicles and Human Drivers" (Insurance Institute for Highway Safety, July 2026), https://www.iihs.org/research-areas/bibliography/ref/2374.

## IMAGE CREDITS

Cover photo composition by Angel Mendoza for Open Plans

Photo by Mat Hayward via Envato Elements

Photo by Sophia Lebowitz, courtesy of Streetsblog

p. 3, Photo by Leo_Visions via Unsplash

p. 5, Photo by Sophia Lebowitz, courtesy of Streetsblog

p. 6, Photo by ESBProfessional via Envato Elements

p. 20, Mat Hayward via Envato Elements

p. 21, Photo by Javanng via Envato Elements

p. 23, Photo by photovs via Envato Elements

p. 24, Photo by Phillip Pessar via Wikimedia Commons