



# What Do We Mean By Safe?

- Rhetoric:
  - “Safety is our #1 priority”
  - “Robotaxis won’t make stupid driving mistakes”
- Acceptable net risk:
  - Positive Risk Balance
  - Risk is managed via insurance
- Requirements beyond net risk:
  - Avoid risk inequities
  - Avoid negligent driving behavior
  - Expectation of safety via engineering rigor



[Dall-e]

# Robotaxis: "Safety Is Our #1 Priority"



Because  
Safety is  
Urgent™

Autonomous Driving  
Technology Can Save  
Lives and Improve  
Mobility

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

cruise

Safety first,  
always

<https://getcruise.com/safety/>



Safety Drives Us

Motional is developing safe  
autonomous vehicles.

<https://motional.com/safety-philosophy>

ZOOX

A new bar for safety

Safety isn't just part of what we do. It's why we're here.

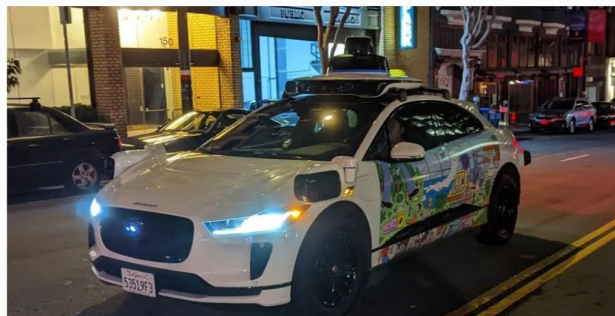
<https://zoox.com/safety/>



# Early 2023: Driverless 1 Million Miles

## Waymo And Cruise have Both Hit 1M Miles With No Driver, But Waymo Publishes Detailed Safety Data

Brad Templeton · Feb 28, 2023, 12:00pm EST



<https://bit.ly/46G07Gg>

Forbes

In January 2023, Waymo reached **1 million rider-only miles**



No reported injuries



Only 2 collisions that met the criteria for inclusion in NHTSA's CISS



18 minor contact events



55% of all events were the result of a human driver hitting a stationary Waymo vehicle



Human drivers violated road rules and/or behaved dangerously in every vehicle-to-vehicle event



10% of all events happened at night



No intersection-related events



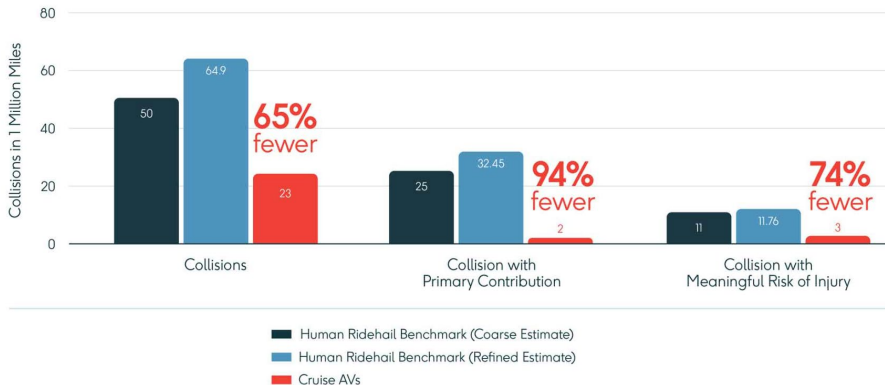
No events involving vulnerable road users

Waymo: Feb. 2023.  
<https://bit.ly/3N5F6xF>

Waymo passenger injury August 2, 2023:  
<https://bit.ly/47Z9pyb>

Both emphasize "at fault" crashes

## Updated Human Ridehail Benchmark vs Cruise AVs in 1M Collision Counts in San Francisco



Cruise: Sept. 2023.  
<https://bit.ly/47W1DVR>

# Summer of Robotaxi Hype: July 2023

## Humans are terrible drivers

42,795 Americans were killed in car crashes last year

You might be a good driver, but many of us aren't. People cause millions of accidents every year in the US. Cruise driverless cars are designed to save lives. Our cars were involved in 92% fewer collisions as the primary contributor\* They also never drive distracted, drowsy or drunk.

<https://twitter.com/kvogt/status/1679517290847694848>



Kyle Vogt  
@kvogt

Follow

We ran this full-page ad in @nytimes and several local papers today.

Human drivers aren't good enough. America can do better, and it is time we fully embrace AVs.



Last edited 11:45 AM · Jul 13, 2023 · 956K Views

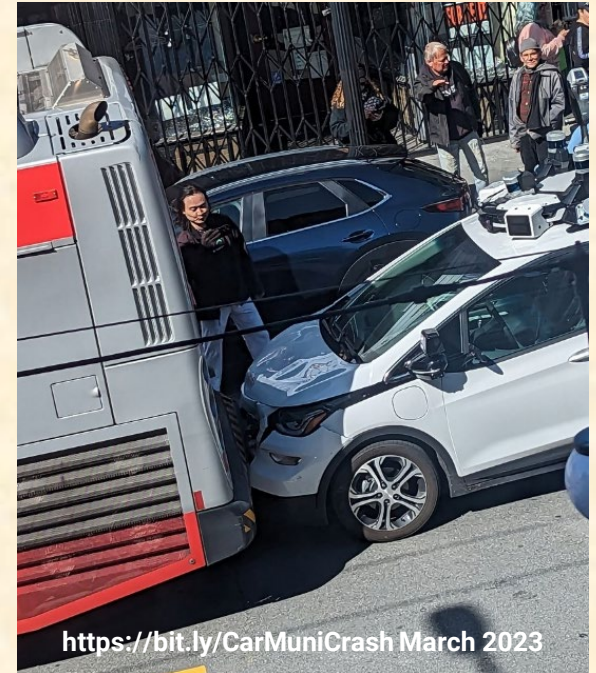


# Human Error → Robot Error

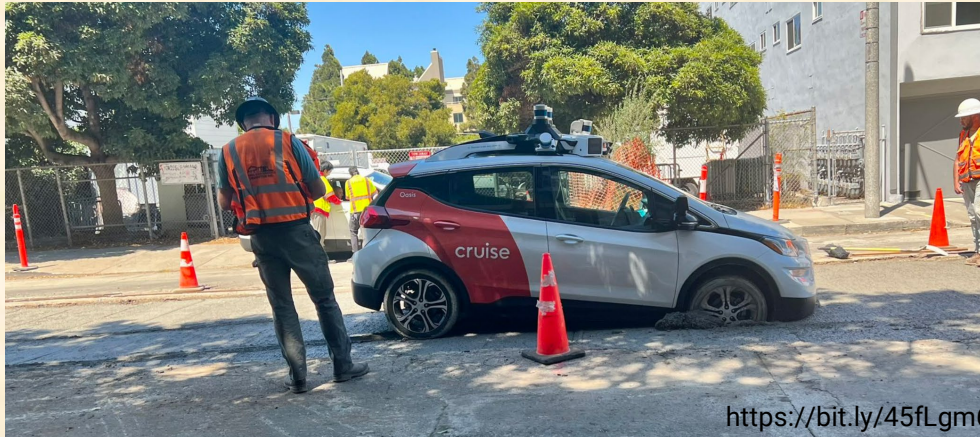


**Aug. 2023:**  
Injury crash with  
fire truck.  
CA DMV asked  
Cruise to  
cut active fleet  
size in half.

**March 2023**  
Are software defects  
the new drunk driving?



**August  
2023**

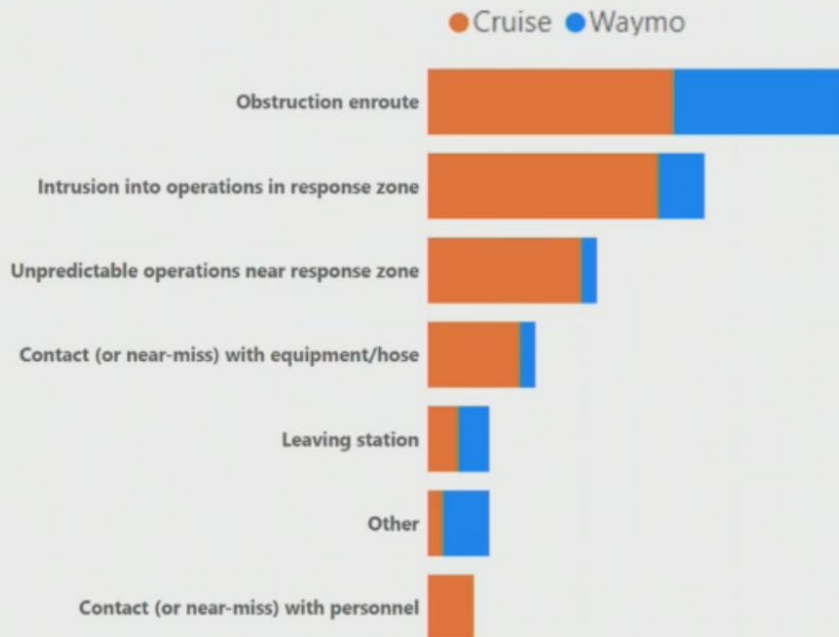


# City of San Francisco Concerns

## AV driving that interferes with emergency response



Emergency Response (SFFD) Impact Incidents by Type (Jan 1 – Sept 27, 2023)



# 2023 Winter of Discontent

## Los Angeles Times

General Motors recalls all Cruise robotaxis after one dragged a pedestrian



General Motors is updating the software of its Cruise robotaxi vehicles after one struck and dragged a pedestrian in San Francisco last month, according to documents posted by safety regulators Wednesday. (Paul Sancya / Associated Press)

- October 2, 2023 crash
  - Human-driven vehicle hits pedestrian
  - Cruise runs over person
  - Cruise robotaxi dragged person *after* initial emergency stop
  - Cruise cover-up (degree and intent is disputed)
  - Oct. 24, CA DMV suspends Cruise permits



# Are Robotaxis Safer?

- Nobody knows when Autonomous Vehicles (AVs) will be safer than human drivers
  - Press releases overstate company study results
  - Study limits: at-fault crashes; ride-hail driver baseline
- Fatality safety rates take 300+ Million miles
  - Currently about 5-8 million miles driverless/company
  - Current studies are predictions and extrapolations
  - Reduced fatality rates are still aspirational
- Declaring safety “victory” at this point is like claiming a medal ... after the first mile in a marathon



# But What Does Safe Even Mean?

- Is it statistical parity with (sometimes drunk) human drivers?

- In reality, it takes a lot more

- #1: Positive Risk Balance (PRB)

- #2: Avoiding risk transfer

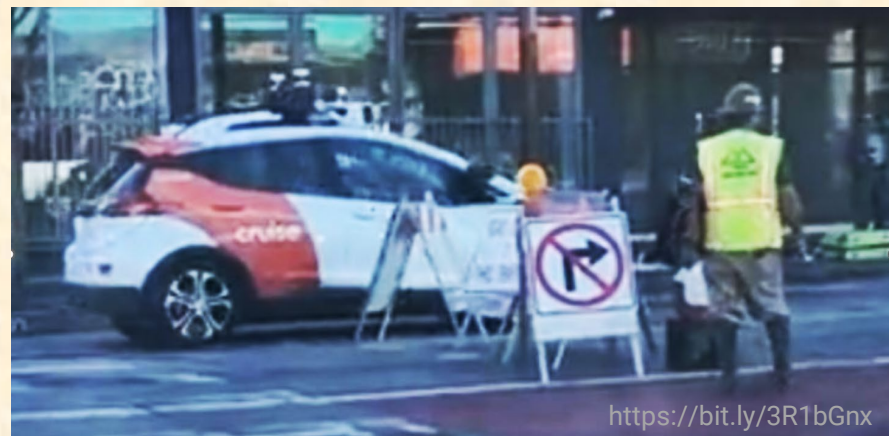
- #3: Avoiding negligent driving

- #4: Safety standards conformance

- #5: Specific risk mitigation / recalls

- #6: Ethical & equity concerns

- #7: Sustainable trust



August 2023

Nobody was hurt.

Does that make this safe?

# #1: PRB – Which, Where, Who?

- Positive Risk Balance: safer than a human driver
- But which human driver?
  - 28% Alcohol/driving under influence fatalities
  - 26% speed-related, 9% distracted, 2% drowsy
  - 60 year old driver is ~3.5x better than 16 y.o.
- Where/Who?
  - 3.4x fatality per VMT variation by US state
  - Victim demographic (e.g., pedestrians)
- Which vehicle?
  - New cars have active safety – BUT average car age ~12 years



[Dall-e]



# #2: Avoid Risk Transfer

- What if children at greater risk?
  - Or disabled pedestrians?
  - Or bicyclists? Etc.
- Caution – this particular article is controversial
  - Regardless, this is an important safety constraint
- Avoid increasing any group's risk
  - Extra effort decreasing risk to vulnerable groups



# #3: Avoid Negligent Driving

- **“Negligent” robotaxi driving involves:**
  - Establishing a duty of care to other road users
  - Was a loss event caused by breach of duty of care?
    - Would a human driver have been negligent?
  - Statistical safety arguments are irrelevant here
    - “Safe” drivers don’t get free passes to run red lights
- **October 2 Cruise pedestrian mishap:**
  - Robotaxi arguably should have increased caution
    - Accelerated toward pedestrian in crosswalk
    - Other car hitting pedestrian was readily predictable
  - Robotaxi should not have moved with pedestrian under vehicle



# #4: Standards Set Expectation of Safety

<b>SYSTEM SAFETY</b>	ANSI/UL 4600		<b>Safety Beyond Dynamic Driving</b>	<b>HIGHLY AUTOMATED VEHICLE SAFETY CASE</b> ANSI/UL 4600
<b>DYNAMIC DRIVING FUNCTION</b>	ISO 21448	SaFAD/ISO TR 4804	<b>Environment &amp; Edge Cases</b>	
<b>FUNCTIONAL SAFETY</b>	ISO 26262		<b>Equipment Faults</b>	
<b>CYBER-SECURITY</b>	SAE J3061	SAE 21434	<b>Computer Security</b>	
<b>VEHICLE SAFETY</b>	FMVSS	NCAP	<b>Basic Vehicle Functions</b>	

**REQUIRED**



# #5: Fine-Grain Risk & Regulators

- Want to avoid regulatory recalls
  - “Undue Risk” in the small – specific issues
  - Informed by test-centric standards
- Recalls are specific, not net risk
  - Rolling through stop signs
  - Phantom braking
  - Malfunctioning display console
  - Software safety & net risk are mostly beyond regulatory scope
- Regulators struggling to predict safety outcomes in advance
  - 2020 Proposal to require industry safety standards is inactive



Part 573 Safety Recall Report

# #6: Ethical & Equity Concerns

- Ride Hail made promises ... with disappointing results
  - Why will this turn out any differently?
- Equity concerns:
  - Labor issues (e.g., displaced ride-hail/taxi drivers)
  - Will disabled community access really happen?
  - Cheap taxis undermine *safer* public transit
  - Municipal preemption / no local control of issues
- Ethical & related concerns
  - Testing risk imposed upon vulnerable people
  - Long-term aspirational safety incurs real short-term risk
  - No required independent safety technical oversight



[Dall-e]

# #7: Sustainable Trust

- Trust-degrading rhetoric:
  - “Robotaxis won’t make stupid driving mistakes”
  - Relentless blame of human drivers
- Trust-degrading actions:
  - Lobbying for municipal preemption
  - Redacting & withholding information
- Toward increasing trust:
  - Talking with (not “at”) stakeholders
  - More transparency on incidents & corrective actions
  - Accepting proportional responsibility for loss events
  - Stating release criteria in advance & tracking metrics



Ford VSSA 2021 <https://bit.ly/3njionT>

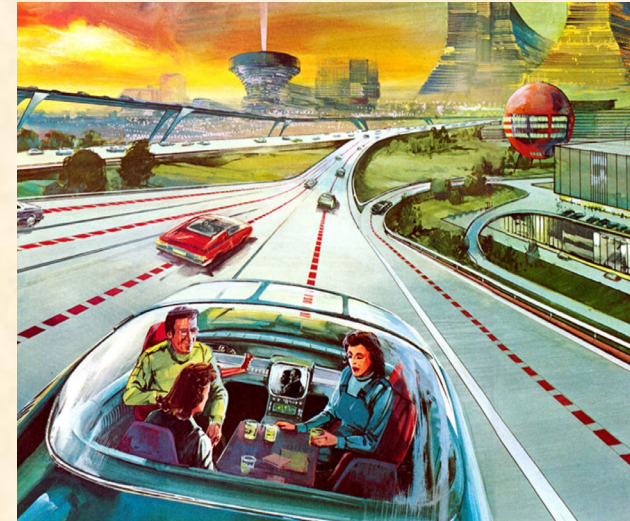


# Lessons for AV Industry Success

1. Net “better than human driver” only a starting point
2. Avoid risk transfer to vulnerable populations
3. Avoid negligent driving behavior
4. Conform to industry safety standards
5. Fine-grain regulatory control of risks
6. Address ethical & equity concerns
7. Build sustainable trust

More talks here:

<https://users.ece.cmu.edu/~koopman/>



[General Motors]