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Robotaxi Safety

How to Bring the Human Back Into the Loop

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What You Should Know

- Robotaxis were initially marketed as a transport revolution, especially for vulnerable populations e.g. those with visual and motor impairments.
- Robotaxi companies chose not to follow this “vulnerable-human-outward” design path. Instead they chose to follow the playbook from the rollout of Uber: Flood cities with minimally viable product, and outmanoeuvre regulators.
- The use of minimally-regulated public-road beta testing can accelerate deployment timelines. But as with any product-centered development process, it also ignores human experience and requires large amounts of money. And in the case of robotaxis, it has led to deaths and injuries.
- If the status quo of ignoring traveller UX continues, robotaxi deployments/mileage collection will be seen as victories, but with costs of longer acceptance timelines and wider valleys of consumer pessimism.





1. Robotaxis' Optimistic History

Introduction: Robotaxis' Optimistic History

- In 2010 Google revealed its self-driving car concept called “Project Chauffeur” (an early precursor to what would become the robotaxi company now known as Waymo).
- Though its origins date from DARPA competitions in the mid-2000s, Google’s big 2010 reveal centered around [a short video following a day-in-the-life of Steve Mahan \(who is vision-impaired\) running errands with help from Google’s self-driving Toyota Prius.](#)
- The decade that followed was filled with new players developing personal automated transport, in the US and worldwide, using a variety of form factors (automated passenger vehicles, purpose-built self-driving minibuses, self-driving golf carts, and so forth).
- OEMs jumped into the fray too, either on their own or with partners in the AV space, partly based out of fear that shared robotaxis could render personal car purchases and ownership obsolete.



Introduction: Robotaxis' Optimistic History

Many other companies flooded the space and began their own mapping and data collection efforts, including but not limited to the following:

- Cruise
- Yandex
- Uber
- Lyft
- May Mobility
- Zoox
- Comma.ai
- Argo AI
- Tesla
- Baidu
- Pony.ai
- WeRide

As development progressed, the consensus among these companies was that the main challenges to be solved were mapping roads and collecting natural on-road scenarios for its algorithm to learn from. Despite these daunting challenges, expectations were high for what these efforts could mean for the future of transport.



Introduction: Robotaxis' Optimistic History

- As mapping and scenario collection were perceived to be the biggest/only challenges preventing wider deployment and adoption, **the status quo for development became public road beta testing**, with assistance from remote operators.
- There are various reasons this became (and remains) the status quo:
 - Developers want real world data.
 - Regulators (especially in China and the US) want to be seen as friendly to business and new tech.
 - Regulators (especially in China and the US) cannot keep up with technology.
 - In the 2020s, lobbyists representing the AV companies ensure that US regulators stay friendly to the efforts.
 - Regulators in Europe have been able to stay out in front of technological advances.
 - Regulators in the US and China have left success (and safety) up to the “free market.”



Introduction: Robotaxis' Optimistic History

- In the US, AV companies and their lobbyists developed voluntary reporting criteria and regulatory frameworks (including, crucially, identification of which crashes to report, and determining which metrics to report).
 - In theory, this could allow innovation to continue unabated.
 - In practice, it meant oversight (including assurance of safety practices) became practically nonexistent.
 - Guidelines such as those developed by [ISO](#) and [UL](#) remain voluntary.
- **Notably missing from this conversation: The objective “boots-on-ground” safety and experience of humans (especially vulnerable populations) traveling in/around robotaxis.**





2. Problems and Key Incidents

Problems and Key Incidents

- As public road beta testing expanded through the 2010s into the 2020s, oversight remained minimal-to-nonexistent, especially in the US and China.
 - The end-user experience and safety (of riders and road occupants) was seen as tangential to robotaxi success.
- This “light-handed” regulation and disinterest in rigorous objective safety practices led to many inevitable on-road incidents involving several AV developers, including but not limited to the following:
 - Tesla
 - Waymo
 - Xiaomi
 - Uber ATG
 - Cruise
 - Zoox
 - Baidu
 - Pony.AI



Problems and Key Incidents: Tesla

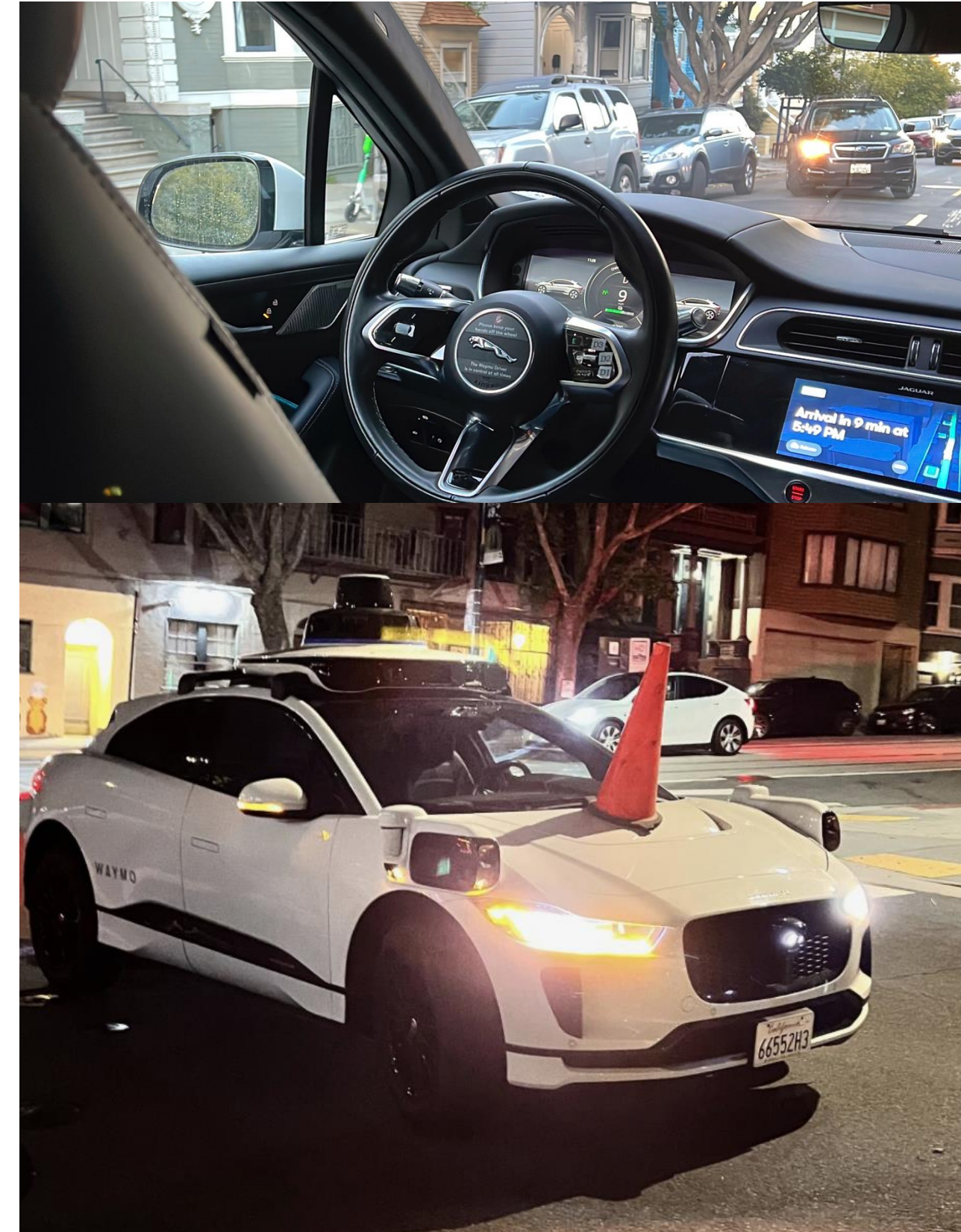
- Tesla has arguably garnered the widest awareness for its efforts in automated transport, with the introduction of its Autopilot semi-automated driving feature, and eventual launch of its maligned “Robotaxi” branded service in Austin.
- [Tesla’s stated intent was to eventually morph Autopilot \(and related features such as Smart Summon\) into a privately-owned robotaxi](#), which Tesla owners could potentially use as supplemental income via a ridesharing service.
- Unfortunately the nature of Autopilot’s deployment as a “beta” software update turned Tesla owners into untrained test drivers, and other road occupants into unwitting guinea pigs.
- To date, Autopilot has been cited as a contributing factor in 460 crashes and 14 deaths in the US alone.
 - After dodging several legal claims, Tesla was recently found liable in a fatal crash involving Autopilot. A jury ordered Tesla to pay upwards of \$250 million, though [Tesla is presently appealing this verdict](#).



Sources: MotorTrend/AP

Problems and Key Incidents: Waymo

- Waymo was the first service to go “driverless” in Arizona in 2017. Waymo then commercialized the service in 2022, and has since expanded into several other US cities including San Francisco and Los Angeles.
- As testing and commercial service expanded, “Waymos” were naturally associated with several adverse incidents:
 - In 2021, residents in a San Francisco neighborhood complained about [Waymos continually routing down a dead-end street](#).
 - In 2023, a Waymo [struck and killed a dog that ran into the street](#).
 - In 2024, residents in a San Francisco neighborhood complained about noise from Waymos [honking at each other in a parking lot at all hours](#).
 - At various times from 2023 through 2025, protestors in [San Francisco](#) and [Los Angeles](#) vandalized or otherwise disabled Waymo cars.
 - In 2024, Waymo [recalled software in its entire fleet](#) after a Waymo struck a utility pole. A subsequent investigation found that [Waymos could struggle in certain on-road scenarios without a hard road edge](#).
 - In 2024 and 2025, there were multiple reports of [passengers becoming trapped in Waymos](#).
- Through 2025 there have been multiple incidences of Waymos [caught blocking the paths of emergency response vehicles](#).



Problems and Key Incidents: Xiaomi Navigation on Autopilot

- Following in the footsteps of Tesla, several automakers in China developed their own automated driving features / robotaxi services. And just like Tesla Autopilot, these features have been associated with several fatal crashes in China.
- One of the most notable crashes involved “Navigation on Autopilot” from Xiaomi. In March 2025, a Xiaomi SU7 driving with NoA active [crashed into a construction zone in Tongling, killing 3 people](#).
- In the wake of this crash and others, China’s implemented significant restrictions on ADAS features, including a ban on public road beta testing.
- China’s Ministry of Science and Technology later published [guidelines for ethical development and deployment of automated driving features](#).



Problems and Key Incidents: Uber ATG

- Uber's fear of being innovated out of the transportation business led to a big push in automated taxi development. This led to the formation of Uber ATG, which operated public-road beta testing primarily in the US state of Arizona.
- In 2018, an Uber ATG vehicle struck a bicyclist.
 - [The bicyclist \(Elaine Herzberg\) was killed in the crash.](#)
 - [The test driver in the Uber ATG vehicle was charged with negligent homicide](#), because the driver was allegedly distracted by their mobile device at the time of the crash.
 - Subsequent investigations found that [a jaywalking pedestrian was not considered as a possible on-road scenario](#) for Uber ATG's automated vehicles.
- Subsequent lawsuits and regulatory pressure led Uber ATG to fold, though [Uber has shown interest in returning to AV development.](#)



Source: NTSB

Problems and Key Incidents: Cruise

- Cruise (backed by GM among others) offered the first commercialized robotaxi service open to the public in San Francisco in 2022.
- While residents, legislators, and emergency responders were skeptical after several incidents involving [blocked fire lanes](#), early adopters and paid spokespeople ([including actor Terry Crews](#)) sang its praises.
 - Cruise made several marketing-oriented attempts to “wash” their reputation, including using its fleet and safety drivers to deliver food during the pandemic ([and circumvent local “stay-at-home” orders](#)).
- This tension peaked in October 2023 after an incident in which a pedestrian was dragged underneath a Cruise vehicle, and [executives conspired to hide details of the incident](#).
 - A post-crash investigation found many other issues, such as [Cruise AVs failing to recognize children on the road](#).
- GM finally shut down Cruise in late 2024.



Problems and Key Incidents: Zoox

- Zoox was founded in 2014, and unlike its contemporaries (most of whom retrofit existing vehicles), Zoox sought to develop a purpose-built vehicle specifically for automated transport.
- Amazon purchased Zoox in 2020, and since then has rapidly expanded on-road testing, [with intent to launch a robotaxi service in several US cities](#).
- As testing expanded through 2025, Zoox inevitably started to experience on-road incidents with other road occupants:
 - In April 2025, a Zoox robotaxi was involved in [a crash with a passenger car in Las Vegas](#). A subsequent investigation found that Zoox cars traveling at high speeds (40mph) are likely to collide with slow-moving vehicles approaching from side streets.
 - In May 2025, [an e-scooter collided with a Zoox robotaxi in San Francisco](#). After the scooter occupant fell to the ground, the robotaxi moved several feet before stopping. Miraculously there appear to have been no serious injuries.



Source: User Driven Strategies



Problems and Key Incidents



Source: Car News China

Pony.ai

- Pony.ai was one of the first to put automated cars on public roads in the US and China, and still operates paid robotaxi services in China. Pony.ai has also been under constant watch by regulators after multiple on-road incidents.
- In 2021, a Pony.ai test AV [crashed into a median](#) after a software malfunction. A subsequent investigation led regulators to [revoke Pony's test permit](#).
- In 2025, [a Pony.ai test AV caught fire in the middle of a busy motorway in Beijing](#).



Source: Shanghai Daily

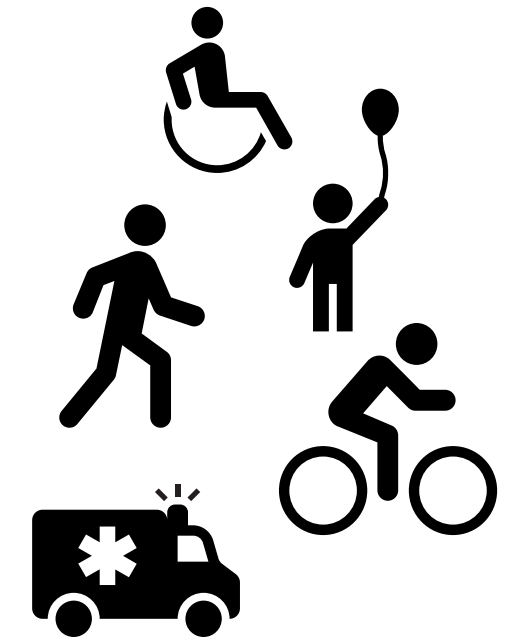
Baidu Apollo Go

- Baidu began research on driverless vehicles in 2013, eventually leading to the launch of its Apolong project (or "Apollo Go") in 2017. The vehicles developed are minibuses without steering wheels or pedals, that can be hailed in certain Chinese cities using the Baidu Maps app.
- 2025 was an active year for the project:
 - In August [an Apollo Go robotaxi drove into a construction pit while carrying a passenger in Chongqing](#).
 - In September [Baidu was granted Dubai's first-ever driverless testing permit](#).



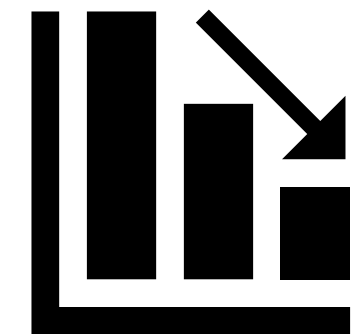
Problems and Key Incidents: What Have We Learned?

- **Vulnerable road occupants and their behavior continue to be ignored by robotaxi developers.**
 - Common behaviors of road occupants such as bicyclists and pedestrians are a surprising blind spot for robotaxis, and have already led to multiple injuries and at least one death.
 - Robotaxi "rules" for bike lanes, taxi stands, and fire lanes are treated as "post-deployment updates" rather than safety-critical design standards.
 - Accessibility for disabled riders is largely ignored, in favor of faster, wider deployments.
- **Minimally-regulated public road beta testing is a huge part of the problem.**
 - When beta tests are conducted in public, and the product involved can hurt or kill people, all occupants of that space become beta testers whether they consent or not.
 - China's willingness to shut down public road testing (after several crashes) demonstrates an ethical standard that is currently absent in the US.



Problems and Key Incidents: What Have We Learned?

- In the US, lobbyists and lawyers are now in full control of the conversation around robotaxi usefulness and safety.
 - All deployments in the US are serving the companies involved, not the communities they purport to serve. [Waymo's "open database" of cherry-picked safety data is a prime example.](#)
- Despite breathless marketing, consumer sentiment remains mixed-to-low.
 - Independent and sponsored surveys (e.g. [JD Power](#), [EVIR](#)) repeatedly show that any interest in automated driving systems and robotaxis is confined to young, early-adopting segments who are less likely to be skeptical of the technology.
 - Rather than designing and refining a service that is objectively safe and useful for all communities, companies are relying on mere presence/exposure and regulatory capture to advance robotaxis.





3. How & Why Did We Get Here?

The Reasons Robotaxi Safety Became an Afterthought

How Did Robotaxi Safety Become Ignored?

The Functional (Surface-Level) Reasons

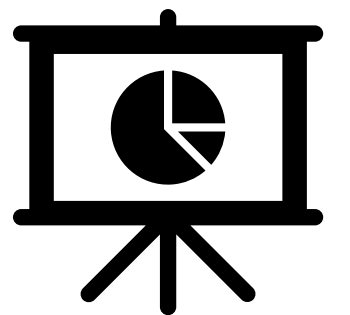
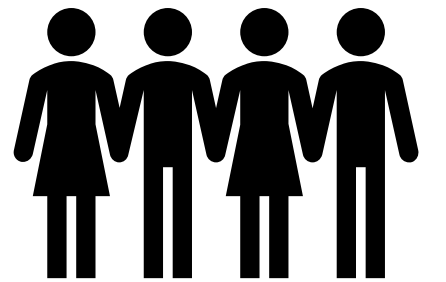
- **Limited oversight means safety assurance is owned by corporate legal teams and lobbyists, rather than independent regulators**
 - AV companies largely helped governments write laws and guidelines that govern their own operation. This has led to several downstream consequences affecting all road users.
 - Using California USA deployments as an example:
 - The permitting authority (CPUC) largely remained inactive in face of repeated incidents involving first responders.
 - By law, AVs cannot be cited for moving violations.
- **Misleading marketing language**
 - A graduate student in Germany coined the term “[Autonowashing](#)” to describe companies’ practice of overstating their automated driving capabilities.



Why Did Robotaxi Safety Become Ignored?

The Actual (Underlying) Reasons

- **The perception of humans as obstacles to be overcome, rather than partners in success**
 - Humans are part of the ecosystem in which robotaxis operate. And yet, when adverse events / robotaxi failures happen, common practice for AV public relation teams is to blame the behavior of human drivers, pedestrians, bicyclists, etc.
 - If we aren't designing for human transportation, who are we designing for?
- **Lack of objective data without confounds**
 - Zoox, Waymo, and others have argued their services are “significantly better than a human driver.” But to date, there has been very little independent data that has corroborated that, without significant confounds (reporting issues, equivalence of mileage, etc.).
 - Waymo is an egregious abuser of subjective data. Their [measurement/readiness rubric](#) is based on “unreasonable risk,” which by all accounts has never been formally defined, or (even worse) could be proprietary to Waymo.



Why Did Robotaxi Safety Become Ignored?

The Actual (Underlying) Reasons

- **Stakeholders use the wrong data to measure safety**
 - “Mileage collected” became the common language by which stakeholders (including regulators) measure progress. But this is a bad metric that does not account for context of the testing environments, or the utility of the AV itself.
- **Executives/stakeholders with minimal experience building safety-critical features**
 - Many (if not all) of the incidents associated with public-road deployments could have been avoided with robust safety assurance before deployment, and a thorough reporting system for incidents once deployed.
 - Each of the above would likely be recommended/demanded by a seasoned human factors or UX team.
 - But because most of the principal architects in robotaxis thus far have come from software development in fields that are not safety-critical (e.g. consumer goods, entertainment), stakeholders are largely unaware of existing automotive/transport safety research, or best practices/processes in the field.





4. Now What?

Recommendations for Human-Outward Robotaxi Development

Now What?

If stakeholders continue their present course, consumer sentiment for robotaxis will stagnate/decline, trust will erode (even among friendly regulators), and development of safe and useful robotaxis will be set back decades.

Here are a few ways robotaxi stakeholders can pivot from product-inward to human-outward development...

- Improvements for test drivers
 - **Cockpit HMI needs specific government regulations associated with it:** Cockpit HMI for robotaxi test drivers is an afterthought- often using jerry-rigged solutions such as mounted tablets and disabled collision alerts. It also contributed to the first documented death involving a robotaxi.
 - Automakers have human-centered design requirements for normal driver cockpits. Robotaxi test driver cockpits should be no different.





Now What?

- Improvements for other road occupants
 - **Further restrict or ban public road beta testing:** After 15 years' worth of effort, minimally-regulated public road testing has proven only somewhat effective in developing a useful transport system. What's worse, the practice has now been associated with several dozen deaths worldwide. China has now severely restricted the practice. The US and other Western countries should follow suit.
 - **External HMI e.g. ground projection should be a requirement:** As outlined in a prior UDS report, visual and audio communication from robotaxis to pedestrians and other vehicles is likely necessary, particularly in areas like the UK and parts of Europe where driving is more collaborative (e.g. giving way or turn taking on narrow streets).



Now What?

- Improvements for other road occupants
 - **Create one single set of government-mandated UX standards for first responders:** At present, each robotaxi developer crafts their own best practices and training materials in case of on-road emergencies such as runaway cars or vehicle fires. With tens of thousands of first responder agencies to train in the US alone, this practice is already unsustainable.



MORE INFORMATION



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For more details about the data described herein, or for User Driven Strategies clients with inquiry privilege who would like additional analyses for this data set, please contact the author of this report.

Derek Viita is a renowned expert in automotive and mobility-service UX, with 2 decades of specialized expertise improving the usability and efficacy of UI for human transport. Beyond cars, Derek's work spans many other segments including mobile devices, virtual telecommunications, mobile payment, physical workstations, and other B2B and B2C contexts.

Derek is a sought-after facilitator, speaker, and behavioral analyst, having produced live research, conference presentations, and workshops on 3 continents. He is also a named author on over a dozen technical and peer-reviewed reports. His work on navigation system usability was honored by the Human Factors and Ergonomics Society.

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