



# Automated Ride Hailing - Status, Projections, and Critical Safety Review

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**Information reported is 3rd party data and NREL's conclusions are relying on their accuracy**

This presentation was produced when the laboratory operated as the National Renewable Energy Laboratory (NREL). The laboratory is now the National Laboratory of the Rockies (NLR).

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# Part of multi-dimensional research of AV public mobility

Current Status of AV Technology

Safety

Other Dimensions

Security

Traffic Impacts

AV Trucks & Freight

Energy & Emissions

Data Exchange / Sharing

Accessibility (MEP)

Electrification

Fleet Management

Curb – Stations - PUDO

Economics, Costs & Business Models

Regulation & Policy

Travel Behavior Impacts

Projection of Societal Impacts

# Status of AV Robotaxi Deployment

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# Leading Firms in Automated Driving System (ADS) Development

## Passenger Transport

- **Google - Waymo**
- **Baidu - Apollo**
- **Amazon – Zoox**

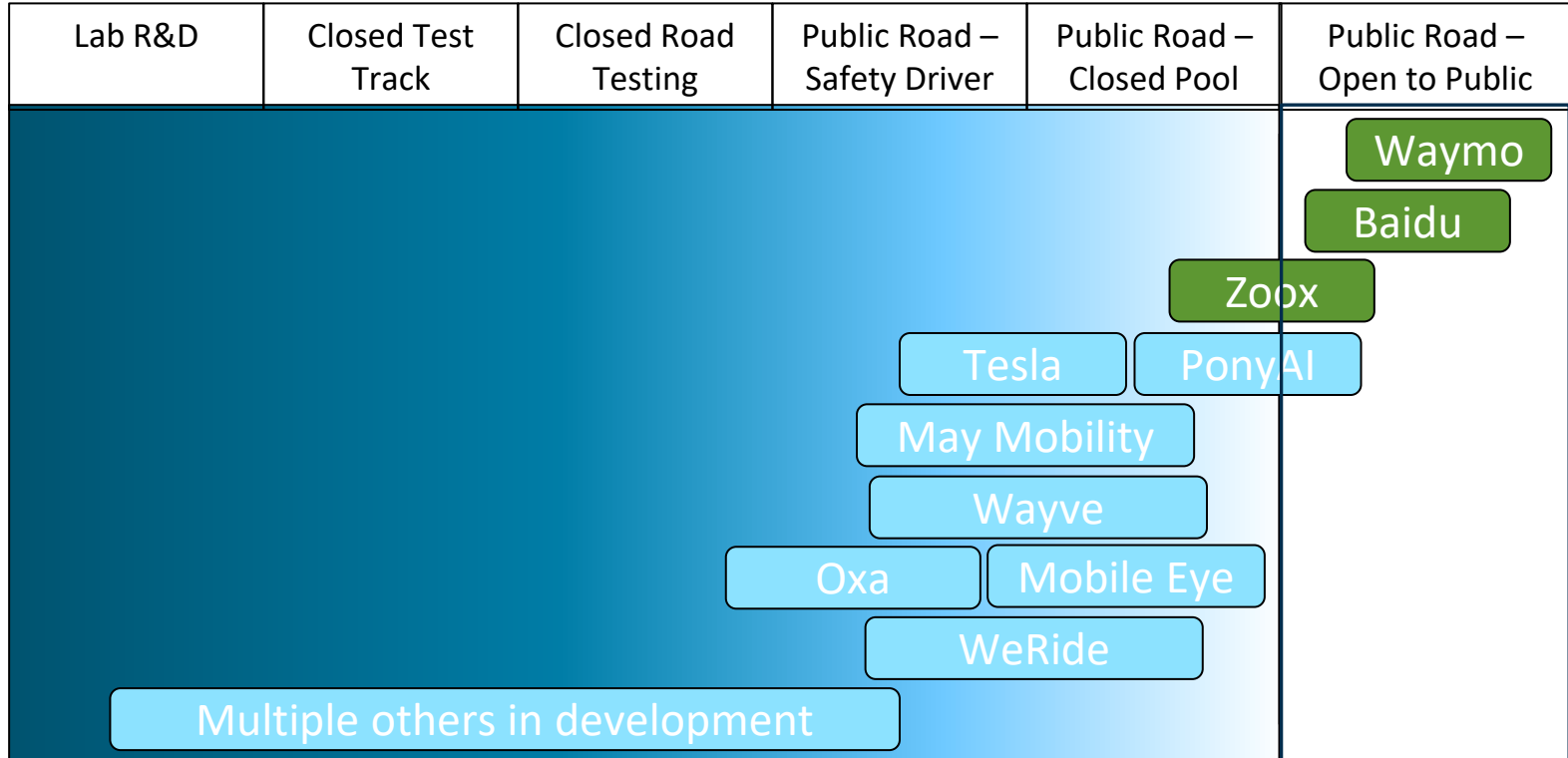
↑ Confirmed Driverless Operations ↑

- Pony.ai
- We-Ride
- Tesla FSD/robotaxi
- Wayve
- May Mobility
- Mobile Eye
- Oxa
- GM
- NVideo



On-demand driverless Waymo vehicle in operation in Phoenix  
Photo: Stan Young

# Stages of AV Development & Testing



# Industry Status of Automated Vehicle Technology Development

## Waymo's Passenger-Trip Milestones

50,000 paid trips per week – May 11, 2024

- <https://www.engadget.com/waymo-says-its-robotaxis-are-now-making-50000-paid-trips-every-week-130005096.html>

100,000 Trips per week – August 2024

- <https://www.teslarati.com/waymo-100000-paid-rides-week/>

150,000 Trips per week – Oct 29, 2024

- <https://seekingalpha.com/news/4221641-robotaxi-stunner-waymo-milestone-of-15000-paid-autonomous-trips-a-week>

● 200,000 Trips per week – Feb 27, 2025

- <https://techcrunch.com/2025/02/27/waymo-has-doubled-its-weekly-robotaxi-rides-in-less-than-a-year/>

● **250,000 Trips per week – Apr 25, 2025**

- <https://www.cnn.com/amp/2025/04/24/waymo-reports-250000-paid-robotaxi-rides-per-week-in-us.html>

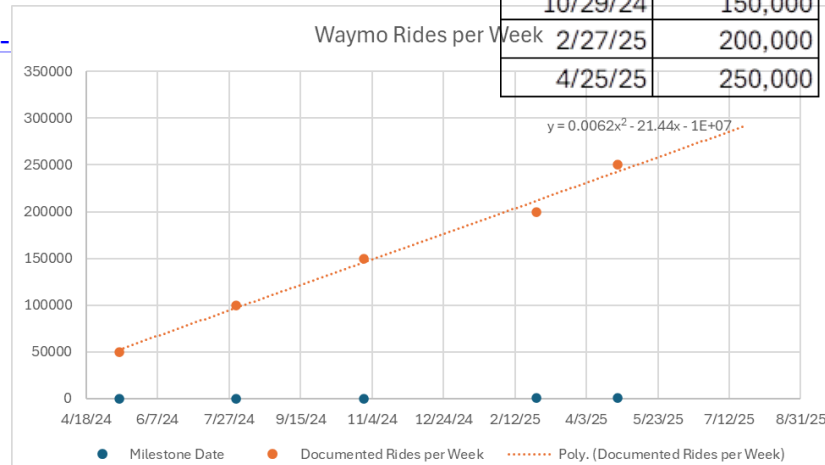
>5 million trips – 12/18/2024

<https://waymo.com/blog/2024/12/year-in-review-2024>

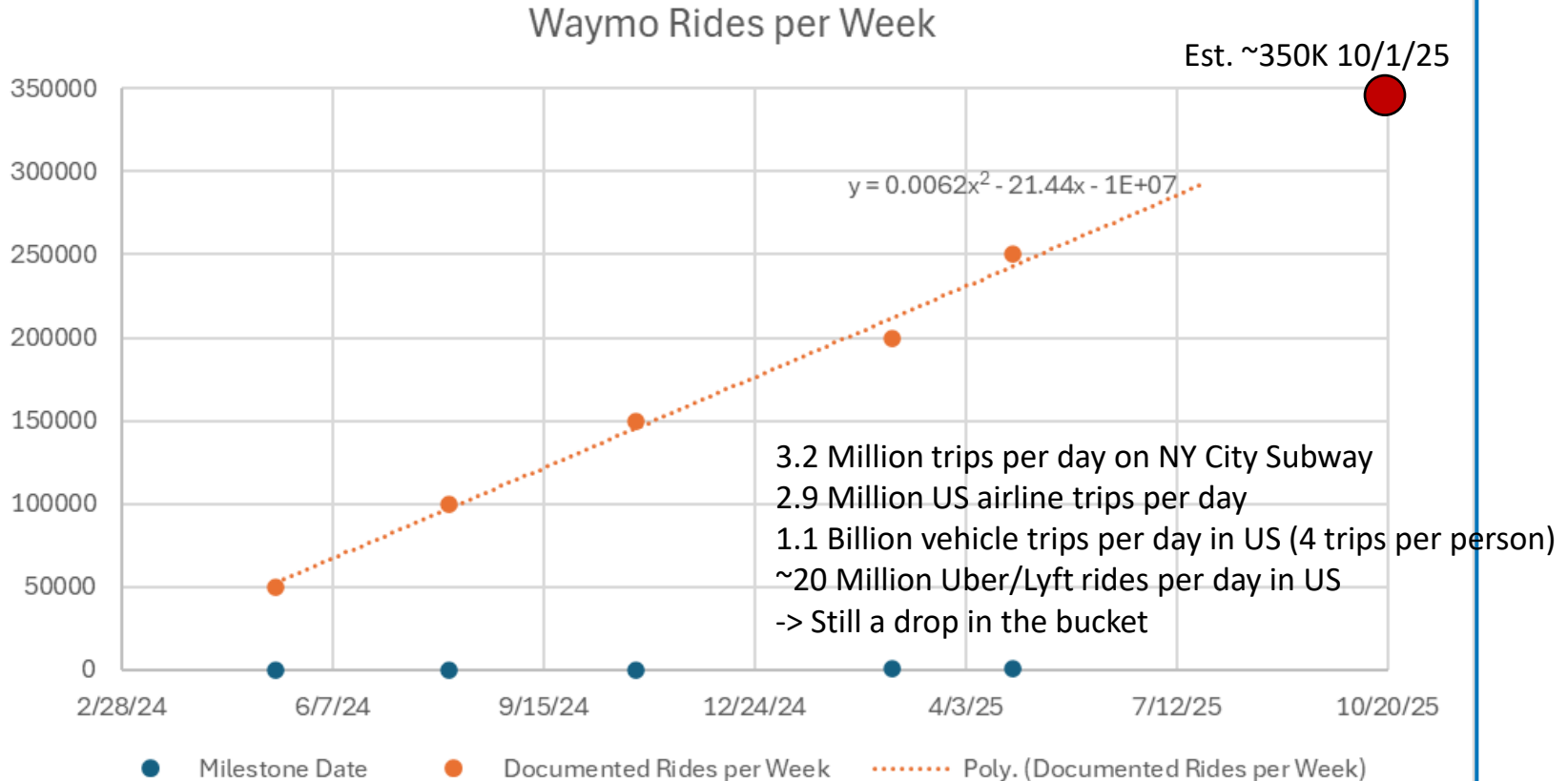
>10 million trips – 5/20/2025

<https://www.cnn.com/2025/05/20/waymo-ceo-tekedra-mawakana-10-million.html>

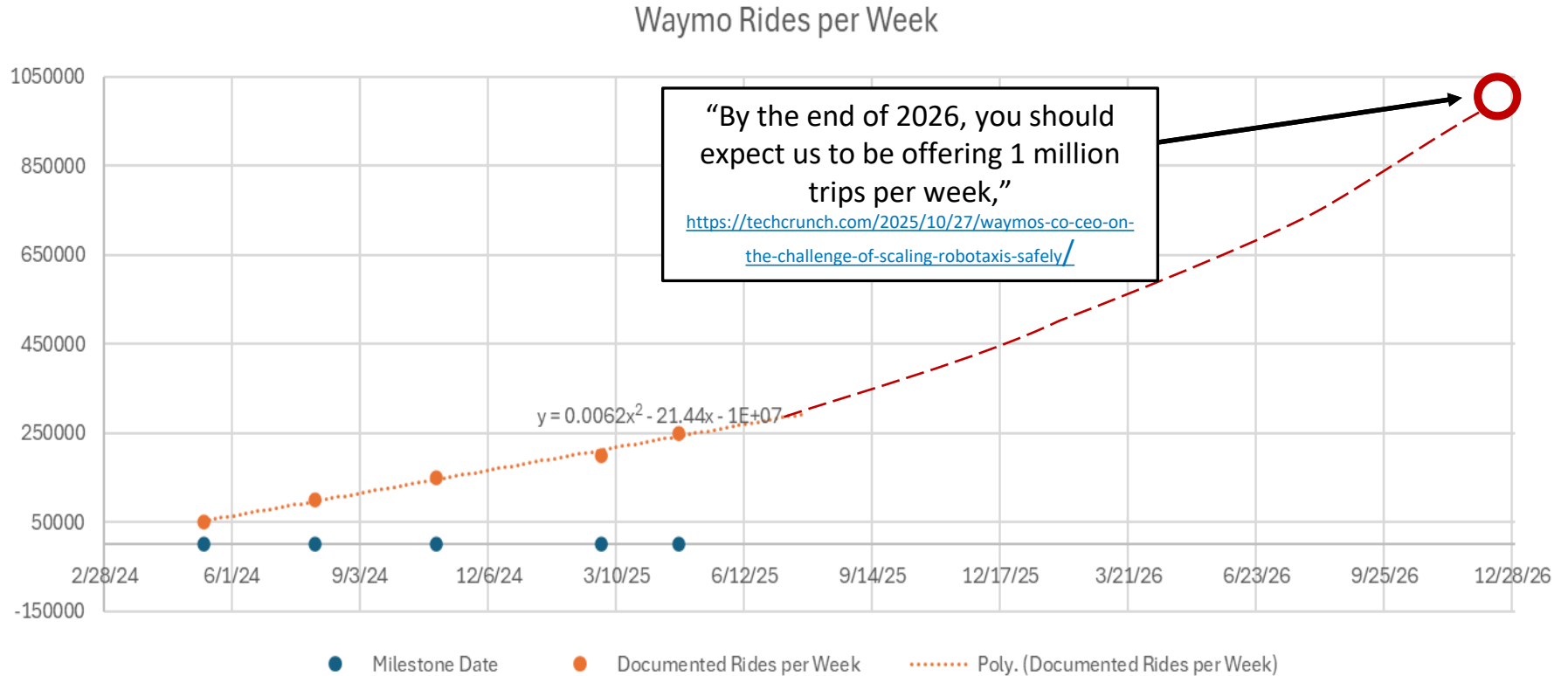
Date	Rides/Week
5/11/24	50,000
8/1/24	100,000
10/29/24	150,000
2/27/25	200,000
4/25/25	250,000



# Waymo Rides per Week – Updated 4/2025



# Waymo Rides per Week – Projection through 2026





# Waymo Milestones

- 1 Million Miles – January 2023
  - <https://electrek.co/2023/02/28/waymo-cruise-1-million-test-miles-will-begin-driverless-rides-los-angeles/>
- 2 Million Miles – May 2023 (@ 10,000 trips per week)
- 25 Million Miles – July 2024 (17M Phoenix, 7M SF)
  - <https://www.benzinga.com/news/24/10/41541316/waymo-fleet-hits-25m-driverless-miles-autonomous-driving-company-says-its-fleet-is-safer-than-human>
- **1 Million Miles Weekly – Feb 2025**
  - <https://techcrunch.com/2025/02/27/waymo-has-doubled-its-weekly-robotaxi-rides-in-less-than-a-year/>
  - The average American drives about 13,500 miles per year. (MS Copilot)
    - Average per week is 260 miles/week
  - 1 Million Miles weekly is equivalent to distance driven by 3,850 average drivers
  - At 200,000 trips per week, average trip distance is **5 miles**
- **100 Million Cumulative Miles – July 2025**
  - <https://www.cbtnews.com/waymo-hits-100-million-driverless-miles-as-robotaxi-rollout-accelerates/>
  - <https://waymo.com/blog/2025/09/waymo-is-coming-to-nashville-in-partnership-with-lyft>
- In comparison - On average ...
  - An American drives about 13,500 miles per year.
  - Over a lifetime (assuming a driving span of around 50 years), this totals roughly 675,000 miles. That's like circling the Earth at the equator about 27 times!
  - **The Waymo Driver system gains the equivalent of a human lifetime of driving experience every 2 weeks.**

# Baidu Apollo Go!!!

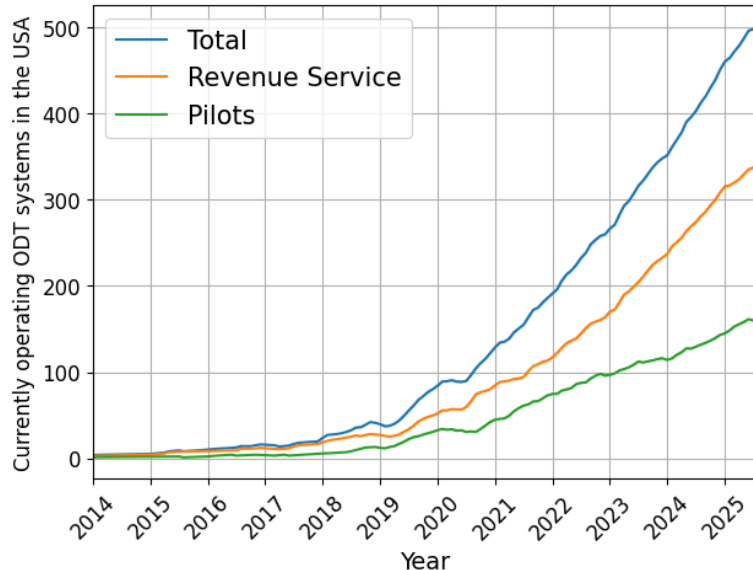
- Q4 of 2024
  - 12,000 rides/day in Q4 of 2024 –
  - 1.1 Million total rides in Q4
  - Accumulated 150 M KM to date
    - <https://www.globenewswire.com/news-release/2025/03/19/3045727/0/en/Apollo-Go-Delivering-a-Smarter-User-Friendly-Autonomous-Ride-Hailing-Experience.html>
- Q1 of 2025
  - 1000 vehicles operating across 16 cities in China
  - Surpasses 11 M rides since launch in 2019
  - Q1 2025 recorded 1.4 million rides, a 75% increase compared to the same period last year
    - <https://www.techinasia.com/news/baidus-apollo-go-surpasses-11m-rides-since-launch>
- Oct 31, 2025 - <https://www.cryptopolitan.com/baidu-run-as-many-robotaxi-rides-as-waymo/>
  - 250,000 rides/week – matches Waymo weekly rides of April 2025
  - 17 million total rides
  - 240 million kilometers (150 million miles)

# On-Demand Transit (ODT)

## On-demand transit (or microtransit) provides high-performance public mobility from rural to urban

- Uber/Lyft like service for public mobility – typically using mini-van type vehicle, sharing is compulsory
  - Rural (Innisfil, Fort Erie, Bastrop) – outperforms inefficient fixed-route transit, scalable, configurable
  - Suburban (Arlington, TX) – provides connectivity within the suburb for ‘inter-community trips’
  - Urban (Houston, Dallas, StL) – provides FM/LM and circulatory services, & connects inter-regional services

## Demand of ODT has outpaced ridership projections



Data source: Lukas Foljanty On-Demand Ridepooling World Map (August 2025)

- September 18, 2025
- Waymo and Via to offer robotaxis for public transit, starting with Arizona
  - <https://www.reuters.com/business/autos-transportation/waymo-via-offer-robotaxis-public-transit-starting-with-arizona-2025-09-18/>
- Arlington – driverless – Toyota Sienna
- MASS – class of ride-sharing like Zoox...

# Amazon Zoox -

Sep 10, 2025, Officially opened to public, free rides on the strip

- <https://zoox.com/journal/las-vegas>

Shared (multi-party),

Custom manufactured vehicles – 5K to 10K vehicles annually

Zoox contracts with Micro-Transit  
*The Routing Company*, for logistics

- <https://techcrunch.com/2025/08/20/zoox-taps-ex-uberpool-execs-startup-for-routing-software-help/>

**First AV robotaxi /  
multi-party service**



July 23, 2025 – Pre-public Release Date



[Linked In Post](#)

# AV Safety Review – Crash Statistics to Date

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# Why Safety?

## An AI Sentiment Analysis reviewed the top concerns for AV

### Top Positive Sentiments (Waymo)

1. Excitement about the future
- 2. Improved safety**
3. Convenience
4. Increased accessibility:
5. Reduced traffic congestion

### Top Positive Sentiments (Tesla)

- 1. Safety and Reduced Risk**
2. Convenience and Time Savings
3. Improved Driving Experience
4. Reduced Stress and Fatigue
5. Increased Productivity

### Top Negative Sentiments (Waymo)

- 1. Safety concerns**
2. Lack of human judgment
3. Job displacement
4. Reliability issues
5. Loss of control

### Top Negative Sentiments (Tesla)

1. Lack of Trust in Musk's Timeline
2. Hype vs. Reality
3. Ineffectiveness in Complex Environments
4. Relying on Radar and Cameras Alone
- 5. Safety Concerns**

# Waymo Safety – 2020-2024

- Waymo Safety Framework – Oct 2020
  - ... explains Waymo's methodologies as applied to the three layers of its technology: hardware, ADS behavior, and operations, and also explains **Waymo's safety governance**.
    - <https://waymo.com/research/waymos-safety-methodologies-and-safety-readiness/>
- Waymo/Swiss Re Insurance Data - Sep 2023
  - **Drove down injury claims by 95 percent** for over **35 million miles**, logging 0.09 claims versus 1.09 claims per million miles for the human baseline. And Waymo also saw a **76 percent drop in the frequency of property damage claims** (a decrease from 3.26 to 0.78 claims per million miles) when compared to human drivers. <https://www.theverge.com/2023/9/6/23860029/waymo-insurance-injury-claims-autonomous-vehicle-swiss-re>
- Accident Stats – June 2024
  - ... compared to humans driving the same 14.8 million-mile (23.8 million-km) distance, had 30 fewer injury-causing crashes and 32 fewer police-reported crashes. The company claimed that these figures made their vehicles **3.5x and 2x safer**, respectively, than vehicles driven by humans.
  - <https://newatlas.com/transport/waymo-driverless-cars-200-percent-safer-than-humans/>

# Waymo Safety 2024 - Current

- Waymo compiles ‘largest ever’ dataset of pedestrian and cyclist injuries – Nov 2024
  - “An accurate, in-depth understanding of the unique safety risks presented to these groups is critical in developing effective strategies to reduce injuries and fatalities,”  
<https://www.theverge.com/2024/11/11/24290338/waymo-vru-pedestrian-cyclist-injury-dataset>
- In 50 million miles, Waymo’s crash a less than human drivers – Apr 2025
  - ... Waymo’s driverless vehicles only got into 13 airbag crashes. **83% percent reduction in airbag deployments compared to humans.**  
<https://arstechnica.com/cars/2025/03/after-50-million-miles-waymos-crash-a-lot-less-than-human-drivers/>
- **Study in Traffic Injury Prediction Journal** – May 2025 – Peer Reviewed
  - ... demonstrated a **92% drop in pedestrian injuries, an 82% decline in cyclist injuries, and 82% decrease in motorcyclist injuries. ... Logged 96% fewer vehicle-to-vehicle crashes at intersections compared to human drivers.**  
<https://www.theverge.com/news/658952/waymo-injury-prevention-human-benchmark-study>  
<https://waymo.com/blog/2025/05/waymo-making-streets-safer-for-vru>  
<https://www.tandfonline.com/doi/full/10.1080/15389588.2025.2499887>

# Waymo Latest Safety Stats – Sept 2025

## Overall Crash Reduction



91% ↓

Fewer serious injury  
or worse crashes  
20 fewer



79% ↓

Fewer airbag  
deployment crashes  
125 fewer



80% ↓

Fewer injury-  
causing crashes  
304 fewer

## Crashes involving vulnerable road users



92% ↓

Fewer pedestrian  
crashes with injuries  
35 fewer



78% ↓

Fewer cyclist crashes  
with injuries  
22 fewer



89% ↓

Fewer motorcycle  
crashes with injuries  
16 fewer

Released by Waymo on X - Sept 2025

[https://x.com/ethanteicher/status/1967980602965246145?utm\\_source=substack&utm\\_medium=email](https://x.com/ethanteicher/status/1967980602965246145?utm_source=substack&utm_medium=email)

- Crash Involvement vs At Fault - Sept 2025

- Crash review from mid-February to mid-August 2025 that was serious enough to cause an injury or trigger an airbag. Of 45 crashes – ... **the large majority of these crashes were clearly not Waymo's fault,**

<https://www.understandingai.org/p/very-few-of-waymos-most-serious-crashes>



# Only type of crash to increase in frequency ...

Although there were no statistically significant results suggesting that the Waymo RO service had an elevated crash rate relative to the benchmark in any of the 11 crash modes examined, a supplemental analysis that split the F2R (Front to Rear) crash type into F2R Striking and F2R Struck rates found the Waymo vehicle had a lower F2R Striking rate for Airbag Deployment and Any-Injury-Reported at a statistically significant level and **a statistically significant increase in F2R Struck crashes at the Any-Injury-Reported outcome level in Phoenix.**

Kusano, K. D., Scanlon, J. M., Chen, Y. H., McMurry, T. L., Gode, T., & Victor, T. (2025). Comparison of Waymo Rider-Only crash rates by crash type to human benchmarks at 56.7 million miles. *Traffic Injury Prevention*, 26(sup1), S8–S20. <https://doi.org/10.1080/15389588.2025.2499887>

## Baidu ...

- **Safety data and statistics less prevalent –**
- In March 2025 – quote from Baidu’s CEO
- “We have proven that robotaxis are much safer than human drivers. As of today, **they are 10 times safer**” -- To date, Apollo Go’s fleet has accumulated more than 150 million autonomous kilometers with an outstanding safety record, underscoring its industry-leading standards. “Apollo Go abides by a 'safety first' principle, prioritizing the safety of all road users.”
  - <https://www.globenewswire.com/news-release/2025/03/19/3045727/0/en/Apollo-Go-Delivering-a-Smarter-User-Friendly-Autonomous-Ride-Hailing-Experience.html>

# Caveats

- Waymo (and other Robotaxis) do not operate on high-speed roadways (>45 mph) at this time
- Deployments are in the ‘Sun-Belt’ – does not reflect snow-ice and other winter related hazards
- Figures and statistics are largely self-reported by Waymo/Industry
- AVs are largely programmed to obey the speed limit
- Stats are ‘Crash Involvement’ not separated as ‘At-Fault’
  - Literature suggests Waymo’s largely ‘not at fault’ in crashes
  - If a self-driving vehicle were never at fault ....
    - **Crash rate (V2V on average) would reduce by 50%**

Safety events by outcome and location (through January 2025 - 56.7M RO miles)

Location	Any-Injury-Reported	Airbag Deployment	Suspected Serious Injury +
Phoenix, AZ	24	8	0
San Fran, CA	16	7	2
Los Angeles, CA	8	2	0
Austin, TX	0	1	0
All Locations	48	18	2

Source:

<https://www.tandfonline.com/doi/full/10.1080/15389588.2025.2499887>

# AV Scaling and Resulting Safety Impacts

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# How Quickly are Robo-taxis Scaling?

Waymo Rider-Only millions of miles by calendar year

Location	2019	2020	2021	2022	2023	2024	June	2X
							2025	2025
Phoenix, AZ	0.0205	0.0739	0.328	0.454	6.52	20.9	18.09	36.1872
San Fran, CA	0	0	0	0.07	2.46	13.5	13.858	27.716
Los Angeles, CA	0	0	0	0	0.14	5.03	11.292	22.584
Austin, TX	0	0	0	0	0	0.555	2.67	5.34
Totals	0.02	0.07	0.33	0.52	9.12	39.99	45.91	91.83

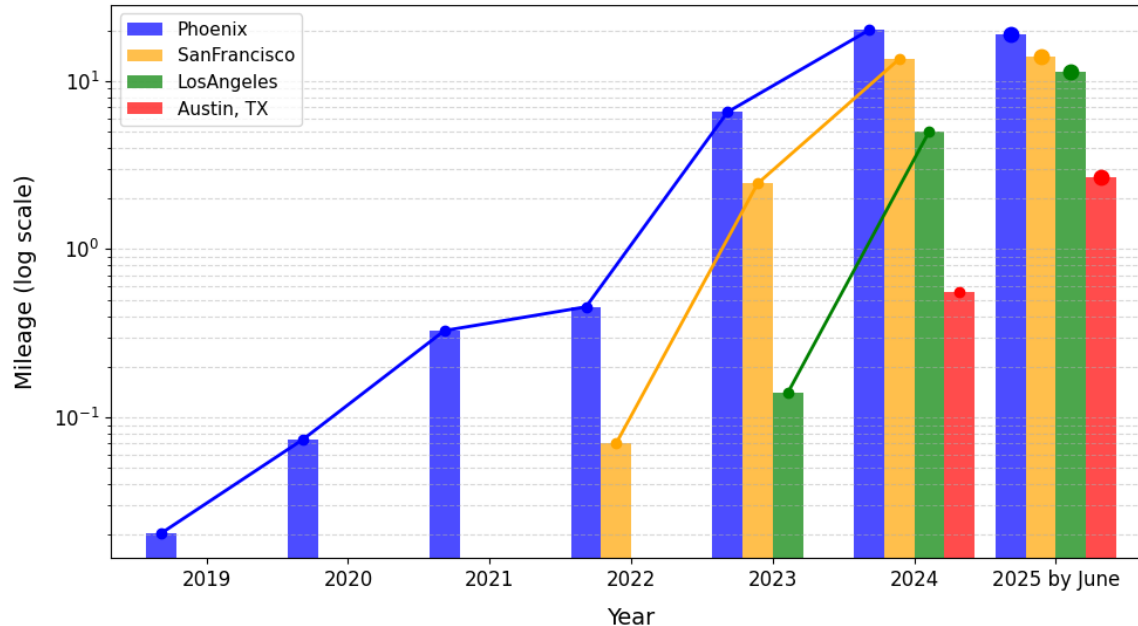
Sources:

<https://www.tandfonline.com/doi/full/10.1080/15389588.2025.2499887>

<https://waymo.com/safety/impact/>

Accessed 11/12/2025

Waymo Mileage Growth by City (2019–2025 by June)



# Waymo Growth Projection

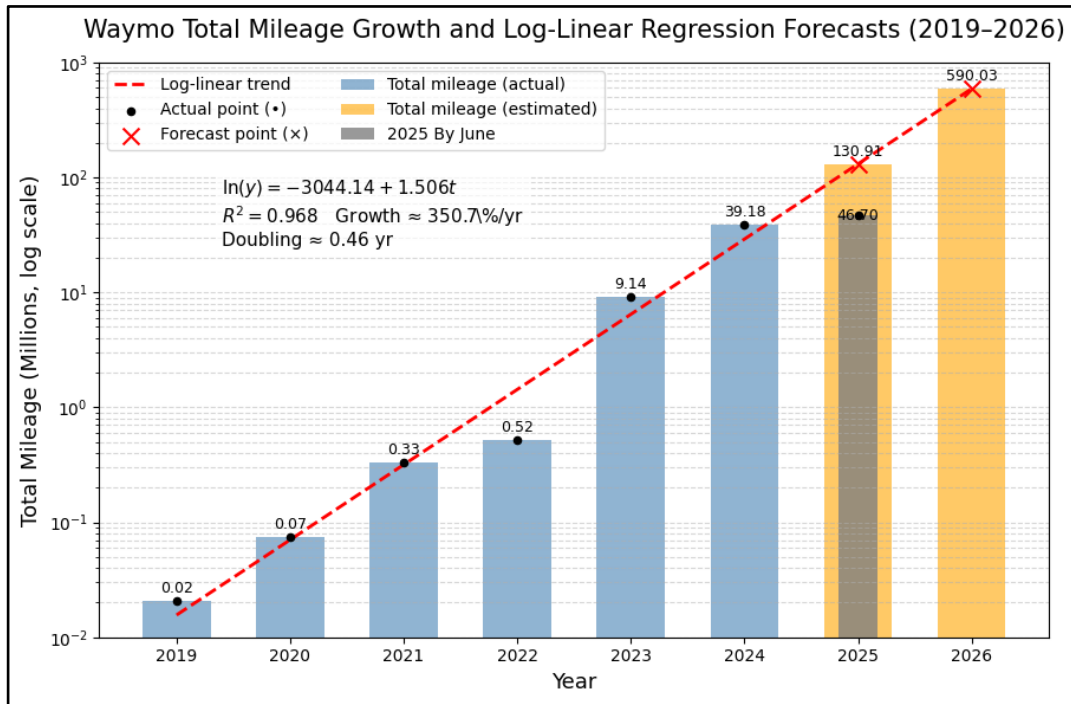
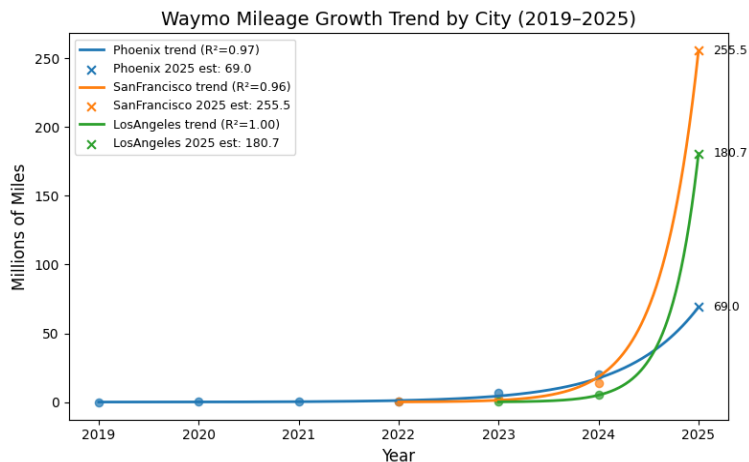
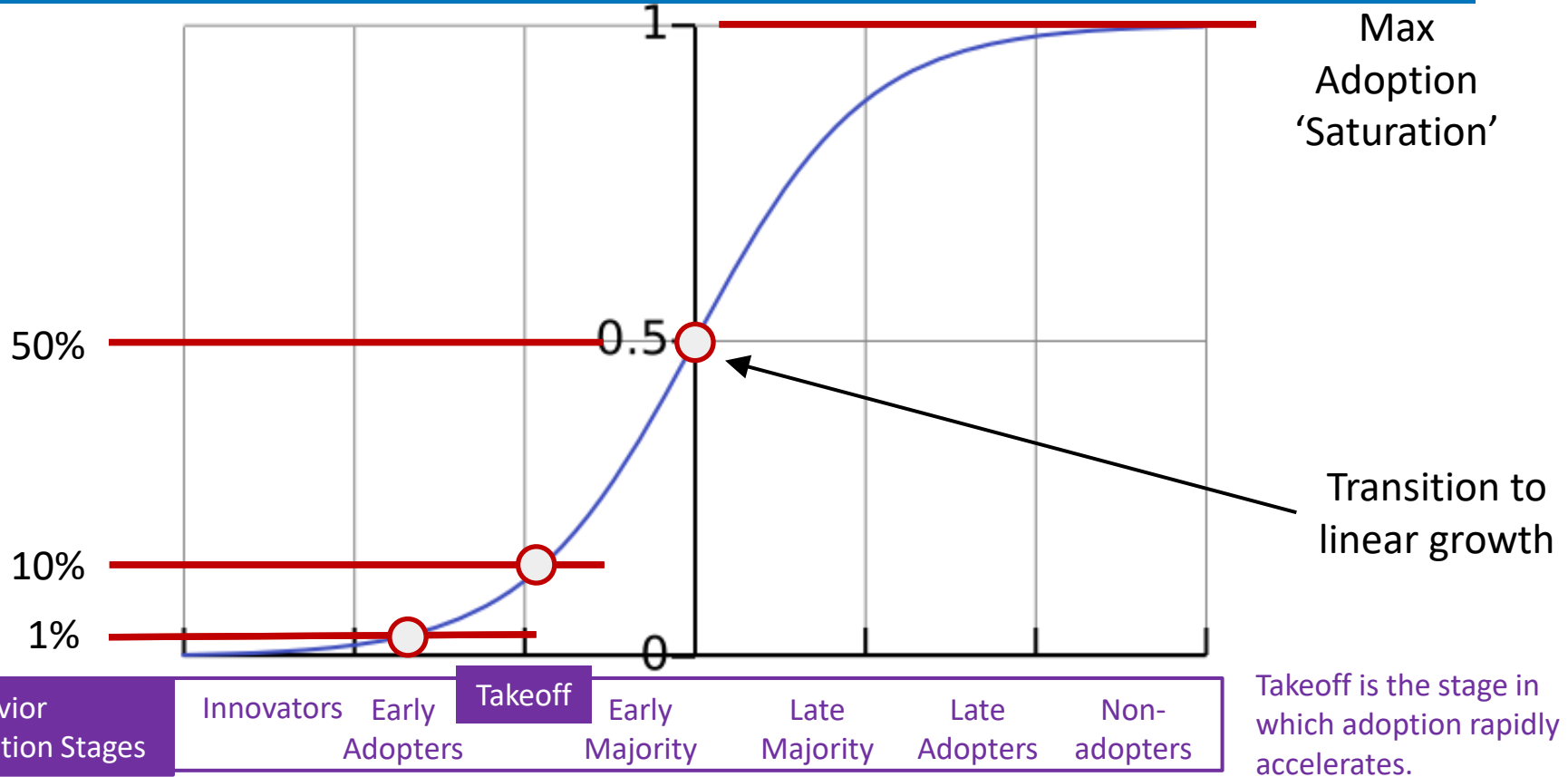


Table 1: Interpretation of log-linear regression growth rates by doubling period.

City	Growth Rate (%/yr)	Doubling Period (years)	Interpretation
Phoenix	$\sim 296$	$\sim 0.50$	Mileage doubles roughly every 6 months
San Francisco	$\sim 1289$	$\sim 0.26$	Mileage doubles roughly every 3 months
Los Angeles	$\sim 3493$	$\sim 0.19$	Mileage doubles roughly every 2.3 months
Overall	$\sim 350.7$	$\sim 0.46$	Mileage doubles roughly every 5.5 months

# Market Penetration Model



# SAFETY BASELINE

## 2023 Crash and Injury Rates --- NHTSA

### Fatality rate:

**1.26 deaths per 100 million VMT** (down from 1.34 in 2022)

### Injury rate:

**75 injuries per 100 million VMT** (unchanged from 2022)

### Property-damage-only crash rate:

**112 crashes per 100 million VMT**

### Overall Crash rate:

**189 crashes per 100 million VMT**

(based on 6.14 million police-reported crashes and **3,247 billion** miles driven)

- <https://www.nhtsa.gov/press-releases/nhtsa-estimates-39345-traffic-fatalities-2024>
- <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813705>

# Market Penetration – Compared to Total Trips

- Americans make 1.1 Billion vehicle trips per day in US (4 trips per person)
- Current Waymo weekly trips ~350K

Scenarios		
Doubling Period		
6 Month	12 Month	18 Month
Aggressive Growth - Current Market Scaling	Conservative Market Scaling	Moore's Law - IT industry

Year	6 Month Doubling		12 Month Doubling		18 Month Doubling	
	Trips (millions) per week	Trips (millions)/ Day	Trips (millions) per week	Trips (millions)/ Day	Trips (millions) per week	Trips (millions)/ Day
2025	0.25	0.04	0.25	0.04	0.25	0.04
2026	1.00	0.14	0.50	0.07	0.40	0.06
2027	4	0.57	1	0.14	0.63	0.09
2028	16	2.29	2	0.29	1.00	0.14
2029	64	9.14	4	0.57	1.59	0.23
2030	256	36.57	8	1.14	2.52	0.36
2031	1024	146.29	16	2.29	4.00	0.57
2032	4096	585.14	32	4.57	6.35	0.91
2033	16384	2340.57	64	9.14	10.08	1.44
2034	65536	9362.29	128	18.29	16.00	2.29
2035	262144	37449.14	256	36.57	25.40	3.63
2036	1048576	149796.57	512	73.14	40.32	5.76
2037			1024	146.29	64.01	9.14
2038			2048	292.57	101.61	14.52
2039			4096	585.14	161.29	23.04
2040			8192	1170.29	256.03	36.58
2041			16384	2340.57	406.43	58.06
2042			32768	4681.14	645.18	92.17
2043					1024.16	146.31
2044					1625.77	232.25
2045					2580.78	368.68
2046					4096.77	585.25
2047					6503.27	929.04
2048					10323.39	1474.77

Current trips per day in US (Millions)	1,100
1%	11
10%	110
50%	550

# Scaling Analysis

- Americans make 1.1 Billion vehicle trips per day in US (4 trips per person)
- Current Waymo weekly trips ~350K

Doubling Rate (months)	Year to X% of all trips		
	1%	10%	50%
6	2030	2031	2032
12	2034	2037	2039
18	2038	2043	2046

## CRASHES AVOIDED

2023 Baseline

3,247,000 Million Miles Traveled

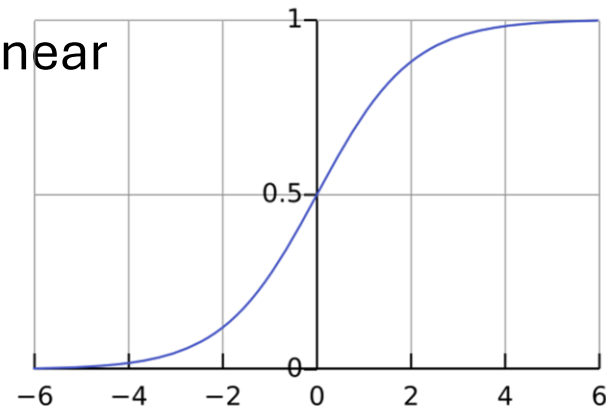
### Projections at various market penetration levels

		Crashes Avoided Yearly		
		1%	10%	50%
Fatalities	1.26 Per 100 million	<b>348</b>	<b>3,478</b>	<b>17,388</b>
Injury crashes	75 Per 100 million	20,700	206,996	1,034,981
PDO	112 Per 100 million	30,911	309,114	1,545,572
Overall	189 Per 100 million	52,163	521,631	2,608,153

\* Assumes 85% improvement in safety

# Caveats

- VMT is greater in taxi services due to deadheading
- Only Robo-Taxi business model at present, soon to add multi-party shuttle
- Growth can come from multiple market competitors and business models
- ‘Saturation Point’ – maximum adoption is unknown
- Mid-point is revealed when growth returns to linear



# Thank You

[www.nrel.gov](http://www.nrel.gov)

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