

# Aurora On Target For Very Limited Launch of Autonomous Trucks

Companies: 9984.T, AMZN, AUR, CON.DE, DTG.DE, F, GM, GOOG/GOOGL, HSAI, INTC, LAZR, MBG.DE, MBLV, PCAR, TSLA, TSP, UBER, VOLV-A.ST, VOW.DE

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## Research Question:

**Will Aurora hit its target of having a fleet of driverless trucks in commercial operation by the end of next year?**

## Summary of Findings

- [Aurora Innovation Inc.](#) (AUR) is likely to meet its goal of fully autonomous trucks in commercial operation by the end of 2024, but only if the scope is very narrowly defined. Navigating the maze of state regulations remains a significant challenge to wider deployment, meaning initial routes are likely to be simple, intrastate, hub-to-hub segments, according to 14 interviews with autonomous-vehicle technology executives, trucking companies, researchers, consultants, and other industry specialists.
- Sources said it will be at least two years and perhaps as long as five before rules are in place to allow autonomous trucks to be used for the types of long-haul routes crossing multiple state lines that will bring the biggest benefits to the industry.
- In the longer term, sources said Aurora—led by a CEO described as a visionary—is well-positioned to succeed if it can bring down the cost of its driver-as-a-service software and hardware kit.
- To that end, sources said [Aurora's production deal with Continental AG](#) (CON.DE) is a significant one, as it will help reduce the cost of most of Aurora's sensor suite, outside of its lidar. While some sources believe Aurora's proprietary lidar is better than that of a chief competitor, [Luminar Technologies Inc.](#) (LAZR), it is also significantly more expensive, making it unclear whether Aurora is taking the right route in pursuing its own solution.
- Despite broad optimism that autonomous trucks will be safer and more efficient than traditional trucks, several sources expressed skepticism about the ultimate profitability of driverless trucking, especially for carriers and logistics providers. While removing drivers can provide labor cost savings, improve fuel efficiency, increase truck utilization rates, and speed deliveries, the trucks themselves may be prohibitively expensive to buy and maintain and will require ongoing services like remote monitoring and HD mapping software.
- Further, issues around insurance and liability are mostly unresolved, which remains a concern for potential Aurora customers.
- Sources said Alphabet Inc.'s (GOOG/GOOGL) [recent decision to pause development](#) in its Waymo self-driving-trucking division gets a formidable competitor out of Aurora's way but raises the possibility that Google sees an easier path to profits in robotaxis than in trucking.
- Sources said [Kodiak Robotics](#) is similarly well-positioned to Aurora. Two sources said they were unimpressed with [Gatik's](#) approach but were split in their assessments of the threat posed by [Stack AV](#) with its [\\$1 billion in backing](#) from SoftBank Group Corp. (9984.T).

## Key Quotes

"It's certainly possible for Aurora to [hit its 2024 target] on a limited [basis], going from point A to point B, ... but it certainly won't be profitable."

"There will be a considerable amount of time where there is still a person needed in the truck, if not maybe forever. The reason for that is flat tires and tollbooths and other incidents where you need a human to make a decision."

"There is money in [autonomous trucking]. ... But if you ask me when this might be profitable and how much [money can be made], I can't answer that. I think it's a real question whether it will ever be profitable."

"There are additional costs that arise from these systems. ... You've got to monitor these systems, and they have to be maintained in different ways than normal trucks are. ... All these things make it hugely challenging [for Aurora]. ... How do you convince Frito-Lay or Coke or whoever that there's a path to profitability here?"

"What [the carriers] will find out is that these trucks need to be supervised, monitored, they need to have a control center. ... You have to make HD maps of every street before you drive them, and they will have to buy this from Aurora as well."

"[Aurora's lidar] is just too expensive. ... You have an overbuilt, overpriced sensor that we're not sure how you ever make money doing something like that, especially when you look at what's happening in China, where you can order something that's better performance for a tenth of the cost."

"[Potential Aurora customers] have some fears about autonomous driving. We see millions of Tesla drivers driving without a problem; but if there's one accident, it's all over the news."

# Aurora Innovations Inc.

	Aurora's 2024 Target	Aurora's Longer-Term Outlook	Overall Outlook for Autonomous Trucking
Autonomous-Vehicle Technology Executives	↑	→	→
Industry Specialists	→	↑	↑
Trucking and Logistics Companies	→	→	→

## Background

Aurora Innovations, a developer of self-driving vehicle technology, is moving closer to its first major product launch. Company executives have said the [Aurora Horizon](#) driverless truck system will be in commercial operation by the end of 2024. Aurora, which went public in November 2021, has an all-star management team that includes the former head of Alphabet Inc.'s self-driving-car team and the former leader of Tesla Inc.'s (TSLA) Autopilot.

The timing of Aurora Horizon's launch is key, as the company is not currently recording any revenue. Aurora [raised about \\$850 million](#) in a financing round in July, giving it about \$1.6 billion in cash and short-term investments, which executives have said is enough to carry the company through the first half of 2025. Aurora burned through \$217 million in Q2, including \$150 million in research and development costs. Though the launch timeline has been delayed once before, Aurora CEO Chris Urmson said in August, "We continue to believe we're [on track to launch a commercial product](#) on the road with no driver in it next year."

Aurora's driverless trucks are being tested in two shipping lanes in Texas. To date, its trucks—under the supervision of a human operator—have [logged 630,000 commercial miles](#) for Aurora's pilot customers, including FedEx Corp. (FDX), Werner Enterprises Inc. (WERN), Schneider National Inc. (SNDR), and Uber Technologies Inc.'s (UBER) Uber Freight. The company claims it has not had a single circumstance in 2023 where a vehicle supervisor had to make a "safety critical" intervention and has had "nearly 100%" on-time deliveries.

Aurora has its own fleet of about 20 trucks that it hopes to have booked at launch but longer term hopes to sell its "[driver as a service](#)" system as a combination hardware and software kit for both trucks and cars. To that end, Aurora has signed partnerships with AB Volvo (VOLV-A.ST) and PACCAR Inc. (PCAR), manufacturers that represent about 50% of the Class 8 trucks sold in the United States. In April, Aurora announced a partnership with Continental to make and service its self-driving hardware kit.

Aurora competes in an industry that has been plagued by outsized expectations and disappointing results. In July, Google said it was pausing development of Waymo Via, its autonomous-trucking technology, to focus on driverless taxis. Uber Freight shuttered its own self-driving-truck division back in 2018. Still, a number of competitors continue working on key pieces of driverless technology, including Kodiak Robotics, which announced a deal in June to sell [800 autonomous driving systems](#) to startup freight broker Loadsmith by the end of 2025. SoftBank, meanwhile, is reportedly putting \$1 billion behind Stack AV, a startup focused on long-haul trucking and led by the founders of the defunct Argo AI, the former self-driving unit of Ford Motor Co. (F) and Volkswagen AG (VOW.DE). Stack reportedly has a test fleet of trucks on the road. In northwest Arkansas, Gatik has been testing driverless trucks on short-haul routes for Walmart Inc. (WMT) since 2021 and has recently [started doing the same](#) for Tyson Foods Inc. (TSN).

A key competitive arena in the race for self-driving vehicles revolves around the development of lidar, a remote sensing system using lasers to detect objects. Aurora is building its own lidar system, which it claims will give the company a critical safety differentiation. Luminar, which has a competing lidar system, said in June that it would be the [exclusive provider of mid- to long-range lidar](#) for [Plus' assisted-driving system](#) for commercial vehicles.

# Aurora Innovations Inc.

## Current Research

Blueshift Research assessed Aurora's ability to hit its end-of-year 2024 target as well as issues related to its longer-term outlook. We employed our pattern mining approach to establish three independent silos, comprising 14 primary sources (including one repeat source). Interviews were conducted Sept. 18-Oct. 2.

- 1) Autonomous-vehicle technology executives (5)
- 2) Industry specialists (7)
- 3) Trucking and logistics companies (2)

## Next Steps

Blueshift Research will continue to monitor Aurora's progress toward a commercial launch of its self-driving-truck platform as well as its efforts to reduce the production costs of its hardware kit.

## Silos

### 1) Autonomous-Vehicle Technology Executives

Aurora should meet its goal of having fully autonomous trucks in commercial operation by the end of next year, but only in the most technical sense, said four of the five sources in this silo. Its initial deployment is likely to be only a few trucks on simple highway routes within a single state. Regulations allowing interstate travel are unlikely to develop before the end of 2024, and more complex routes, such as in and around cities, remain a challenge. Three sources said that while the financial advantages of self-driving trucks are substantial—lower labor costs, better fuel efficiency, higher utilization rates—there remain long-term questions about the ability of autonomous trucking to be profitable for carriers and logistics providers. The high cost to build such trucks, the additional cost to maintain the trucks' expensive hardware kits, and the need for ongoing services like remote monitoring and mapping make the business model challenging. Sources said Aurora will need to significantly reduce the cost of its hardware system in order to appeal to shippers, with one estimating it needs to bring the cost down from about \$100,000 per truck closer to \$15,000. Two sources said Aurora's deal with Continental will help reduce those costs in some areas but not with Aurora's lidar, since Aurora has chosen to use a proprietary system. Two sources said most of the technical challenges around self-driving trucks have been solved, including one source who said Aurora appears to have solved an important and challenging calibration issue allowing its truck to maneuver safely within depots. Two others, however, said the technology needs quite a bit more testing and development for rare but potentially dangerous scenarios. One speculated that autonomous trucks might always need a human operator on board even if the truck is doing the vast majority of the driving.

Two sources expressed some surprise with Waymo's decision to stop developing its autonomous-truck technology; both see robotaxis as offering a much tougher path to profitability. However, both said Waymo could easily get back into the truck side at some point. A third source said Waymo's decision does raise some concerns about driverless trucking's outlook, as Waymo likely weighed the greater risk involved with trucking, the higher development costs, and the more difficult regulatory environment. Sources said Aurora is as well-positioned as anyone to succeed in trucking, with two offering high praise for its CEO and technology team. Kodiak and Daimler Truck's [Torc Robotics](#) are legitimate contenders, according to one source each, while another said Waabi's simulation-focused approach will eventually need some infrastructure investment. Two sources were skeptical of Gatik's strategy but were split in their assessment of whether Stack can challenge Aurora. Three think Aurora has a superior technical approach to lidar than competitors like Luminar. Two said they see only a supporting role for Mobileye Global Inc. (MBLY) in autonomous trucking.

The regulatory landscape remains a huge variable in the evolution of autonomous trucking, with two sources skeptical that any federal legislation will help clear things up anytime soon. Insurance issues are also an obstacle to adoption; a high-profile accident could not only bankrupt a technology developer like Aurora but also halt the entire industry for an extended period. One source said that the current patchwork approach to insurance—with some policies covering just the truck and some covering the software—is not a scalable solution and that insurers do not yet understand the whole ecosystem involved with self-driving vehicles. Political considerations around protecting jobs could also slow adoption of autonomous trucks, two sources said.

### Key Silo Findings

#### Aurora's Commercial Launch Timeline

- 4 of 5 expect Aurora to meet its publicly stated goal of having driverless trucks in commercial operation by the end of 2024.
  - o All 4 said such operation will have to be extremely narrow in scope, such as a single route, hub-to-hub deployment.
  - o 1 said more complex routes, especially in and around cities, remain a difficult problem to solve.
- 1 said legislative issues around driverless trucks are unlikely to be sorted until 2025 at the earliest, making it impossible for Aurora to meet its initial target.
- 1 said Aurora's first deployments of fully autonomous trucks will not be profitable.
  - o His company operates autonomous trucks in China, and its cost-conscious approach has allowed it to make a very small amount of profit.

- 3 said the costs associated with building an autonomous truck, combined with the higher costs to maintain them compared with traditional trucks, plus the need to remotely monitor them, make it an open question whether the venture can be profitable anytime soon.
  - o 1 estimated the additional cost for Aurora's sensors and computer hardware to be at \$100,000 per truck, a figure that needs to come down to closer to \$15,000.
- 2 said Aurora's partnership with Continental is a major step toward improving production costs.
  - o 1 said Continental's willingness to take on some of the upfront costs is a huge boon to Aurora.
  - o 1 said that because it will take a relatively long time to scale production of Aurora's driverless technology kit, Continental could feel some pressure in the interim to stop devoting resources to it.
- 3 said the cost of Aurora's proprietary lidar is much too high.
  - o 2 said Aurora could have improved the cost-performance equation of its lidar by using an experienced automotive supplier like Continental.
  - o 1 said Chinese manufacturers have developed better lidar systems for one-tenth the cost of what Aurora has created.
  - o 1 said it will be difficult for Aurora to tap into economies of scale since it will be producing lidar only for its own use rather than selling it more widely.
- 2 said most of the technical hurdles around self-driving trucks have been solved, but 2 said more testing and development is needed for very specific but potentially dangerous scenarios.
- 1 said Aurora appears to have solved a very complex calibration issue that allows its trucks to safely move into and out of tight spaces in a depot.
- 1 said there will continue to be a need for a human operator in autonomous trucks for a while and possibly forever because of situations like flat tires, tollbooths, and certain types of emergencies.
- 3 said the advantages of autonomous trucking include reduced labor costs, higher truck utilization rates that shorten delivery times, and improved fuel efficiency.
  - o 1 said removing a human driver can provide fuel savings of 15% to 20% and overall cost reductions of 40% or more.
- 1 said long-haul routes that are mostly highway driving are more financially viable for autonomous trucks than short-haul routes, which involve slower speeds and sometimes waiting at customer sites.
- 1 said that even though robotics have come a long way, it continues to be challenging to find profits in high-level automation.
  - o One of the few successful examples is Amazon.com Inc.'s (AMZN) [Amazon Robotics](#) because its warehouse automation system is able to work in a well-defined, well-organized space.

## Competitive Landscape

- 1 said Waymo's decision to stop developing self-driving trucks raises questions about the industry's future.
  - o Waymo likely concluded that trucking is a much bigger challenge than passenger cars because of the greater risk, higher expenses, and a less friendly regulatory environment.
- 2 said they see a much harder path to profitability in robotaxis than in autonomous trucking.
  - o 1 said he was quite surprised by Waymo's exit from autonomous trucking for that reason.
  - o Both said Waymo could get back into trucking later on.
- 1 said Kodiak is the last main competitor to Aurora, while 1 other listed Daimler Truck's Torc Robotics as a legitimate contender to succeed with driverless trucks.
- 1 said he does not see any obvious advantage that Kodiak has over Aurora.
- 1 said Waabi has focused solely on simulation and will eventually have to invest in real-world testing.
- 1 said he believes the ex-CEO of TuSimple Holdings Inc. (TSP) has secured funding for another autonomous trucking venture.
- 2 questioned Gatik's strategy.
  - o 1 said Gatik has taken a very simplistic approach to self-driving technology and is likely far away from solving any of the more complex issues around maintenance, durability, and calibration.
  - o 1 said Gatik's focus on "the middle mile" does not offer a clear ROI.
- 1 said the autonomous-trucking companies that have failed to date invested too much, too early in infrastructure, and Aurora is in a better position because it started later and has manufacturing partners.
- 3 said Aurora's approach to lidar, while more expensive than Luminar's, appears to be superior.
  - o 2 said Luminar's performance is not exceptional; 1 of them said it does not have an automotive-grade sensor that meets temperature specs.



- 2 said the jury is out whether Aurora's lidar is better than Luminar's.
  - o 1 said users still gravitate toward rotational lidar rather than Aurora's solid-state product because the former seems more accurate and doesn't drift.
- 1 said any camera-heavy approach to self-driving, such as that advocated by Mobileye and Tesla, is not going to be as effective as efforts that incorporate lidar.
- 1 said that if Mobileye gets involved in autonomous trucking, it will likely be as a partner with a legacy truckmaker for some driver-assistance capabilities.
- 1 said he is surprised that Stack's CEO was able to secure funding for another autonomous-trucking venture and that Aurora should not be concerned about Stack as a competitor; 1 other said Stack has some catching up to do, but the backing from SoftBank and experience of its leadership team make it a legitimate player.
- 2 lauded Aurora's CEO and management team and consider them a competitive advantage.

## Key Industry Issues

- 2 said that regulatory pieces to allow interstate autonomous trucking are not yet in place and that no federal legislation is likely anytime soon.
- 2 said insurance issues remain an obstacle to wide deployment of autonomous trucks.
  - o 1 said that while driverless trucks should be safer than ones operated by humans, a high-profile mishap could bankrupt a company like Aurora or Kodiak.
  - o 1 said the insurance products available to date are a hodgepodge of coverages that cannot scale and do not seem to recognize the full value of the autonomous ecosystem.
- 2 said the political climate is such that any effort like driverless trucking that costs jobs is likely to get some pushback.
  - o 1 said the industry needs to frame the narrative around the idea that autonomous trucks are safer, more reliable, and more efficient, and will need human operators for some time.

## 1) Cameron Gieda, director of business development for [Pony.ai](#), an autonomous-driving technology company

Aurora could hit its 2024 target of driverless trucks in commercial operation on a limited hub-to-hub type of route but is a long way from being profitable. Its deal with Continental should lower the cost of its sensor suite but is unlikely to get the cost of its lidar on par with what Chinese manufacturers are offering. Waymo likely backed out of trucking because it couldn't see a path to profitability—as opposed to ride sharing, where the profit model is clearer. While driverless trucking is now largely feature-complete, the combination of extremely high hardware costs and regulatory hurdles makes the trucking industry a tough nut to crack, and it will continue to move slowly in the United States.

### Aurora's Commercial Launch Timeline

- "It's certainly possible for Aurora to [hit its 2024 target] on a limited [basis], going from point A to point B. It could make sense, but it certainly won't be profitable."
- "Our [autonomous] trucking operations are only in China and just started commercially this year. We just do the software, and we create these ventures where we have a logistics partner—in this case [Sinotrans](#)—and they are like a FedEx or UPS. And then we have another partner in [SANY](#), which is a trucking OEM. We're building trucks with [SANY] at their factory to be autonomous. And then the joint venture we created between the logistics company and Pony buys those trucks and puts them onto the Sinotrans fleet, basically to carry goods for them."
- "So, we created the ready receptacle for the technology, as well as the logistical system to manage it and put people in it and then benefit from it by profiting from the joint venture with a profit-sharing model. The JV [joint venture] is making money now in the first nine months of operation, but it's a pittance. We've delivered something like 200 million freight-ton miles—one ton moving one mile. We have a route from Beijing to Guangzhou; we also have inner-city routes and ones closer to the ports."
- "Aurora will deploy some sort of POC [proof of concept] that will be fantastically not profitable, and they will do that probably with a logistics partner in Texas because the [Texas Triangle](#) initiative [lends itself to doing business there]. I believe Kodiak is working there [in Texas], and I bet Waymo is in Texas, too. It's a very accommodating regulatory environment; you can't even run an unmanned semitruck in California."
- "Operationally, I think Aurora will likely do some kind of hub-to-hub operation, where it's a long range with a single route, that sort of model. And then maybe that can translate into a hub-and-spoke. I think that's plausible."

- “[But] is it profitable? I don’t have the exact numbers, but think about the trucking industry in general and how razor-thin your margins are going to be with a human driver. Your removal of the human driver saves 30% to 40%. Some people are a little more aggressive on that number, and I think it could go higher.”
- “But we boil it down to the cost per mile to deliver the product. The human-driven truck, without any of these sensors and computers, let’s say that’s \$2 a mile, which will fluctuate with fuel costs. Then you add [the sensor suites]—and this is the interesting difference between our company and Waymo and [General Motors Co.’s/GM] [Cruise](#) and Aurora and others—the sensor suites [Aurora] is deploying are typically not automotive grade. The sensor stack and the compute that they’re deploying in these trucks is not built for large scale or designed for manufacturing. It’s a rack-style computer in the back of the truck. I would venture to guess the cost of that additional equipment on the truck is probably over \$100,000.”
- “I know with the Waymo taxi, [the sensor suite] is \$280,000, and Zoox is similarly very, very expensive. So that’s the biggest challenge that Waymo has.”
- “From a technology standpoint, [driverless vehicles] are almost feature complete; and I believe Aurora has articulated the same, meaning that the truck can stay in the lane, it doesn’t run into people, and so on. So it works, but it’s got to cost \$10 a mile or something like that in amortizing their very expensive computer platform and sensor suite. And until they get that [sensor suite and computing cost] down to something like \$15,000—which is almost a tenth of where they are today—that’s the only range where you can, at large scale, make any money with trucking.”
- “The benefits therein aren’t immediately apparent because I think there will be a considerable amount of time where there is still a person needed in the truck, if not maybe forever. The reason for that is flat tires and tollbooths and other incidents where you need a human to make some snap decision, especially in emergencies. Or cargo theft.”
- “In our model, for instance, in China, we’re doing the longest-distance automated trucking runs in the world right now, by a long way, which is 2,000 kilometers straight. That’s with three people in the truck. None of them are skilled truck drivers; they’re all lightly trained safety drivers. And they just observe the truck, take over as needed, and then switch places doing the observation; because in China there’s no eight-hour rest rule—the rest can be had while the truck is still in motion.”
- “We just got the permit in China to do driverless trucks.”
- “That’s another rub with NHTSA [National Highway Traffic Safety Administration] and DOT [Department of Transportation in the U.S., where you can’t even operate the vehicle for that many hours, to take advantage of the fact that it’s autonomous. You don’t benefit from this 24-hour operation or being able to route traffic continuously, which is one of the gains of these systems, as well as fuel savings. I think you can see 15% to 20% in fuel savings just by removing a human’s foot from the pedal and applying some algorithms to speed it up for hills, etc.”
- “What TuSimple was trying to do was basically competing directly with human-driven logistics operators, creating their own logistical system and deploying the trucks on that system, and then competing for the actual work to carry the goods. That is going to piss off lots of people, I believe, in the unions and in the regulatory community, and it’s going to be hard to scale that without those partners.”
- “At the end of the day, if I go to Daimler [Truck Holding AG/DTG.DE] or PACCAR and want to sell them one of these systems, whether that’s [Plus.ai](#) or Aurora, they don’t care. They’ll say, ‘Go ask the people that need it, because they’re buying it and using it.’ So you have to talk to Coca-Cola [Co./KO] or whoever is going to move the goods and sell them on the idea of autonomy and broker the deal with them.”
- “There are always some companies that have interest in this technology—PepsiCo [Inc./PEP], Walmart, and others—and they periodically do pilots with [the autonomous-vehicle companies] that may or may not lead to direct business. Aurora uses these POCs to attract more investment and will tell the world how well it’s all going, just like every startup does.”
- “I think the carriers are often left out of the [autonomous trucking] conversation. They’re the ultimate customer, and understanding their motivations, appetite, and ultimate concerns about this stuff, I think that’s the crux of [whether this works]. Unions are pretty popular right now—looking at the UAW strike—and as soon as you say it’s an unmanned truck, there will be pushback. It’s just the nature of the political climate in the U.S. right now.”
- “The trouble with software companies—and we face the same issue at Pony—is when you aren’t a Tier 1 [automotive supplier] and you have this software, you still have to embed that among some Tier 1’s automotive-grade

“From a technology standpoint, [driverless vehicles] are almost feature complete, ... meaning that the truck can stay in the lane, it doesn’t run into people, and so on. ... But it’s got to cost \$10 a mile or something like that in amortizing their very expensive computer platform and sensor suite.”

Cameron Gieda, director of business development for Pony.ai, an autonomous-driving technology company

equipment—radar, lidar, cameras, computers, domain controllers—because they’re the only ones that can offer that at a very low price and at a very high scale. That’s for a couple of trucks. But once you hit 100 or so [trucks], it just doesn’t make sense to put these spinning lidar and all the rest on it.”

- “Plus.AI has done [an interesting thing with Bosch](#) where they’re doing that. It’s not only the software but a kit with all of the sensors that can be attached to the semitruck and then runs the software. But then you still have to deal with the deployment of the software, which requires mapping and a bunch of other stuff not dissimilar from an automated ride-hailing service.”
- “There are additional costs that arise from these systems and jobs created, which is a good thing. But you’ve got to monitor these systems, and they have to be maintained in different ways than normal trucks are. There’s additional costs that aren’t obvious. Plus, I don’t know how long these systems last on the hardware side; I don’t think a lidar will outlast the life of a truck. That’s a million-plus miles for a decent semitruck. All the vibration makes for a challenging environment for any [hardware], especially optical sensors.”
- “I do believe all these things make it hugely challenging [for Aurora] and aligning that with, how do you convince [PepsiCo’s] Frito-Lay or Coke or whoever that there’s a path to profitability here? I wonder how [Aurora] even gets paid in those POCs.”
- “Maybe [Aurora’s partnership with Continental can get the cost of its lidar down]. Continental is new to lidar. We work with Luminar, so I know the price points there. The Chinese are just killing it on lidar products. I don’t believe Conti [Continental] can ever reach these very, very low costs that you would need to make thousands of these systems, especially on lidar, maybe on radar and cameras. And with domain controllers, we all kind of drink from the same pool.”
- “But lidar being a central technology and probably the most expensive thing, save the computer, companies like [RoboSense](#) and [Hesai](#) [Group/HSAI] are a tenth of the cost already. So I think getting in bed with a Conti or a Bosch is great for Conti because it’s a new business for them. But I think you really need to look at these very low-cost sensors to deploy in very, very large scale.”
- “[Aurora’s lidar] is just too expensive. And similar to Luminar, it’s the same problem: You have an overbuilt, overpriced sensor that we’re not sure how you ever make money doing something like that; especially when you look at what’s happening in China, where you can order something that’s better performance for a tenth of the cost [of Luminar and Aurora’s lidar].”  
“[The Chinese lidar] are cheaper and are automotive-grade. Luminar doesn’t even have an automotive-grade sensor yet, and the biggest rub there is it doesn’t meet the temperature specs. And in Texas in the summers, you’d better have a thermally robust system. I agree with the statements around Luminar performance [not being exceptional]. This is a common sentiment in the industry.”
- “Aurora [developing its own lidar] at all is too expensive and can be better achieved via partnership.”
- “With lidar, I know [Aeva](#) is doing it. [Aeva’s] lidar is near military-grade if I’m not mistaken—1550 nanometer, similar to Luminar, which is a very expensive laser diode to buy because they’re not as ubiquitous as the 905 stuff. By military grade, especially for optical things, it’s to say it will have extremely crazy performance, but it will be purpose-built for one thing, like being on a helicopter.”
- “If Aurora can get a friendly regulatory environment that allows them to scale, which I believe will exist in Texas, there’s a [path forward] there. And they are partnered with PACCAR, so there’s an agreement there, and I can imagine that this will morph into something where there’s a factory-built system, in collaboration with Continental, and then you get a truck that can be deployed right from the factory that’s autonomous.”
- “But the biggest challenge [for Aurora] will not go away until they adapt their sensor [suite]. Looking at their [autonomous] truck, here’s an estimated rundown of the costs today:
  - High-resolution, long-range lidar: \$10,000 each times four [per truck]. In a very high-volume automotive application, these would cost \$1,000, but you need to sell millions to get to this level.
  - GNSS/INS [global navigation satellite system/inertial navigation system]: \$15,000.
  - Nvidia [Corp./NVDA] domain controller: \$25,000. This includes two complete computers to meet redundancy standards.
  - 10-plus cameras: \$100 each.

**“Aurora [developing its own lidar] at all is too expensive and can be better achieved via partnership.”**

Cameron Gieda, director of business development for Pony.ai, an autonomous-driving technology company



- Five-plus radar sensors: \$2,000 each for 4D imaging radar. These are less expensive in very high volume like we see with passenger cars, but the volume of trucks is 4.3% of total vehicles on U.S. roads.”
- “So I think \$100,000 might even be a little low for how much all this stuff costs.”
- “Once the software is developed, that can be amortized through licensing. But these continual [hardware] costs, with the amount of sensors they’ve got on these tractors—it’s bristling with expensive sensors that are not automotive-grade. I believe that’s their challenge. They need better integration and lower costs. They need to completely reimagine their hardware suite to be profitable. I think that’s their biggest challenge.”
- “I think [Waymo backing out of trucking] raises concerns about the viability of the whole thing. It’s easier from a regulatory standpoint and from a scale standpoint to deploy [passenger vehicles].”
- “[For example] Waymo had already made this investment with Jaguar, buying 10,000-plus [I-Pace](#) vehicles. And because they’re so vertically integrated, [Waymo] can control the car. They make their own sensors and software, but you can make money in an automated ride-hailing service today because you can already deploy those in cities without drivers. And with a taxi model, we calculate as high as a 60% increase in profits if you can remove a person. If you deliver 10,000 rides a week, you’re doing pretty darned good profitability-wise.”
- “With trucking, you have much greater risk, much greater expense in the system, and an unfriendly regulatory environment. And you have a hard time getting rid of the [drivers]. So I think it’s just a harder nut to crack, and that was probably an economic decision on the part of Waymo, more than they thought it wasn’t possible.”
- “[The argument that autonomous trucking is the low-hanging fruit] is true, but that’s because [the southern freeway, hub-to-hub model] can only be served by so many folks. Until you can operate these things outside of sunny and flat Texas, [it won’t be hugely profitable].”
- “The other thing to think about in this space is the total available market. Think about the existing resources to move these goods that are there and aren’t going to go away very quickly. How many openings are there to drop in these vehicles and then start making money with them? It’s kind of fractional. And there will only ever be a handful of these trucks—100 or so—deployed for any particular route, so it takes a long time to make your money back doing that, I think.”
- “Robotaxi has the same problem. Look at LA: There are already thousands of Uber drivers and buses and everything else; you drop in Waymo on top of that, it’s a novelty. Where is the market for that? The only market is really that those things can sit and wait for a rider and not burn any money. Whereas if I’m in my Uber, I need to be paid; I’m a constant expense.”
- “The reason we have been able to make our trucking venture profitable is that Pony is pragmatic. The company is hyperfocused on the cost of deployment; we wouldn’t ever do an unpaid POC with a company, for example. I think Pony benefits from the fact that these technologies are less expensive in China.”
- “From the beginning, we knew the basic calculation of the dollars per mile for both those [ride hailing and trucking] businesses; you can’t have these fantastically expensive sensors. Our [upper level] personnel costs are also lower than a company like Aurora.”
- “It’s just a completely different model, and we really try to maintain the [business model] position of just software and offload those operational expenses to someone else, which maintains a higher profit margin for us.”

“Think about the existing resources to move these goods that are there and aren’t going to go away very quickly. How many openings are there to drop in these vehicles and then start making money with them? It’s kind of fractional.”

Cameron Gieda, director of business development for Pony.ai, an autonomous-driving technology company

## Competitive Landscape

- “I think Kodiak is the last man standing since [Embark](#) left. The ex-CEO of TuSimple, [Xiaodi Hou](#), is [reportedly] doing another trucking venture and I believe already securing funding. That’s just anecdotal, but I heard that he was back in trucking and trying to do it again.”
- “I think [the trucking space] will happen very slowly, much slower than automated ride hailing. Because in my experience, the trucking business moves very slowly. PACCAR is glacial because they’re risk-averse.”
- “To be profitable, you really have to fill in some gap that humans can’t do, that the regulatory environment allows, and that you can scale; and I think that’s a hard thing to solve.”
- “PACCAR has looked into [autonomous driving] internally, but as far as I know, they haven’t pushed it down the throats of any of their customers, because the customers aren’t asking for it. I think J.B. Hunt [Transport Services, Inc./JBHT] and others care about insurance and their margins.”
- “I think a bigger win for these trucks is to make trucks safer than when humans are driving them. But the fantastic profits that are expected don’t come along with those types of systems.”

## Key Industry Issues

- “The U.S. is a regulatory patchwork. Every state has different rules about how to run these systems, so interstate trucking autonomously can’t exist yet unless the feds come out and unify some regulations on how to deal with it. That part we obviously won’t see [any time soon].”
- “The insurance piece is still unsettled. I do believe Mercedes [-Benz Group AG/MBG.DE] has put a flag in the ground with their L3 system on their personal vehicles, wherein if it crashes in L3 mode, and it’s deemed to be their software’s fault, they will cover the cost. But this is in your S-Class or EQS that very few people will actually own, so the risk is somewhat limited. And those systems are only really available in very specific situations right now, so I think Mercedes is willing to take that risk.”
- “Aurora is different. We always go back to this thing we call the nuclear verdict, when the comedian Tracy Morgan’s limousine was hit by a semitruck, and that was a [reported] billion-dollar verdict in his favor. It opened people’s eyes to, if I’m Kodiak or Aurora, and our trucks crash into some high-value person, it could bankrupt us. And that problem is still unsolved. But I think you’re leveraging that risk against the fact that your system is way safer than a human [driver].”
- “I think being able to frame the autonomy part as not being completely without a human driver, that’s a narrative we will have for some amount of time. It’s really just about how to make things safer, more reliable, and efficient with autonomy. And then delivering that on the same par with what humans can do already. That’s going to be the test.”
- “We see that in the taxi business already, where we can deliver an automated ride in a taxi at about 80% of the speed with which [DiDi](#) delivers, which is China’s version of Uber. And because of that, we charge 20% less [than DiDi].”
- “I don’t think automated trucks can go as fast, and that will be another point of contention. I see semitrucks in California regularly going 80 miles an hour; there’s no way an automated truck will be allowed to drive anywhere above the speed limit because of that massive insurance risk and regulations.”

## 2) Fleet operations executive for an autonomous-passenger-vehicle company

Aurora will hit its target of having driverless trucks on the road by 2024 if it sticks to the low-hanging fruit of highway-only driving. Aurora is light-years ahead of the competition, benefiting from its CEO’s unparalleled experience and knowledge. On the technical side, Aurora appears to have solved a difficult calibration problem, a crucial step toward full autonomy. On the downside, the capital-intensive ecosystem of the trucking business is a major hurdle to profitability—not just the hardware, including multiple sensors, but also the software and maintenance. The complexity and cost of autonomous-driving software also will be an important factor in the cost of insuring self-driving fleets.

### Aurora’s Commercial Launch Timeline

- “From an R&D standpoint, we’re seeing that [autonomous driving] is possible. [Aurora] will meet their target of getting a commercial fleet on the road by the end of next year—depending on how you define autonomous.”
- “[Aurora CEO Chris] Urmson is focused on how to get to market quickly. The [self-driving] market is now changing toward simplification of implementation. In the trucking industry, if you look at what [driverless trucking] can bring, it’s an uninterrupted [set of] trucks in the slow lane, platooning all next to each other, long-distance driving with whatever range or capacity they have, whether it be diesel or EV [electric vehicle]. But [the concept is to] do a long-haul portion and then get to a destination like a hub spot and then have a human take over. That’s the vision of what we’re seeing.”
- “It’s easy to go down the freeway. It’s a matter of staying in a lane, having enough computing power on board to be able to see far enough ahead and to have a reaction, which really is just braking. There’s not the navigation of signage and lighting and pedestrians and bicycles. All you have to worry about is going in one direction for the most part, not having to worry about any other trajectory in front of you. The highway problem is the easy problem [from a technology standpoint]. It’s the in-city problem that’s the hard problem, because you have so many variables going on at any given moment.”

**“[Aurora] will meet their target of getting a commercial fleet on the road by the end of next year—depending on how you define autonomous. ... They can have a driverless truck with a remote guardian operations person, the truck on a freeway, from one hub to another, outside of cities. That’s absolutely doable.”**

Fleet operations executive for  
an autonomous-  
passenger-vehicle company

- “[Sticking to the highway, Aurora and others] can say they will get the autonomous miles, only limited by the capacity of the truck. We’re starting to see some immediate low-hanging fruit of using autonomy. They can have a driverless truck with a remote guardian operations person, the truck on a freeway, from one hub to another, outside of cities. That’s absolutely doable.”
- “The other thing to ask [when figuring out Aurora’s definition of autonomous] is whether it’s just a beta period, because we see that a lot—companies doing driverless testing and saying they’ve achieved it, then stopping it until further testing and tweaking.”
- “I’m very intrigued by how [Aurora] calibrates those trucks. If you see how the trucks go into awnings and out the other end, the fact that they [appear to be able to] calibrate themselves is a big deal.”
- “The technical calibration space is a maintenance nightmare on our end [in the passenger space], and any kind of calibration for a car today is nothing compared to the calibrations required for a truck. [So it’s a big accomplishment that Aurora Driver trucks] could leave the depot, leave the awning, and drive through those AprilTags, get an answer by the time they drive through that—meaning the software system has done the review of the calibration and confirmed that sensors are aligned. The tags are used to define how the different sensors overlay themselves, to look for the crispest image possible before the vehicle leaves.”
- “What the AprilTags are looking for with the different sensors—cameras, lidars, and infrared and radar—what you’re looking for is getting a visual image from a camera to overlay with a lidar image, and you’re looking for the definition of the edge of that tag, where it turns black and white. Half a millimeter out or off for a car being out could be very off—by a few meters—if [the edge of definition is] 150 meters out [on a truck].”
- “Calibration teams everywhere are struggling to get the speed of the results. Even in one or two minutes, you’re hounding through a good one or two gigabytes of data to ensure all the patterns line up. Lighting is an issue; glare is an issue. You’re looking for absolute precision when you calibrate those. So if Aurora has gotten that down where it doesn’t need to be exact—it could be raining outside, it’s bright sunlight, or a little darker—then that’s pretty amazing.”
- “The next level after that is to go to cities and to their final destinations, but that is very complex—not just for cars but [even more so] with a 53-foot truck and trying to navigate and move and have no blind spots. It’s a whole different challenge.”
- “Chris Urmson [is a reason Aurora could be successful where other companies have failed]. He led the entire effort at Google, and everybody else has spun off from that. He truly understands autonomy and what’s necessary [to take the technology to market]. The fact that he’s backed away from passenger vehicles to focus on trucking, I think he’s wanting to see some ROI rather quickly.”
- “I was part of [Waymo’s trucking venture], and it seems that unless Urmson has some very signed-up contracts with vendors that are very focused on helping the capital cost of all this, [it will be difficult to make this profitable]. Think about the software side of this. You’re asking the software companies to suddenly become trucking companies and taxi companies when they were never really in the hardware; the gravy was always in the software, because licensing and replicating cost nothing.”
- “[Autonomous software] is the general name for the different levels of what processing is happening internally [in the vehicles]. You’re looking at all the sensors and all the data from that, from the cameras and lidars and radars, and you’re painting the picture in real time of what that sees. It’s where the bottleneck happens because they can’t get enough chips from Nvidia because it’s all GPUs [graphics processing units].”
- “There are perception and behavior functions [for the software], and then another layer is prediction. That’s where the struggle of software is—doing all that in real time. It’s not a software that’s somebody is buying, because everyone’s using their own vehicle platform to test their version of software. You’ve got the main name players—Aurora, Waymo, Nuro, Zoox, Stack, all of which have founders who in some way are associated with the Google self-driving project or the DARPA challenge way back in 2006-07. Those folks have the most knowledge to building what is necessary to make it reliable because they were able to solve that challenge.”
- “Now you’re asking [software companies] to be in the very capital-intensive environment; unless Chris Urmson has got some really great contracts signed with partners and vendors to see that through, the capital intensiveness is one [hurdle] to profitable delivery.”
- “Number two [hurdle] is one I’m grappling with constantly, which is how can we make this cost-effective to maintain those trucks and vehicles? How can we keep sensors clean, keep them from road damage, all the software updates, and things like that? It’s the whole ecosystem. If you go to EV trucking, it’s the entire infrastructure problem of getting the vehicles charged and in the right area. Who’s taking on those capital costs?”

- “It obviously costs a lot to have a truck. The sensor stack on top of that, you could almost add another 50% [in costs]. They’re trying to drive down the cost of all the hardware components [with the Continental deal, for example], but at the end of the day, this software is not like Windows with a slight maintenance upgrade. As you see problems that the fleet goes through, you’re going to need software updates, mapping updates. Who is consistently mapping those streets and roads for closures and breakdowns? There’s just a whole ecosystem around this.”
- “For Aurora, if you’ve got heavy trucks, hopefully there’s the contracts behind that. But hopefully there’s also the maintenance depot. Maybe Aurora is not willing to purchase all that real estate and infrastructure, but hopefully there is some kind of third party that would help make that ecosystem, or there are brand partners—the Pepsis and the Frito-Lays and J.B. Hunts that might be willing to really invest in the infrastructure needed to maintain those trucks.”
- “[When Waymo was still in trucking], [PACCAR’s] Peterbilt and [Daimler’s] Freightliner and [Volvo’s] Mack were working closely with Waymo, and I think they ended up backing away and saying, ‘Let me know when you get there.’ The calculations would have been, ‘Can I run a business on this?’ And they stepped back from it.”
- “The question is, is it just cheaper to have drivers at the current rate than a driverless truck with all the infrastructure around it? I want to see it work, because there are benefits there [in fuel efficiency, safety, and other measures]. The question is, is it cost-effective? And I think that’s a huge business narrative right now.”
- “With solid-state lidar [like Aurora’s], compared to a rotational lidar, everybody seems to still gravitate to the rotational because it seems to be more accurate, and it doesn’t drift sensor-wise compared to the solid-state ones. But even to get the cost of the lidar down, [the question is] what is the maintenance, and what is the calibration necessary?”
- “[Aurora] can say they have a sensor stack that self-calibrates, which means that [the sensor] knows—because it’s gone down the road—it knows the telephone poles and buildings, which it can use as edges instead of AprilTags. And with confidence, that sensor stack can kind of self-calibrate itself. That would be a stair-step improvement to daily operations for these autonomous vehicles.”
- “I think we’ll get there, and as long as the money keeps flowing, we’ll iterate. But it’s one thing to sell a sensor for a passenger-carlike ADAS [advanced driver-assistance system] to GM and Ford, where there’s very low maintenance and low cost and very low touch point to calibrating those sensors. But when you have [as with trucks] four to seven lidar and maybe nine to 16 cameras, all kinds of things can happen in that space. We’re still fighting the durability part of it.”
- “Can Aurora say they’re going to have some trucks on the road? Yes. But what is the definition of that? If they’re going to go from point A to point B, mostly highway speed, they’re on the road. They’re doing it autonomously.”
- “But if you talk about going to a depot to deliver, the narrative changes. What’s the operational design domain or the ODD? Are they just going to do long-haul freeway?”
- “Even a passenger car at \$20,000 to \$30,000, vs. a heavy truck at \$180,000 to \$200,000, is a different narrative in maintaining that truck. It’s the same type of sensor stack on top of it, but it’s a huge capital investment, plus the space required to maintain it is also an issue.”
- “The bigger narrative around this is what is Waymo doing [as a business model], because they’re so far ahead of everybody else. Not in trucking, but it helps to paint the picture of the asset situation. So, will a car drive down the road? Yes. Will a truck drive down the road? Yes. Have we seen that successfully done? Yes, for quite some time.”
- “But in a commercial model, where you’re now asking to maintain these vehicles, from my point of view as a fleet manager, is Google or GM really signing up to be in the taxicab business? If they did, they would have done it 50 years ago. I don’t think it’s that business model. It’s more like, how can I sell a unified package? And just maybe it can be modified for trucks or for your delivery van.”
- “I think it’s a license situation. How can I use this as a capital investment but then leverage it for an ongoing licensing of either hardware or software, or the combination of that? I think that’s what [Aurora and others] are going for.”
- “It would be interesting to see how Aurora measures their autonomy. Typically, you’ll see miles per kick-out, or miles per engagements, as the primary metrics. So, when does human involvement—either physically and/or remote—[affect whether] they’re [considered] autonomous or how many are true autonomous miles?”

**“Is it just cheaper to have drivers at the current rate than a driverless truck with all the infrastructure around it? I want to see it work, because there are benefits there [in fuel efficiency, safety, and other measures]. The question is, is it cost-effective? And I think that’s a huge business narrative right now.”**

Fleet operations executive for  
an autonomous-  
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## Competitive Landscape

- “My two cents on Gatik is that it is just throwing a bunch of sensors on vehicles and saying, ‘We’ve got things going with Walmart’ and others. If you peel back that onion, if they’ve done it once, then they can say they’re doing it. But is there truly a fleet that is integrated? They don’t [solve] any of the same problems that we have: vehicle maintenance, durability, calibration, sustaining the vehicle. I think companies like this are just doing one- or two-sie-type efforts and then claiming they’re doing something [novel] as a way to secure funding.”
- “The way that the tech is being done and the maturity of it, I question the way that those stacks are being put on those [Gatik] vehicles.”
- “I work extremely closely with lidar engineers, and I think the jury is out on [whether Aurora has a competitive advantage with its approach to lidar]. There are others out there, too. You go to CES, and everybody wants to say they have a solid-state lidar and that in and of itself has frequency issues and problems.”
- “A lot of Mobileye’s focus is on camera technologies. You want to have various types of sensors to get a stair-step in improvement. If you want to use Mobileye cameras, or Tesla wants to use cameras to say it’s a level above humans, sure. But if I’m asking you to detect with absolute precision, in all conditions, to be better than the best human driver, you’re going to need some other kind of sensory input. And to use cameras only, it’s an issue. It’s why radar, camera, and lidar seem to be the trio. If you want to add the fourth one of infrared camera, it’s like we’re trying to say that absolutely without a doubt you could drive this vehicle with all lights out.”
- “Lidar is so good at picking up objects in real time that cameras just kind of fall by the wayside. Any company that’s just focusing on cameras alone, it’s a problem. And that’s Tesla and that’s Mobileye in the camera space, unless they’re working on some kind of other radar or lidar solution. But knowing [Mobileye majority owner] Intel [Corp./INTC], they usually get into something buzzy and hype it up, and they don’t [develop it fully].”
- “I think you have to have other sensors to have that extra next level of human skill driver.”
- “I don’t think Aurora [should be worried about Stack]. I’m actually shocked that [CEO Bryan Salesky] got another billion in funding. What didn’t he get done with the \$5 billion from Ford and Volkswagen that now he’s going to do with trucks?”
- “Aurora is way ahead of Stack. I like to think of Aurora as ‘Google 2’ because of Chris Urmsen. He led the entire effort at Google. He knows all the players and understands every component of autonomy.”

**“I don’t think Aurora [should be worried about Stack]. I’m actually shocked that [CEO Bryan Salesky] got another billion in funding. What didn’t he get done with the \$5 billion from Ford and Volkswagen that now he’s going to do with trucks?”**

Fleet operations executive for  
an autonomous-  
passenger-vehicle company

## Key Industry Issues

- “All the companies I’ve been involved with have a very clear policy and government team to try to help educate and give people the bandwidth to be able to test on public roads. I think more transparency is needed for these government agencies to really understand what’s going on. For example, California requires companies to show all the disengagements or any accident that happens. If we did that in all 50 states, maybe we’d be able to say, ‘Maybe it’s not ready.’ Or, ‘I’m not worried that my job will be taken.’ ”
- “At the policy level, it’s about changing the narrative of taking jobs away, to safety and different kinds of jobs that will be created in this industry—maintenance jobs and safety jobs. The policymakers need to see it that way, and it’s still an uphill battle.”
- “Adding more transparency [from the autonomous companies] is key. My company is doing all it can around this. [Conversely], we were talking internally about the recent publicity around Cruise, and that they are setting a bad example of what autonomous vehicles are about. Or, more egregiously, the Uber vehicle that killed a person, when [the technology used properly could have prevented it].”
- “Insurance is a whole different ball of wax. Insurance companies don’t yet truly understand the cost of the components behind this. One of the narratives I keep seeing is that somehow the software is free. Fifty percent of these companies are software engineers, and for some reason that doesn’t make the books.”
- “So when you’re talking about break-even scenarios and cost scenarios, and all the maintenance and software and mapping, all the engineers and data uploads—for some reason that doesn’t seem to make the financial statements. The question is, are we really painting the true picture for insurance companies on even the software costs that go along with these vehicles? It’s more than just hardware replacement. Are we insuring the entire totality of the ecosystem?”



- “You look at one of these [Toyota Motor Corp./TM] Prius or Cruise [vehicles], and it’s going to be easily a quarter-million dollars. Are we telling insurance the whole narrative? Some companies will only insure the vehicle, other policies will do the IT. Companies are piecing together insurance policies to try to get one vehicle covered.”
- “I worry about that scaling. If we can’t figure this out, this hodgepodge to get us on the road is one thing, but what is this larger ecosystem? I don’t want it to be the death blow to our industry. We need to make sure policymakers and insurance companies are on board and understand the true process.”

### 3) Executive with expertise in lidar and sensor hardware

Aurora will hit its target of having a commercial fleet of driverless trucks on the road by the end of 2024 but likely in a very limited scope. It will be a long time before autonomous trucking in the U.S. is profitable for carriers, which will have to not only buy expensive trucks but also pay for services like remote monitoring. Aurora’s proprietary lidar gives it a competitive edge over Luminar and others but at a massive cost, making it an open question whether Aurora has taken the smarter route. Aurora’s deal with Continental will get the cost of the sensor suite down, but the partnership won’t have the same effect on the production costs of its lidar. Waymo’s exit from trucking was surprising, but there’s no reason Google could not come back into the space if it saw profits to be made.

#### Aurora’s Commercial Launch Timeline

- “[The question of whether Aurora will hit its target of having a fleet of driverless trucks in commercial operation by the end of next year] is an easy one, because it’s a technical question. Yes.”
- “I don’t want to be cynical, but if I was running a company that was looking for a new round of funding, I would put a lot of engineers on a job to have at least five trucks that can bring clothes from one Walmart shop to another. And I can guarantee you 100% that this will work.”
- “This will be a commercial, fully autonomous fleet; and it will be on a road which is easy to automatize; and it will go day and night and around the clock; and it will be a big announcement. That’s my forecast.”
- “The technical hurdles are pretty much solved. The vehicles as you see them today have great capabilities; if a Cruise vehicle can drive the streets of San Francisco, then you can imagine that a truck can drive a straight road and maybe even take on-ramps and off-ramps from designated spots. That’s possible.”
- “Aurora will buy all the sensors from Conti, plus the integration into the slots that they put on the vehicles, the mounting locations and brackets, and also the mass production of the computers.”
- “What will be produced by Conti but is not originally coming from Conti is the lidar, so that’s the exception in the game. And while I can tell you that buying automotive sensors from a big Tier 1 like Conti is certainly saving you costs, it’s [also] a very good idea to buy from Conti because you can avail huge manufacturing volumes, and you can avail products that have been developed over many years and are deployed in millions of cars—so they must be cheap and amazing quality and functionality to survive automotive.”
- “But the lidar, Aurora chose not to buy from Conti but, rather, to develop and sell, because [Aurora] thinks they have the best lidar. Will it be cheap? No, because they didn’t buy it from Conti.”
- “Maybe the choice of hardware will make them faster and better than competitors, and this will bring in earlier and bigger revenues. ... All I can say is that Aurora chose to invest a lot into a costly but highly performing lidar technology.”
- “This is new technology, and nobody knows what is the right recipe to win. Normally, it is not a bad idea to invest into the best technology before you start saving on every component. Those who claim that they can do better with less money only make assumptions, and time will tell who is right or wrong .”
- “I know Aurora’s technical concept and their business models pretty well, but it’s always difficult to predict whether they will be successful or not.”
- “In all robotics—and this is not only in the automotive space—it’s always been difficult to find applications that are profitable for higher levels of automation. When you forward a video from Boston Dynamics, for example, you can guarantee that people will love seeing those humanoid robots doing fun stuff, and everybody loves it. But over 30 years, I don’t think Boston Robotics has ever been profitable. I think the only profitable robotics company is now known as Amazon Robotics, because they do their warehouse automatization for all the packages. It’s such a well-defined, well-organized space where this can really be executed in the perfect way.”

- “So it’s difficult to make any automation profitable, but there are different chances of being profitable. And if you compare the robotaxi world and the autonomous trucking world, I think the likelihood that trucking will be profitable is so much higher.”
- “The reason is simple. How expensive can a taxi ride be to pay for such a complex robot from Waymo or Cruise? It’s hard to imagine that they’ll become profitable. But on the truck side, you earn not only by replacing the driver, which is just a small part of it, but you also earn by a much higher utilization of the whole logistic infrastructure. You can drive 24/7; you have no waiting time; you have no sleeping time; you can shorten delivery times; you can change your prices, because suddenly you have the ability to transport something—say, long-haul distances in half the time.”
- “I’m not a logistics expert, but if I was starting a logistics business, and I could offer you half the delivery time [vs. a competitor], then you would pay me for it. So replacing the driver is just a small part of [the calculation of autonomous trucking].”
- “The software stack called Aurora Driver does the sensing and the driving. But as everybody will tell you, you can’t build a stack that’s independent from the hardware, so this would be related to the hardware that they’ve partnered on with Continental.”
- “It means that the kit is hardware and software, which is also the business model that Conti is interested in. Then Aurora will say they can do their own trucks, or they can offer it to Volvo, PACCAR, and others. What [the carriers] will find out is that these trucks need to be supervised, monitored, they need to have a control center ... you have to make [HD maps](#) of every street before you drive them, and they will have to buy this from Aurora as well.”
- “It then becomes a service model where you have to first invest in the hardware, and then you basically pay per mile driven.”
- “The logistics providers will be paying for this primarily, and they might either buy the kit, or the kit will be an option that they can buy from the truck companies as like a high-end autonomy—like you buy a Tesla today, where they give you the option of buying driver software for \$15,000 or a monthly fee, although I’d argue that you can’t buy decent hardware from Tesla.”
- “The trucking industry is paying by the mile. [A comparable model] is basically the model that made the old telcos rich. First you have to buy a phone, then they put a cable into your house, then they charge you a rental fee for that old phone every year, and then you pay for every minute you talk.”
- “This is how they win. If you want autonomy, there will be three or four players in the world that can give you that full kit. They have operations with truck manufacturers who can offer this kit off the shelf, and once you buy this, you are stuck with the ‘telecom.’ The [shippers] pay per mile driven whenever they have no driver in, and maybe they pay rental costs to the leasing company which has financed that expense for the robovehicle.”
- “So yes, there is money in this, and these [autonomous trucking] business models are much easier to bring to profitability than logistics in a robotaxi. But if you ask me when this might be profitable and how much [money can be made], I can’t answer that. I think it’s a real question whether it will ever be profitable.”

“If you compare the robotaxi world and the autonomous trucking world, I think the likelihood that trucking will be profitable is so much higher. ... On the truck side, you earn not only by replacing the driver, which is just a small part of it, but you also earn by a much higher utilization of the whole logistic infrastructure.”

Executive with expertise in lidar and sensor hardware

## Competitive Landscape

- “[Waymo’s exit from trucking] is a head-scratcher. In the beginning, they said they were getting into trucking because they said it was way more profitable. And then they stopped it, and I’m scratching my head. Maybe Waymo has the software stack they think they can sell to OEMs, or they have a business model that we don’t know about. I don’t understand why robotaxis would be more profitable than autonomous trucking.”
- “I don’t see why Waymo couldn’t go back into trucking.”
- “I don’t believe Luminar has the best [lidar] technology. I don’t think they are that good at what they do, despite being successful and popular.”
- “The performance of Aurora’s lidar is much better than Luminar’s [Iris](#). But [Aurora’s] will also be bigger and power-hungry. Luminar is already expensive, but Aurora is much more expensive.”
- “Aurora is developing their lidar via the two acquisitions, Blackmore and [OURS](#) [Optical Universal RISC Systems]. OURS is helping them to integrate this on chip, which is planned over the coming years. It’s enabling Aurora to develop a proprietary lidar which they are convinced is a competitive advantage against others. It’s why they’ve spent a huge amount of money on lidar already.”
- “[Aurora] decided not to go with the lidar made by Conti, which would have been much better in the cost-performance equation. Players like Conti build products which are good enough for high volume in many

applications, but they wouldn't build a product that would only be good enough for a single truck program. [What Aurora is building] has got to be incredibly expensive, so it better be good; otherwise, it's a total failure."

- "I will say that while it's good to be fast and cheap, at the end of the day, it also has to work and not make a single mistake. And so maybe Aurora's money is well-spent. Profitability only comes when you do this over many years without crashing, and so maybe they will get there. It's hard to say."
- "What I can tell you is that they'll hit their targets next year and will do a lot to make this happen. They have a great team and great technology, which is as good as others or better."
- "Profitability comes through scaling, and nobody can predict whether the market will pick up. We've seen more than a few companies doing this, and it will be a long time before they can really compete. There will be big players in China that will be profitable. There will be big players in the U.S., hopefully more than one. But will it be profitable? It's hard to say."

#### Key Industry Issues

- Did not discuss.

#### 4) Former executive with an autonomous-trucking company

Aurora should be able to demonstrate some small use of driverless trucking that will allow it to say it hit its 2024 target, but it will be a long time before it reaches real commercial scale. Demand for autonomous trucking is strong, but the technology is not quite at the point where it can handle all of the real-world variables. The industry is likely to evolve more slowly than most are expecting. Aurora's deal with Continental is a big benefit to Aurora, though Continental could start to feel some pressure during the long ramp-up period. Aurora needs to bring the cost of its lidar down—something that will be a challenge, given that it is only producing it for its own use.

#### Aurora's Commercial Launch Timeline

- "I think Aurora will be able to demonstrate something by 2024. It will be a much smaller scale, and it will be more limited in terms of capabilities. And it will take many more years to ramp it up to a reasonable commercial scale."
- "Real world has so many unpredictable things, and I don't think the AI technology is there to verifiably handle the uncertainty in the world."
- "The demand is there. The demand could not be stronger. But it will require a lot of hard work to prove that the technology is actually safe."
- "There will be a hard, painful learning process. It is going to go slower than most everyone is anticipating, hoping, or wishfully thinking. But the demand is 100% there."
- "Autonomous trucking is an evolving field. We now know infinitely more than what we did five, six, or seven years ago. There is no precedence. This has not been done before in this particular way. We never had completely autonomous systems driving next to a school bus on a public highway. The safety elevation process does not have clear guidelines on how to know when we are absolutely safe."
- "As a technologist, I personally think the technology is not there to completely take over all the things that humans are doing on the driving tasks. Robots are machines and, in general, better than humans in certain tasks. But there are certain things, like using common sense, that the average human has no problem doing but the most advanced machines are struggling with. I still haven't seen evidence yet that we are there."
- "There will be a period, just like any nascent technology, when there will be manufacturing issues, quality-control issues. There is no such thing as a perfect product launch."
- "More than half of the components [in Aurora's trucks] are black boxes. They are building them, so there will be issues. It will take a lot to track down those issues and get all of the ducks in a row."
- "I am hoping most of these will be around inconveniences and system availability and maybe lackluster commercial benefits, but not safety issues; because if there is a catastrophe caused by some form oversight or negligence from the autonomous point of view, the consequences will be dire, and it will shut down the entire market for a long time."

**"As a technologist, I personally think the technology is not there to completely take over all the things that humans are doing on the driving tasks. ... There are certain things, like using common sense, that the average human has no problem doing but the most advanced machines are struggling with."**

Former executive with an autonomous-trucking company

- “Aurora’s deal with Continental is pretty significant. It’s a big deal for an established company like Continental to agree to shoulder some of the upfront costs. That, clearly, is in Aurora’s favor.”
- “The roadblock will be that it will take much longer to scale it practically. Continental might be under pressure to not continue to spend resources there. Other than that, the deal is as good as it gets. Continental is extremely interested. The time frame is my question.”

## Competitive Landscape

- “I don’t see anything special about Kodiak. I frankly don’t know what they might be doing differently or better than Aurora.”
- “Gatik is interesting. Back in the day, when we studied their business model, it was our conclusion that they were not a great ROI. Gatik is focusing on something they call the ‘middle mile.’ Technically, the middle mile is actually long-haul trucking; they just repurposed it and rebranded it to their liking.”
- “From a technology standpoint, no matter what [Gatik] says about repeatable routes, I don’t buy the argument that just because a route is repeatable that it is easier to navigate because the road never changes. Any road is repeatable from that point. But what you encounter on that same route every time you drive it is not repeatable.”
- “Ideally, you want to keep your trucks as busy as possible around the clock. The goal is to keep trucks moving for 20 or 22 hours a day. If you can get something like that, you are getting more out of your fixed investments into the truck, doing more work, and your top and bottom lines improve. That is viable.”
- “We found that to drive to that level of utilization, you need to make sure you are carrying more stuff farther. That requires you to go at higher speeds, which is more possible if you are doing long-haul, where 80% to 90% of the route is highway, and you are cruising at your maximum speed of 65 to 70 mph. Short-haul routes, especially the local routes, tend to involve surface driving and might involve waiting at the customer sites. If your truck needs to wait in the traffic for two hours, that is not very feasible.”
- “Long-haul routes are more viable than short-haul routes and definitely more viable than what the Gatik folks call the middle mile.”
- “Aurora’s lidar isn’t the only FMCW [frequency modulated continuous wave] on the market. There is another company called Aeva doing FMCW. But [Luminar’s] and Aeva’s products are not as mature yet. One of the challenges for Aurora would be to bring the cost down.”
- “Aeva is manufacturing lidar units for everyone to use. You can assume that if your product is good enough, you will sell a lot of it to a lot of people who are ready to use your product, so you can scale faster. If you can scale faster, you can tap into the economy of scale.”
- “Aurora will be their only customer [for their lidar], so even if not immediately, they will have to spend hundreds of millions of dollars of R&D costs on every single unit they are using, and they will have to charge for it. That will probably make it harder to bring the costs down fast enough. Not impossible. But it is a challenge.”
- “Technology-wise, whatever you can do to see farther, see better, and make the numbers work is an advantage. [Better lidar is] not the silver bullet that will solve autonomy by itself, but another nice thing to put on your side.”
- “When you look at the landscape now, I think Aurora is the perceived leader in trucking. They are the largest and oldest company still in a serious position. TuSimple was perceived to be the farthest ahead, but they are dealing with a number of management issues. Waymo can come back to trucking anytime they want and be as formidable as they ever were because they are not getting out of the autonomy game, they are just focusing their resources and efforts into robotaxis, which they must feel is moving faster than the trucking.”
- “A big competitor like Waymo temporarily pausing their efforts is clearly better for Aurora.”
- “Trucking is not just the best-use case for autonomy; right now it is the only viable use for autonomy. Robotaxis will continue to be a loss leader for probably a decade to come. It will be impossible to turn a profit with robotaxis.”
- “If anything, I would expect [Mobileye] to team up with a legacy truckmaker and provide some sort of driver-assistance feature.”
- “Aurora should be concerned about Stack AV’s [backing from SoftBank]. Stack AV was started by a very experienced team who have been building autonomous systems for the past 20 years. Before Argo AI, Bryan Salesky was at Google with Chris Urmson. Peter Rander and Brett Browning were at Uber Advanced Technologies. Before that, everybody was at Carnegie Mellon.”
- “Leadership like that with that hefty war chest from SoftBank—if things go well, they will be able to get more money from Softbank—that is definitely a concern [to competitors]. But Aurora has a good five years in trucking over Stack AV. Stack AV folks will have to do a little bit of catch-up. But it’s not going to take them five years. If I were Aurora, I would keep close track of Stack AV.”

## Key Industry Issues

- “On the regulatory landscape, there are two parts—the federal part and the states. The different entities control different parts of the regulations. The state can require, for instance, a physical driver to be present in the cab. The federal level is controlling different things—like if you get in an accident, you need to respond and deploy the cones and flares within 10 minutes of an incident.”
- “Federal requirements might change tomorrow, but given the rule-making speed of the regulations, we were anticipating it would be many, many years before anything changes at the federal level.”
- “[In California], our interpretation [of the legislative effort to require humans in driverless trucks] was that this was motivated by organized labor. It was less about the actual safety concerns and more about protecting future job openings.”

## 5) Software developer in driverless technology

Aurora is unlikely to hit its end-of-2024 target because driverless trucks have not yet received regulatory approval to operate completely autonomously. Deployment is more likely to take place in 2025, when more testing and legislation fall into place. Aurora also faces technical hurdles, as not all use cases have been fully documented. For driverless trucking to be approved in many states, officials require hours of testing of use cases through simulation and on the road. Aurora’s advantage over other companies that have failed is its deep-pocketed investors. Aurora is avoiding its predecessor’s mistake of investing too heavily in infrastructure before it is profitable by signing partnerships with major OEMs and transport companies. For now, demand for Aurora’s autonomous trucks is not high, but potential customers will gain interest when it has [Level 4 autonomous trucks](#) on the road. Potential customers will see the cost savings of autonomous trucks. Aurora and Daimler Truck’s Torc Robotics are the two leading competitors in the space. Aurora would benefit more from Luminar’s lidar technology than in its own frequency-modulated approach.

### Aurora’s Commercial Launch Timeline

- “I don’t think Aurora will hit its target by the end of 2024. It’s legislative. Autonomous trucking has not yet been successful to date to be authorized to operate completely autonomously. I believe Aurora is still only at L3 [Level 3 autonomy]. L4 will still take some time. For L4, we still need legislative support. L4 means that you can operate without a driver in a specified area that legislation has given you access to.”
- “For autonomous taxis, California has approved L4 operation. But for trucking, they haven’t even started. It could happen in 2024, but from there to actual deployment, it might be more by mid-2025.”
- “Legislation is definitely an obstacle. When a company is ready, they need official approval of the process, which then allows them to operate completely autonomously.”
- “Apart from that, the autonomy itself is an issue. They have to do rigorous testing before they can deploy the trucks on the road.”
- “The test cases have to be approved. This is particularly difficult in trucking because trucks drive on highways. For example, if there’s heavy rain or something breaks down, what will the truck do? Would it come to a standstill on a highway? That would be dangerous. Or would it pull over on the side?”
- “And if there’s heavy rain that affects visibility, would it still pull over? Those are important questions, and I haven’t yet seen any news about how they’ll be resolved or documentation about what the backup plans are. I think they will have it worked out by 2025.”
- “We’ve heard about autonomous taxis in San Francisco stopping in the middle of the road, holding up traffic. That would be a huge issue on a highway where traffic is at very high speed. If a truck stops in the middle of a highway lane in heavy rain, there could be very serious accidents. These are scenarios that have to be very well tested.”
- “[What Aurora has going for it is] investment in the company. Amazon [is an investor](#), for example.”
- “Even if Aurora doesn’t meet the end-of-2024 goal, I think they can succeed.”
- “I don’t think there’s very high demand as of now. Demand might kick in once potential customers see Aurora demonstrating L4 autonomy.”
- “It will benefit transport companies to have a truck operated with one driver rather than two when they consider the rising wages in the trucking industry. Autonomous trucks would cut down on costs, and this would create a shift to autonomous trucking. Bringing transport costs down would have a wider benefit to consumer prices.”

**“I don’t think Aurora will hit its target by the end of 2024. ... Autonomous trucking has not yet been successful to date to be authorized to operate completely autonomously.”**

Software developer  
in driverless technology



- “I don’t think it’s necessarily realistic that they’ll have their fleet booked by the end of 2023. The end of 2024 is more likely.”

## Competitive Landscape

- “The companies that went underwater in the last two years had invested heavily in infrastructure. Embark, for example, had invested in trucks and other inventories, which I feel they didn’t really need yet. You need people first to develop the technology and to do simulations. Having just one or two trucks is fine. But a big infrastructure investment when you don’t have a fully working solution yet is a massive weight on the company. I think Uber was in a similar situation.”
- “Aurora has partnerships with OEMs and trucking companies that will help them, so they don’t need that big an infrastructure investment.”
- “Aurora and Torc are the two companies best placed to succeed in driverless trucks. Torc has a very solid backing from Daimler Trucks.”
- “Waabi has a different approach. They are focusing heavily on simulation, taking a bottoms-up approach where they are trying to make the simulation as near to reality and perfection as they can, with very minimal infrastructure investment. When they succeed with their simulation, they will start investing in infrastructure in autonomous trucking.”
- “I don’t think Aurora’s FMCW approach to lidar gives them an advantage. Luminar’s technology has more long-range lidar support than the frequency-modulated technologies. They would benefit more from Luminar’s lidar technology. I think Volvo and Mercedes use Luminar’s technology.”

“Companies that went underwater in the last two years had invested heavily in infrastructure. ... A big infrastructure investment when you don’t have a fully working solution yet is a massive weight on the company.”

Software developer  
in driverless technology

## Key Industry Issues

- “As states look at legislation to allow autonomous trucks, they are looking at the different use cases and backup plans, such as where and how the truck stops if it breaks down. Arizona, California, and Nevada are definitely looking at these reports of use cases. There have to be specific numbers of hours of testing in simulation of the use cases. There are also a certain number of on-road testing hours required. Once Aurora proves they can do it, it’s a step toward the legislation.”

## 2) Industry Specialists

Aurora can only meet its 2024 target for fully autonomous trucks in commercial operation in the most limited sense, said three of the seven sources in this silo. Any deployment without a driver in the cab would have to be on relatively short stretches of highway within a single state with favorable weather and might even face further limits on the time of day the trucks can operate. State-by-state regulations are not yet in place for broader use, four sources said, with two estimating it could take two to five years for such regulations to develop. Texas is the most likely state to greenlight fully autonomous trucks, three sources said. One said he foresees human operators still being needed in trucks for the foreseeable future and is skeptical of Aurora’s hitting its 2024 goal. One source speculated that early uses of autonomous trucks could be in platoons with a driver in the lead truck, while another said the quickest path to adoption is in specialized sectors that can operate the trucks in confined, off-road areas like construction sites. Autonomous technology is close to being road-ready, but a tiny percentage of edge cases continue to pose safety risks. In addition to the regulatory environment, obstacles to broader adoption include the high cost to manufacture driverless trucks, the higher cost per mile to operate them compared with traditional trucks, and concern about insurance and liability issues. One source said Aurora may have a better path to profitability if it focused on licensing its self-driving software and avoided any involvement on the hardware side. Two sources said Aurora is the clear leader in autonomous trucking, at least partly because of its CEO and leadership team. Waabi, Kodiak, and Torc were all identified as legitimate competitors. Two sources believe Waymo paused its trucking operation because it saw an easier path to profits in self-driving cars through ride-hailing services. Two said autonomous trucks will provide billions of dollars in supply chain efficiencies as well as improve safety.

## Key Silo Findings

### Aurora’s Commercial Launch Timeline

- 3 of 7 sources said Aurora could have fully driverless trucks in commercial operation by the end of next year, but all three said such operation will be extremely limited.

- All 3 said fully autonomous trucks are likely to be restricted to short stretches of highway within a single state with favorable weather and possibly limited to certain times of day when there is less traffic.
- 1 said companies are exploring segmenting routes—using a human driver to get a truck from a depot to a highway and allowing the truck to drive itself to a different hub, where it is met by another driver to handle city miles.
- 1 said it would be very optimistic for Aurora’s to think it can get approved to operate trucks with no driver in the cab before the end of next year.
  - More likely, Aurora’s autonomous fleet will still have drivers handle more complex sections of the route but allow the truck to operate itself for simpler stretches of highway.
  - He noted that Aurora, unlike Sweden-based [Einride AB](#), is building its trucks with a cab, suggesting it sees a role for human operators for the foreseeable future.
- 1 said early adoption of autonomous trucks will be in specialized, off-road sectors like construction or mining, where the vehicles can operate around the clock in confined areas.
- 1 said a possible mechanism for initial use of self-driving would be a platoon of vehicles with a human operator in the lead truck.
- 4 said state-by-state regulations around self-driving are in flux and remain a significant challenge to wider use.
  - 2 said it will be at least two years and perhaps as long as five before autonomous trucks can be used for long-haul routes that cross multiple state lines.
  - 2 noted that 2024 is a presidential election year, making it unlikely that any federal legislation to approve autonomous trucking will develop.
- 3 listed Texas as among the most likely states to allow autonomous trucking in the near future; 2 named Arizona, and one each suggested Florida and New Mexico could be early adopters.
- 3 said autonomous technology is getting close to being road-ready, a series of edge cases and variables still pose risk.
- 1 said potential buyers of self-driving trucks remain leery of possible negative publicity if accidents occur.
  - More testing and more data will be needed to make trucking companies comfortable.
- 2 said the high cost of manufacturing and operating fully autonomous trucks is an obstacle to broader adoption.
  - 1 said an Aurora truck could cost \$1 million to buy and as much as 35% more per mile to operate.
    - Over time, however, the operational cost spread between traditional and autonomous trucks will decline
  - 1 predicted that insurance costs will be a significant expense.
- 2 said it’s realistic to think Aurora will have its fleet of driverless trucks booked for work by the end of this year, while 1 other said it will probably take until next year.
- 1 said there will be more demand for autonomous trucks on long-haul rather than short-haul routes because the driver shortage is not as acute in the latter.
- 1 suggested Aurora’s best strategy for success would be to focus on licensing its self-driving software and to stay out of the hardware side of the business.

## Competitive Landscape

- 2 said Aurora has a competitive advantage with the quality of its leadership team, particularly its CEO.
  - 1 said the company has terrific engineers and top-notch technology.
- 2 listed Aurora as the most likely to succeed in autonomous trucking; 2 named Waabi, 1 Kodiak, and 1 Daimler’s Torc as key competitors.
- 1 said any advantage Aurora has is more likely around savvy marketing than superior technology.
- 2 said Waymo likely paused its autonomous-trucking development because it saw an easier and quicker path to profitability in robotaxis.

## Key Industry Issues

- 1 said political considerations around driver job losses could slow government approval of autonomous trucking; 1 other said self-driving trucks will not replace drivers but, rather, fill in gaps where no drivers are available.
- 1 said there is real debate within the industry about whether there truly is a driver shortage that would build demand for autonomous trucks.
- 2 said the advantages of autonomous trucks are manifold, including increased safety, reduced driver fatigue, improved fuel efficiency, and vastly better utilization rates that will speed delivery and decrease inventory levels.
- 4 said issues around insuring self-driving trucks remain unresolved, while 1 other said such insurance products already exist.

- 1 said public perception around the safety of autonomous trucks will be an important factor in how quickly regulations are developed to allow them on the road.
- 1 said California is likely to be a leading indicator in the regulatory area.
- 1 said demand for autonomous trucks may develop slowly because so much time and energy are being devoted right now to the transition to electric vehicles.

## 1) Senior industry leader with a background in digital technology and over-the-road trucking

Aurora can only reach its goal of having driverless trucks in operation by the end of 2024 in very limited scenarios, such as on short stretches of approved roads at certain times of day. Two key barriers stand in the way of widespread adoption of autonomous trucking: high operating costs and a system of individual state highway regulations that make it hard to deploy the trucks nationwide. It will take two to five years for these issues to resolve. Initially, autonomous trucks will be deployed for short distances. Aurora can succeed where Waymo and others have fallen short because it is benefiting from its legacy Uber platform, top-notch engineers, excellent capitalization, and a visionary CEO. Gaining the necessary regulatory approvals will depend on whether autonomous-truck companies can convince the public that these 80,000-pound machines are safe without a driver. There will be plenty of demand for autonomous trucks because of the cost savings of not needing drivers. The two leaders in the space are Aurora and Waabi. Insurance issues will have to be worked out around liability and indemnification. They are likely to be the highest costs.

### Aurora's Commercial Launch Timeline

- "Aurora's target of 2024 assumes that legality issues around autonomous driving will be resolved in some counties and some states; and they will be able to send their autonomous trucks on short, pre-approved stretches, perhaps at certain times of the day when there is less traffic."
- "It's not legal yet without a CDL [commercial driver's license] holder [in the truck]. I'm not convinced we are at the point where we can have a truck without a driver because we don't have the legislation yet. We have an election year coming up. I don't think the [U.S.] Department of Transportation with [Transportation Secretary Pete] Buttigieg would enable it."
- "I think we're about two years away. There will be legislation. If diesel and oil prices keep climbing, there will be more pressure to legislate and approve autonomous trucks."
- "There are potentially certain counties who will enable a portion of a highway to have driverless vehicles. I think what [Aurora's CEO] is stating is true [about having driverless trucks on the road by the end of 2024], but people tend to conceptualize it in a different way. A pickup in Dallas with a delivery in Houston is something that's not going to happen without a driver in the car for safety purposes. But maybe what we'll have is an autonomous truck driving five miles down the road without a driver. It's semantics."
- "In terms of legislation, it will depend on the county. Texas allows it, and if there's a progressive community or a road that isn't traversed much going inland, maybe at a certain time of the day, like the wee hours of the night. I don't think it's going to be how we are imagining it."
- "The CEO is not going to say something that specific about [the timeline for] autonomous trucks unless he's pretty confident he can do it."
- "I think for now there are only a handful of states [where driverless trucks might be allowed]—Arizona, Texas, and maybe New Mexico. It seems unrealistic that that number will grow by 37 states [by the end of 2024]. It will depend on legislation. I believe, though, Aurora feels comfortable enough to deploy it in 40 or 50 states. It comes down to bureaucracy and legislation."
- "Autonomous trucking is occurring now in Texas and Arizona. However, state regulations make it difficult to deploy nationwide, as each state has their own highway legislation."
- "I think [for autonomous trucking to become] mainstream is still five-plus years out, but Aurora and Waabi are active with routes right now."
- "There are two key barriers: cost and legal. The operational costs to run and manufacture autonomous trucking are extremely expensive. R&D costs will need to come down. If not, freight will be the cost of doing business."
- "Comparing costs, a leased truck costs about \$1,600 to \$2,000 a month. A Waymo or Aurora truck is about \$1 million."

**"There are two key barriers: cost and legal. The operational costs to run and manufacture autonomous trucking are extremely expensive. R&D costs will need to come down."**

Senior industry leader with a background in digital technology and over-the-road trucking

- “I believe Aurora is already Level 4, but it depends how you define it. They are not actively operating without a driver, but that’s mostly a safety-driven consideration as they work to improve the decisioning on that last 1% of events. Seems like it’s overall very capable without the human driver.”
- “[Their trucks] can make their own decisions, but they require a driver in the truck now. They are fully functioned to drive and operate without a driver, but the law still states there has to be a driver in there.”
- “They want to make sure of the safety. This is because they have 80,000 pounds of machinery driving at 65 miles per hour. It’s scary, and they want to assuage fears.”
- “Autonomous trucking is going to take off for short distances—for example, within San Diego or from Los Angeles to Rancho Cucamonga or from Chicago to Naperville. You can get multiple turns in a day, and you don’t burn up driver hours. In short, intercity runs, you can have high utilization numbers. With a driver, you couldn’t do that.”
- “For example, a driver in Chicago could get five runs a day before they run out of hours. An autonomous vehicle could get 10. The potential efficiency gains are remarkable.”
- “There may be a technical hurdle around charging the vehicles if there is no driver.”
- “I don’t think there is anymore data still needed. It’s the legislation that is lagging.”
- “Autonomous trucks are competing with truck drivers. That said, the industry is vast and big. There are 3.5 million truck drivers, but there’s a need for autonomous trucking in the space.”
- “There will never be a lack of demand for autonomous trucks. It’s a multitrillion-dollar industry. It’s an \$860 billion dollar marketplace just for over-the-road freight. This means there is plenty of demand for autonomous trucking. Today, there are capacity limitations. But the question is what the American public’s appetite is. Can the autonomous manufacturers build a product that is economically viable to compete with a human driver? The costs are much higher.”
- “As an example, a trip from Chicago to Indianapolis is just 200 miles. The trucking company might charge \$2 a mile or \$400 total. Autonomous vehicles testing with Aurora, Waymo, or Waabi would charge at least 70 cents more per mile because their costs are much higher, including for R&D. Freight is the cost of doing business. With a product that is environmentally and socially governed, you can pass the cost back to the consumer. But if you’re shipping a commodity like rubber or copper whose price changes all the time, with the addition of 70 cents a mile, you are now paying \$500 instead of \$400. You are losing \$100 of margin that you were making on that product because the cost of trucking bled through the margins.”
- “Eventually, we will get there. At some point, the costs will diverge and meet. The operational cost of trucking has gone up about 20% year over year since COVID. Insurance premiums, tires, and care and maintenance have gone up. Those fixed costs are not going away. But also, drivers’ wages got higher. In 2016, drivers were earning about \$17 an hour. Now some fleets are paying up to \$31 to \$36 an hour in California and \$27 an hour in Florida. Those wages can’t be reset. As wages go up, operation costs go up, and the efficiency gains of Aurora’s autonomous trucks [bring costs] down, and they meet in between. I think we’re probably five years away from that happening.”
- “It makes sense that Aurora can have a fleet of 20 trucks booked by the end of 2023. It sounds realistic.”
- “I rode in an autonomous truck, and it was the most exhilarating experience. The technology is absolutely incredible. It can pick out something moving 30 feet away on the side of the road, like a rabbit. There was a driver in there, but he did nothing except for being there as guidance in case of an emergency.”

## Competitive Landscape

- “I think the space is there’s for the taking now that Waymo is out.”
- “Aurora and Waabi are the two leading the space. They are in the best position to win the autonomous-trucking vertical, especially now that Waymo is out.”
- “Aurora is the most well-capitalized of all the competitors in autonomous trucking. They got a head start from their legacy Uber platform. Aurora has terrific engineers, and they have [one of] the largest fleets. The technology with Carnegie Mellon is truly top-notch.”
- “At some point, Waymo was the best capitalized. Waymo got out because the unit economics of self-driving taxis and cars made much better sense. You can get more turns, and the cost of the insurance risk of moving 80,000 pounds on a highway is different than the liability indemnification of moving a taxi in San Francisco. Also, they couldn’t scale across all the different states.”
- “Chris Urmson, Aurora’s CEO, is a tremendous visionary. If anybody can do this, it’s him.”
- “I feel very bullish about this.”

## Key Industry Issues

**“Aurora and Waabi are the two leading the space. They are in the best position to win the autonomous-trucking vertical, especially now that Waymo is out.”**

Senior industry leader with a background in digital technology and over-the-road trucking

- “The goal is for legislation allowing driverless trucks. That’s probably a few years away, too. They have to consider the perception of the American driver on the road. If you’re driving on the I-5, and you pass an autonomous truck, your reaction is that the technology is amazing and unbelievable. But then people start worrying about the 80,000-pound beast without a driver who is sharing the road with them. That perception needs to change, and I think it is slowly coming around with what Tesla is doing. People are getting accustomed to it. However, a 2,000-pound car is not an 80,000-pound truck.”
- “California is the leading indicator of the market. When they start, other states follow fast. If California adopts legislation for autonomous trucks, you know Illinois and New York will adopt it, too.”
- “Insurance is always an obstacle in this business because they are insuring 80,000 pounds without a driver. Indemnification is an important aspect. Who is liable? Companies want indemnification based on negligence. It can be the number-one cost.”

## 2) Logistics adviser with a focus on technology

Aurora is unlikely to have a fleet of completely self-driving trucks in commercial operation by the end of next year. It may have trucks that operate autonomously for portions of a trip but will still require a human operator on board. Regulations are not yet in place to have completely driverless vehicles, and it could take two to five years to develop such rules that would allow an autonomous truck to cross multiple states. Aurora, as well as Kodiak, has a good chance of succeeding because it has learned from the failures of some predecessors. Aurora’s strength is in its relationships with truckmakers and transportation partners. Demand for and interest in autonomous trucks is growing. Driverless trucks will add billions of dollars in value to the U.S. supply chain. The end of this year may be too soon to see Aurora’s fleet of 20 vehicles booked by customers, but it will happen by next year. It’s going to take 10 to 20 years before we see millions of autonomous trucks on the roads.

### Aurora’s Commercial Launch Timeline

- “Having their platform for trucking ready [by the end of 2024] would be pushing it. ... The regulations are not in place to have that in the short term.”
- “In the U.S., autonomous regulations are decided on a state-by-state basis, not at a federal level. For example, Texas is very open to testing autonomous driving.”
- “Texas, Arizona, and Florida might be the first to allow it, but I have not seen anything in writing that guarantees that to happen in 2024. With 2024 being an election year, I would doubt something somewhat controversial like driverless trucks would be approved.”
- “It seems there is a lot of confusion on the topic [of regulations]. I checked with two other autonomous-trucking companies. One said three states might allow it next year, and one answered 20 allow it today.”
- “There are a lot of misconceptions when people talk about autonomous trucks. People think autonomous means a driverless truck. ... The trucks [from Aurora] are not like Einride, who built their trucks without a cab. There isn’t even room for a driver to sit. Aurora, Kodiak, and TuSimple built their trucks around a cab, where there is a driver and where they still see a driver playing a role in the foreseeable future.”
- “We are going to see models with drivers in the cab more quickly than models without any driver. For example, Einride is used in Europe for short 20- or 30-mile trips from the warehouse to the port in an industrial environment. In a more complex environment like the U.S., where you have to go across multiple states, Aurora and Kodiak’s approach [with a cab for a human operator] is definitely the best way forward.”
- “While they haven’t reached autonomous [Level 5](#) where they can be completely driverless—and also there is no regulation at this time for mass autonomous trucks to drive on highways without a driver—they can use it for autonomous driving up to a certain level, [such as] autonomous Level 3, and that has a lot of benefits. Level 3 is the truck driving itself but where you still need a driver behind the wheel to take over at any point. It increases the safety of the vehicle and helps with driver fatigue. It’s taken a lot of the white-knuckling away, and the driver is happier and less stressed. The driver is getting assistance from the truck.”

“There are a lot of misconceptions when people talk about autonomous trucks. ... Aurora, Kodiak, and TuSimple built their trucks around a cab, where there is a driver and where they still see a driver playing a role in the foreseeable future.”

Logistics adviser with a focus on technology



- “As in a warehouse, where people think you are replacing a worker with a robot, the level of autonomy in an Aurora truck actually augments the driver’s capabilities to make them safer, and it makes their job more attractive. It’s also more fuel-efficient.”
- “I drove in a Kodiak truck a few months ago, and I’ve driven in others like Plus and a few others. They still have a driver and an engineer. It’s the truck driving, and the driver or engineer are there to take over as on a plane, like a pilot. People don’t talk about planes as autonomous vehicles, yet the pilot only controls a few minutes on a flight—maybe seven or eight minutes. The rest of the time, the plane is on auto pilot or autonomous. The pilot is only there so he can take over and go manual if something happens.”
- “Aurora’s goal of having driverless trucks [by the end of 2024] means that at some point [during a route] they will have sections of the drive being taken over by the truck. For example, they would have the truck driver handle the metropolitan area to be able to go to the facility to load and unload. But on the highway one hour out of Dallas going west, with 10 hours of the most boring drives ahead, they can hit the button for autopilot.”
- “You can do that right now as long as the driver is behind the wheel. The driver can’t go to the back to go to sleep. There are no regulations yet to allow the truck to drive so the driver is off the clock. This would be important because drivers are only allowed to drive a certain number of hours before they are required to have a rest. There are no regulations yet today that recognize autonomous trucks.”
- “We are still a while away from when the truck can go on autopilot, and the clock stops for the driver, and they can go on a rest break.”
- “Until then, legislation has to be voted on state by state. Many of the autonomous trucks are meant for long haul, to cross multiple states. Going from Texas to California, all the states where you’re going to drive need to have the same legislation that will allow you to go end-to-end autonomously. That could take two to five years.”
- “Even with cars, where there is less risk, we are only seeing cars used without a driver in very few locations—San Francisco, Phoenix.”
- “Staying within the state would accelerate the timeline. For example, Aurora could initially go from the [Mexico] border up to Dallas, which now has more volume coming out of Mexico, as we see more near-shoring and which already is a pretty long drive.”
- “However, even if Texas is pro-autonomous trucks, there is no regulation in Texas that allows you to drive the autonomous truck without the driver. In the short term, we are not going to see a truck without a person in it. For now, we will always have a pilot and an engineer in the vehicle. The legislation remains an obstacle.”
- “Technically, the AI part takes away the nonsense of when truck drivers get tired or distracted. However, the autonomous truck also doesn’t have common sense. They don’t have all the information to fully function on their own. It’s not quite foolproof yet, but we’re getting very close to where at least driver-assisted driving can be used.”
- “The truck’s machine learning helps train it as well as all the trucks doing that kind of driving. It also allows us to have enough data to convince insurance companies and local governments that they’ve driven millions of miles without incidents, and they can now accelerate the legislation to allow this kind of driving.”
- “[Potential customers] have some fears about autonomous driving. We see millions of Tesla drivers driving without a problem. But if there’s one accident, it’s all over the news. Many large companies also have private fleets with their name and logo on the truck. If they get in an accident—like what happened to Walmart, causing fatalities—it would be very bad advertising for that company. On the other hand, as the technology evolves, and we get a history of safety records, even more now than two years ago; and as we do more testing to get even more of that data, companies will feel more comfortable with it.”
- “Having driven in several of these autonomous vehicles, I felt more secure than in other vehicles.”
- “As long as you’re on a highway where you have nonautonomous vehicles, there are always going to be issues on the road. The regular driver might be responsible for the accident, but in trucking, most of the time it’s the truck that is found to be responsible. People always point fingers. Also, when you have an accident with a truck, it does more damage than a regular car.”
- “We’re getting to a point now where the more advanced trucking companies, as well as the larger manufacturing companies even with private fleets, are starting to see [autonomous trucks] coming, and they want to start investing in it and start using it.”

**“[Potential customers] have some fears about autonomous driving. We see millions of Tesla drivers driving without a problem. But if there’s one accident, it’s all over the news.”**

Logistics adviser with a focus on technology

- “However, for the rest, it will still take a while. The number of autonomous trucks is still very low, and even if we had legislation in place today, you wouldn’t see a million autonomous trucks on the road in a couple of years.”
- “Maybe this year, not yet [will Aurora have its own fleet of trucks booked by customers]; but next year, definitely. I think it’s the same with Kodiak. They have a similar number, with some being test vehicles and some driving. They have newer models and new partners for testing their software. They have new versions of their hardware and software. [Kodiak] has put everything in the side mirrors so they can easily replace it in about one hour of work.”
- “I think [Aurora and Kodiak] will be able to fill their entire fleet with work, but to see a million of these trucks on the road, it’s still going to take 10 or 20 years.”

## Competitive Landscape

- “The earliest companies were also the first to run out of money. Aurora and Kodiak were not the first, and they didn’t have to go through the same things. They started five years ago, not 10 years ago. They have the ability to be more up to date and can learn to spend their money more wisely.”
- “What Aurora has especially going for it is their transportation ecosystem. They work with OEMs like Toyota, PACCAR, Volvo Trucks; and they work closely with some of the largest transportation providers, like [Knight-Swift Transportation Holdings Inc.’s/KNX] [U.S. Xpress](#), Werner, [Covenant \[Logistics Group Inc./CVLG\]](#), Schneider, and [Ryder \[System Inc./R\]](#). That way, they are instilling trust. They are also getting some good use cases that will help move them forward.”
- “The earlier companies might have hoped that the legislation would be accelerated to allow them to get further than they were.”
- “For companies that are in test mode and can’t charge to get revenue for what they’re doing, it’s very hard to keep surviving on just the money that was invested.”
- “Kodiak is already doing runs between Dallas and Atlanta and getting paid to haul loads. They are already creating revenue for their trucks because they are so efficient. Normally, you can turn Dallas to Atlanta around twice a week. They are doing it three times a week with their autonomous trucks, generating revenue for the clients.”
- “If I were to bet money on them, I would say Kodiak and Aurora are among the few that I see having more of a path to success where others have failed. Out of all the companies that are still in autonomous trucks, Kodiak and Aurora are each ahead in certain areas.”
- “Since some of them have failed, like Embark and because of what happened with TuSimple, some people will say it didn’t work, but it’s just for the early adopters that it didn’t work out.”
- “Timing can be everything. If you start too early, you run out of money because you can’t generate revenue. You also have to look at legislation [and whether] it’s going to come in time so you can start to generate revenue out of the technologies, and they won’t be in test phase for 10 more years.”

## Key Industry Issues

- “I am a true believer in this technology. Some people think it’s going to replace truck drivers. We have a shortage of truck drivers. Robots are not replacing personnel in warehouses, and autonomous trucks are not replacing truck drivers. Warehouses are filling shortages with robots, and autonomous trucks are trying to fill the gap of the shortage of drivers.”
- “It’s also going to make the drivers’ lives better. There will be more of a focus on humans to do the local work. Going, for example, from the port of LA to Jacksonville [Florida] takes five to six days for a regular driver. With an autonomous truck, that would take two days.”
- “That kind of speeding up will have an enormous impact on inventory. Last year, U.S. business logistics costs went up 19%, and logistics costs are now 9.2% of GDP. The increase in inventory carrying costs was responsible for 60% of the increase. Everyone was sitting on way too much inventory because of COVID and lower consumer demand.”
- “Companies also needed to increase their inventory because of consumer expectations to have things delivered rapidly. There are huge distribution centers being built now to house inventory in the DFW [Dallas-Fort Worth] area. Imagine if you can deliver something in 18 hours instead of two days [and] you don’t need a local inventory point. You can just ship it overnight from another location. It’s going to have a major impact on real estate costs for the inventory. It is going to be billions and billions of dollars in value for the U.S. supply chain.”
- “[A remaining issue is] how much insurance would a driverless truck need, as typically you need insurance for the truck asset and the driver. Not sure that has been decided, and no one will move product on a truck without insurance.”

### 3) Business development executive with a road-mapping software company

Aurora's strategy of starting with freeways and in areas with good weather seems to be the fastest route to commercialization. That strategy sidesteps many of the hurdles plaguing autonomous vehicles, many of which involve edge cases connected to road mapping and real-time object detection.

#### Aurora's Commercial Launch Timeline

- "One of the things we do is friction and roughness mapping, which we have in our embedded software for production vehicles. We're collecting dynamically the friction information, and that gets to our back end in real time, and we can map that out. Friction conditions can change in a relatively short period of time, so you need constant updates every 30 minutes, which means getting a lot of vehicles on the road at all times."
- "Our target is to get our embedded software on vehicles. My long-distance radar is on autonomous-vehicle activities. I don't see any revenue possibilities [in self-driving vehicles] for probably five years; the earliest would be three years."
- "I've never worked with Aurora directly, but they are working on some of the issues that we are dealing with. We map out the condition of the road dynamically. If you look at all the autonomous activities going on, there's a reason it's being done in the southern U.S. or even in California, where there's not a lot of precipitation."
- "The first thing that Aurora is talking about is the southern route. It's because they can eliminate a lot of [weather issues]—not a lot of rain, certainly no snow or ice."
- "However, that doesn't mean it doesn't get dangerous on the road. A large part of driving autonomously is sensor data, lidar—which I think any autonomous vehicle needs to use—radar, as well as camera information; and then bringing that all together and trying to understand and classify all the obstacles around the vehicle. It's a lot of work, and it has to happen in real time. We have to predict the path that the vehicle can take based on all this obstacle detection."
- "When it comes to the dynamics of the vehicle, the speed of the vehicle, the tires on the road make all the difference; you can't accelerate or decelerate or corner without having good traction. And I know it's still an obstacle for autonomous driving. If you're taking a southerly route, you can maybe take [that obstacle] away."
- "If you limit yourself to highways and in a fixed geographical area, autonomous driving is an easier thing to do than, say, in a city like San Francisco, where we've seen AVs have issues. But there are still a lot of edge cases that are very difficult, without knowing specifically what Aurora can do."
- "For example, lane centering functions, where cameras are sensing the lanes on roads—there are a lot of areas where you lose that information on highways and elsewhere where the lane markings aren't visible for whatever reason. That's not necessarily an edge case, but combined with other factors that don't normally occur, it creates an edge case. Those cases are something that every autonomous-vehicle manufacturer tries to capture. But it's this thing where you can't possibly capture all the combinations. It's the 0.1% of things that can create issues with autonomous vehicles."
- "I tend to think that it's going to be difficult to truly go and service multistate [deliveries] with an autonomous truck. Also, because you need to get all states to agree [on the regulations]."
- "I don't know the details of [Aurora's] Continental deal, but it's not the hardware that's the real problem; it's the software. I imagine they have a pretty extensive base of software that they can develop on top of; otherwise, it wouldn't make sense."
- "One thing I think has the most possibility is that if you platoon trucks, you could have a driver in the first truck, even if that truck is operating autonomously. And then the other ones, it's almost like a train, where the trucks are communicating, and do the same operation. I've always thought that was something that should be able to fly in a relatively short period of time."

**"If you limit yourself to highways and in a fixed geographical area, autonomous driving is an easier thing to do than, say, in a city like San Francisco, where we've seen AVs have issues. But there are still a lot of edge cases that are very difficult."**

Business development executive with a road-mapping software company

#### Competitive Landscape

- "There are a couple of [Level 2 autonomous vehicle] systems on the road right now—[Ford's] [BlueCruise](#) and [Cadillac's] [Super Cruise](#). They will, hands off, drive the car, change lanes; but only on certain roads which are defined, which are highways. That shows you that [Aurora] is on the right track because it's an easier mapping

process and less traffic. You typically don't need to worry about oncoming traffic, so you can eliminate more variables."

- "In trucking, because there's a strong business case, it should be one of the first autonomous areas that is doable."

## Key Industry Issues

- "Regulatory bodies [such as] NHTSA are so far behind on this. They are trying to catch up."

## 4) Strategist for an autonomous-vehicle consulting firm

Aurora can meet its commercial launch timeline with deployments of driverless trucks in select states and in short segments that are all or mostly highway driving. Autonomous trucks are safe but face the challenge of sharing the road with human drivers, who can be unpredictable. Aurora's advantage over predecessors is its CEO, one of the top autonomous-vehicle leaders in the world. Waymo backed out of trucking because it can scale revenue faster with its robotaxi. There is very strong demand for trucks with driverless technology because of the driver shortage. The remaining regulatory issues around autonomous trucks should not be difficult to solve. California had been the most challenging regulatory environment, but the governor's recent veto of a bill that would have required drivers in autonomous trucks was an important development. Insurance is not an issue for autonomous trucks as several companies, such as [Koop Technologies Inc.](#), have insurance products.

### Aurora's Commercial Launch Timeline

- "I don't have any reason to believe that Aurora would fail to hit their target. Chris Urmson is one of the most respected autonomous-vehicle development leaders in the world. He also tends to be pretty conservative in his predictions."
- "I don't know if Aurora specifically will not have anybody in the truck. What's happening in the industry now is that all the trucks have somebody in the cab. They are usually labeled as safety operators, a kind of human backup system in case the vehicle makes a wrong decision or gets stuck. There have been very few safety instances where the autonomous vehicle did something it wasn't supposed to. TuSimple had the most heinous one, where it went off the road one or two years ago. Then the safety driver pulled it back."
- "I don't know where Aurora is in their development process, but it's likely they will have somebody in the cab still next year with a plan somewhere in their road map to remove that person from the cab."
- "There is also a wide definition of what commercial operations would look like next year. Some of the trucking companies have had commercial contracts already for the last two or three years. Gatik and Kodiak do, for example. Some of the companies are teamed up in commercial operations with logistics companies or retailers. It doesn't mean they are at full Level 4 [autonomous driving] 100% of the time, but they do have customers."
- "There aren't that many obstacles [to hitting Aurora's target]. They are probably regulatory, depending on the state. California hasn't figured it out yet. The speed of deployment is primarily driven by the technology."
- "Autonomous vehicles are pretty safe already, but the challenge is that they are not yet fully reliable to handle every situation. Sometimes they just stop as they try to figure out the situation."
- "It depends on the application [as to when drivers will be out of trucks]. In certain applications, it could happen next year, by the end of 2024. In trucking, it would depend on where the truck is driving and its mission. For example, if it's driving from North Dakota to South Dakota on the open highway with very little traffic, it probably can be done now. Some of the companies could handle it now. For that to happen in New York City, it might take two or three more years. The complexity of the mission will be the determining factor."
- "Segmentation is something that's being looked at. For example, with a long-haul trip from Ohio to Phoenix, can a human driver get it from the depot onto the highway; pull off the highway; and do a transition, with the human driver going back to get another truck from the depot while the truck continues on to the Phoenix depot, where a human driver picks it up and drives it into the city? If that's the case, even as early as next year, the autonomous truck wouldn't necessarily need a driver in it. This will be looked at on a case-by-case basis."

**"The biggest challenge for autonomous vehicles is that the road is also occupied by humans. Driver behavior and habits are unpredictable. It's hard for a computer to figure out the billions of different behavioral driving conditions that are out on the road."**

Strategist for an autonomous-vehicle consulting firm

- “The biggest challenge for autonomous vehicles is that the road is also occupied by humans. Driver behavior and habits are unpredictable. It’s hard for a computer to figure out the billions of different behavioral driving conditions that are out on the road. They are getting closer to being able to handle this main challenge. The challenge is operating in mixed traffic, because humans are very hard to drive around. As humans, we have trouble with that, too.”
- “Companies saying they will be able to take the operators out of the cockpit include minivans, sedans, cars, and full-size trucks. They are saying they will be technically ready to remove the human being from the cockpit. That doesn’t necessarily mean they will do it right away, but many companies are claiming the technology is ready.”
- “Waymo and Cruise are already operating [passenger cars] without any operator on board.”
- “Chris Urmson was one of the technical co-founders of Waymo. He is one of the top AV people in the world. That’s why we’re confident he can do it. He has learned from years of development. He has been developing autonomous technology since around 2006 or 2007.”
- “There is strong demand in trucking because of the driver shortage. There is a big shortage for all sorts of drivers—delivery, middle mile, long-haul. COVID impacted the supply chain, and it is constrained by human resources. It would be good to get autonomy up and running to take some of the burden off. It’s not about replacing people’s jobs, because there is a shortage. This technology can help.”
- “Yes, [Aurora could have its fleet booked by the end of 2023]. Other AV truck companies already have commercial contracts.”

## Competitive Landscape

- “I don’t think [Waymo backing out of commercial trucking] disrupted confidence in the autonomous-trucking industry, but it opened a couple of doors for startups to gain a foothold. Waymo sees that it can get to bigger revenue faster with the robotaxi product because it’s higher-volume, and they want to focus on that.”
- “People acknowledge that Waymo and Cruise are the top companies. I would put Aurora in the next tier after because of the talent they have, their funding, their history, and their experience. Aurora is a world-class company.”
- “Torc and Daimler are important competitors. I’ve heard Waabi is pretty strong.”
- “I haven’t heard that Mobileye is expected to enter commercial trucking.”
- “The answer [about Aurora’s approach to lidar] is going to be an opinion no matter who you talk to. You can get four different opinions from four different Ph.D.s. My guess is that it’s not that significant of an advantage either way.”

## Key Industry Issues

- “[Autonomous-driving regulations] are state by state. It’s not very difficult in the majority of the states. One of the most challenging has been California, and now the governor has vetoed a bill requiring an operator in the cab of an autonomous vehicle. He doesn’t want it to be mandatory. It was groundbreaking for California to stand up and say that.”
- “Texas and Florida already have operations going on. I believe they can legally do it without an operator in the truck, but I don’t know how technically comfortable they are doing it.”
- “[Insurance issues are] not at all [a significant obstacle]. I’ve worked on creating some of the first insurance products for autonomous vehicles. There are several insurance companies that insure autonomous vehicles, including trucks. Koop in Pittsburgh was created just for autonomous vehicles. Insurance is not an issue anymore.”

## 5) Chief analyst at a market research firm specializing in logistics; repeat source

Aurora may reach its target of driverless trucks in commercial operation by the end of next year but will be highly limited by state regulators dictating where they can drive and even the time of day they can be on the road. The high cost of manufacturing and insuring autonomous trucks might limit their appeal. Aurora’s CEO might be too optimistic about the near-term outlook for driverless trucks. It is not clear that there is much demand for autonomous trucks right now because there is too much trucking capacity and debate about whether a driver shortage really exists. Aurora has good marketing and has sold itself as a top company, but it might prove to be no more special than other autonomous-truck companies.

## Aurora’s Commercial Launch Timeline

- “Aurora may have driverless trucks by the end of next year, but they will be limited on where they can use them. It will be limited by each state they are going to cross, because this [industry] is state-regulated.”



- “Will the state allow them to operate in their state? If they do allow them, there will be other requirements. Will they be able to go on all the interstates or major highways at any given time, or will there be restrictions? It’s going to depend on the limits each state sets.”
- “Texas seems like an obvious state where the autonomous trucks will be allowed to drive. It’s huge and there are miles and miles of highway there with nothing on the road. It would be a great example of where an autonomous truck could go. However, I can imagine even Texas might say they need to put somebody in the truck for an initial period of a year or two.”
- “Insurance will also be an issue. It will not be cheap. Adding to that is the high cost of manufacturing these vehicles.”
- “In Atlanta, Forward Air is testing out Kodiak trucks. It’s in the evenings. I believe there is a driver present in the truck. You’re going to see that across the board—even in Texas, where they love autonomous trucks—that there is a requirement for someone to be in the cab. I think [the driver requirement will continue into 2024].”
- “When Aurora’s CEO states his goal, he should be defining what he considers to be ‘confident in the safety’ and also how much insurance they will have to put on each of the vehicles. I think he’s being overly optimistic.”
- “There’s about as much demand for autonomous trucks as there is for a basic new freight truck. The freight market has been described as being in a recession. The volumes are not there. We’re coming off the big highs during the pandemic. The trucking industry is struggling. I don’t think there are a lot of companies standing in line to get an autonomous truck.”
- “I was just at a trucking conference. There’s been a debate in the trucking market. One of the reasons for acquiring an autonomous truck is the lack of drivers. But the debate has been over whether we really have a shortage of drivers. It’s a huge question.”
- “Many people say there are plenty of drivers, and the problem is there is too much capacity in the market, too many trucks. The other side says there’s a shortage of drivers. The American Trucking Association says there’s a shortage of drivers. They have been saying that for over 20 years. Their viewpoint is that they see a shortage.”
- “The average age of the truck driver is in their late 50s, and it’s a very fragmented market. Some people have one or two trucks, and in bad times they just park the truck and find another job elsewhere until the market improves. Then they bring capacity back into the market. Those ins and outs in the market are creating the view that there is a shortage.”
- “Some of the major trucking companies have said even with ads on the backs of the trucks, they can’t hire enough drivers. They’ve invested in driving courses where they pay people for their CDL license. That has created interest in autonomous trucks.”
- “I’m on the fence about whether there’s a driver shortage. There are some parts of the market that are experiencing shortages in drivers, and there are other parts that aren’t.”
- “The people who can afford these trucks are more interested in trying them out, maybe getting one or two to test them. I don’t see that changing by the end of 2024.”
- “I think driverless trucks will be in operation at the earliest five years from now, and that’s a stretch. Besides the high potential cost of insurance and the state-by-state regulations, there just isn’t enough freight volume for those additional vehicles to come in.”
- “I don’t see this as a good time for autonomous vehicles, in part because of the way the freight market is now.”
- “At the conference, many of the carriers said they did not see any signs of improvement until the second half of next year or even the first part of 2025. That’s when freight volumes will improve.”

“Aurora may have driverless trucks by the end of next year, but they will be limited on where they can use them.”

Chief analyst at a market research firm specializing in logistics

## Competitive Landscape

- “I don’t see Aurora as more special than the other autonomous vehicles that are out there. Their chances are just as good as any others.”
- “There was a lot of smack talk in freight forwarding about [Flexport](#) [Inc.], that it was special. That’s how they marketed themselves. When you peel back the layers, there is nothing special about Flexport. They are just like any other freight forwarder. I believe it’s the same thing about Aurora. When you peel back the marketing and selling, Aurora is really the same as any other.”
- “It’s true that Aurora has some heavy hitters like FedEx, Schneider [National Inc.], Werner [Enterprises Inc.], and U.S. Xpress. To me, that means they are good at marketing and selling their ideas more than anything else. Their chances are just as good as any others.”
- “I can imagine Aurora might still be looking for more investment.”

## Key Industry Issues

- “[Insuring autonomous trucks] definitely won’t be cheap. It won’t be the basic car and truck insurance. It will have to be a very specialized and niche type of insurance.”

## 6) Brad Kelley, president and CTO of the [Pendragon Group](#), a technology consulting firm

Aurora’s best strategy is likely around licensing of autonomous-driving software rather than developing hardware, given supply chain challenges and rapid technology changes. The autonomous-trucking market may evolve slowly because equipment makers and large companies are more focused right now on the transition to low-emission vehicles. Further, the regulatory landscape remains unclear, including around liability issues. Political considerations related to potential job losses also could slow development. However, autonomous trucking is appealing in specialized circumstances where such vehicles can operate in confined areas or direct highway routes, situations that could garner regulatory approval more quickly.

## Aurora’s Commercial Launch Timeline

- “For Aurora, a strategic approach would be to offer licensing options for its technology to equipment producers. This would pave the way for more adaptable sales strategies and foster collaborative ventures.”
- “Diving into the manufacturing of proprietary hardware components, such as sensors and cameras, might not be prudent [for Aurora] given the rapid technological advancements and potential supply chain intricacies.”
- “Instead, a focus on crafting versatile software capable of interfacing seamlessly with a plethora of hardware brands and models will not only widen the operational spectrum but also amplify opportunities for tech licensing.”

“Diving into the manufacturing of proprietary hardware components, such as sensors and cameras, might not be prudent [for Aurora] given the rapid technological advancements and potential supply chain intricacies.”

Brad Kelley, president and CTO of the Pendragon Group, a technology consulting firm

## Competitive Landscape

- Did not discuss.

## Key Industry Issues

- “Based on current legislation, regulations, and economic conditions, most companies are focused on compliance and transitioning to ULEV [ultra-low-emission vehicle] and ZEV [zero-emission vehicle] assets.”
- “Although it currently applies only to federal agencies, Executive Order 14057 requires the annual reporting of carbon footprint for owned and nonowned assets—vehicles, buildings, and consumable resources. ... Although this EO does not apply to commercial entities, equipment manufacturers and large corporations are already focusing on quantifying these metrics in anticipation that the standard will become a regulation. In other words, their current focus is on compliance and transitioning to zero-emission vehicles and equipment.”
- “We’re witnessing a proactive response from equipment manufacturers and corporate giants. They are gearing up, meticulously calculating these metrics, foreseeing that such standards could soon become mandatory regulations.”
- “Given the pressing regulatory and legal imperatives to embrace low-to-zero emissions, combined with the obligations of compliance reporting and ESG [environmental, social, and governance] considerations, the emphasis on autonomous vehicles has been somewhat overshadowed.”
- “The legislative landscape for autonomous vehicles remains in flux, especially around pivotal issues like greenlighting driverless vehicles on public roads and determining accountability in the event of mishaps.”
- “Furthermore, socioeconomic challenges like the potential job losses for drivers have caught the attention of political leaders, labor unions, and self-employed drivers.”
- “However, the allure of autonomous vehicles shines brightly in specialized sectors. Off-road industries such as construction, mining, and oil and gas find them particularly advantageous since these vehicles can operate around the clock in confined regions, optimizing output while cutting down on human resource expenses.”
- “The appeal also extends to on-road scenarios, especially for material-handling firms and operations where assets transition between specific points, like ports to warehouses. Here, the primary routes are highways and industrial terrains. With targeted permitting, state and local jurisdictions might offer a green signal for such transit modes.”

## 7) Systems scientist for a university research lab focusing on urban and highway driving

Safety and insurance issues are the greatest obstacles for widespread adoption of autonomous trucking.

### Aurora's Commercial Launch Timeline

- Did not discuss.

### Competitive Landscape

- "From a technological standpoint, long-haul trucking is more or less equivalent to short-haul trucking. In both cases, the truck needs to enter a highway, follow it for a distance using distance-keeping and lane-change maneuvers, and exit the highway. The length doesn't change things much."
- "From an economic standpoint, short-haul routes are more likely to be attractive to drivers who don't want to spend long periods away from home, so autonomy is not as strongly needed."

### Key Industry Issues

- "The question of where liability resides is not fully answered from a legal standpoint for passenger cars. The safety problem is the principal reason for the absence of wide deployment of autonomous vehicles to date, and trucks are capable of inflicting far greater damage in accidents than passenger cars."

## 3) Trucking and Logistics Companies

Aurora could meet its 2024 goal for driverless trucks, said one source in this silo, but the other said such deployment is much further off. The more optimistic source said that the technology is largely ready for autonomous highway driving and that companies are building transfer points off highways so that drivers can drop off trucks that can then travel on their own. The more negative source said there are still too many emergency scenarios where a driver is needed to believe full autonomy is close to reality. The short-term deployment of driverless trucks should be limited to shipper depots before progressing to simple, repeatable routes, he said. Having skilled remote operators will be key to adoption of self-driving trucks, one source said. One said he had planned to deploy autonomous trucks developed by [Locomotion Inc.](#) because the company was building a product that still had a role for human operators. He has not engaged with other providers since Locomotion shuttered its operations. The other source plans start a trucking company using [Tesla Semi trucks](#), though he noted the emphasis in marketing the trucks has been on electrification rather than autonomy. The regulatory landscape and high cost of insurance will slow deployment of autonomous trucks, though one source said federal lawmakers will have an incentive to put a system in place for self-driving trucks to keep China from becoming the leader in the industry.

### Key Silo Findings

#### Aurora's Commercial Launch Timeline

- 1 of 2 said it is realistic to believe Aurora will have fully autonomous trucks in operation by the end of 2024, at least for straightforward highway routes.
  - o Companies are building transfer points just off major highways to allow transitioning from a driver to a fully self-driving operation.
- 1 said there are so many emergency scenarios where a driver is needed that it is going to be a long time before fully self-driving trucks are in use for long-haul routes.
  - o Autonomous trucks need to start within parking lots and then progress to repeated, shuttle types of routes to a single location before multicity and multistate segments are realistic.
- 1 said demand for autonomous trucks will be enormous because of the cost savings.
  - o A driver is roughly 40% of a trucking operation's costs.
- 1 said having skilled remote operators will be key to enabling self-driving vehicles.

#### Competitive Landscape

- 1 said he had chosen the now-defunct Locomotion as his provider for autonomous trucks because the company was developing a product that still had a role for drivers.
- 1 said he has put down a deposit for 10 Tesla Semi trucks.
  - o Tesla will have a big advantage because its trucking system can leverage data from millions of miles driven on its car platform.

## Key Industry Issues

- 1 said the state-by-state regulatory landscape is an obstacle to anything other than short-haul autonomous trucking.
- 1 said that insurers are going to charge huge premiums on self-driving trucks and that motor carriers will have no choice but to pay them because they could be bankrupt if an autonomous system was at fault in a major accident.
- 1 said there is not a true driver shortage but, rather, a retention and satisfaction issue for drivers.
- 1 said federal lawmakers are going to be motivated to approve autonomous trucking for fear of China taking the lead there.

## 1) CEO of a Missouri-based trucking company

Autonomous trucking will not be a reality until beyond 2027. Driverless trucks have not been proved safe yet, state laws might throw up roadblocks, and insurance companies are going to attach high price tags. Also, chip shortages are preventing technology from advancing as quickly as it might otherwise.

### Aurora's Commercial Launch Timeline

"Aurora is hanging on. They have done some decent stuff. They have some good technology. But they have to lower their bar [for when they can launch]. It's not happening in 2026 or '27."

- "There are many obstacles with driverless vehicles that you just can't plan for—a person running out in the road, a blowout on a tire, a deer, a flat, engine breakdown. You can't plan for that. So many things require that someone be there to monitor that vehicle. That could be some sort of other licensed vehicle—it doesn't have to be Class-A CDL driver."
- "Anybody that is trying to take the driver out—and that has been the mission from day one—they don't have enough money to be successful."
- "I believe in autonomous opportunities, but we have to back up to where we can prove the autonomous concept in the most safe way possible."
- "If we start by moving in our parking lots and our shippers' parking lots, that should be an easy win. Then we can go to a shuttle business—18 miles one direction, where we pick up at the exact location and go to the exact location every time about 50 times a day, all interstate except the 1.5-mile two-lane road to get to the interstate—that is an easy route to plan. We have to do those sorts of things before we start talking about going from Memphis to Knoxville [Tennessee] or El Paso to Houston. That's too big."
- "Everybody says we're right around the corner, but we're not. We have a public image problem already. We have to talk about what we can do instead of all the chatter."
- "Technology can grow rapidly, but we have a chip shortage that doesn't allow us to build pickup trucks and cars that we drive every day. Peterbilt had 5,000 [autonomous trucks] built, but not completely because of chip shortages. When a chip goes bad, where do you get the part to fix it?"
- "There's just not enough money out there right now."

**"There are many obstacles with driverless vehicles that you just can't plan for—a person running out in the road, a blowout on a tire, a deer, a flat, engine breakdown. ... Anybody that is trying to take the driver out—and that has been the mission from day one—they don't have enough money to be successful."**

CEO of a Missouri-based trucking company

### Competitive Landscape

- "We were comfortable with [now defunct] Locomation [for self-driving trucks]. The reason we went with them is that they were going to develop a product that still had drivers in trucks."
- "We aren't currently engaged in any discussions with the other AV companies. We are waiting on the Class-8 OEMs to deliver more [autonomous] products, like Freightliner and PACCAR."
- "[Waymo and Uber] have run out of money or have given up."

### Key Industry Issues

- "The regulatory landscape is being built state by state, and that is going to be an issue on anything other than intrastate."
- "Autonomous trucking needs to start with shorter haul. Repetitive runs can be proven fairly easily."
- "I believe that in the race to get to the moon—with the moon being [autonomous] trucks driving up and down the highway—all the autonomous manufacturers missed the breeding grounds. That should start in the parking lots of our shippers and terminals. We should have put autonomous trucks out on our lot and pulled trailers into the facilities. That would have been the place to start."

- “In California, they are serious [about regulating self-driving trucks]. If someone says they are going to require a driver, then they are serious about it. And they won’t back off. No matter what path they go down, they will not back up. They are serious.”
- “The autonomous manufacturers take on a lot of liability. [Insurers] are going to [evaluate] it in towers so it is hard to understand. They are going to ask the motor carriers to take on the standard level they have at their company, then they are going to put towers, starting at \$5 million increments and probably top out at \$20 million increments. They have to do that because the motor carriers, in today’s litigious climate, would not be able to survive an accident if there is fault with an AV.”
- “Articles say the driver shortage isn’t really [a shortage], and I would agree. We have a driver retention issue and a driver satisfaction issue. We have people entering the industry because they don’t know what else to do. Then they exit, and then they re-enter when the need to make money.”

## 2) Entrepreneur planning to launch a trucking business with Tesla Semi trucks

Aurora’s plan to have a fleet of driverless trucks on the road by the end 2024 seems realistic. Tesla claims it is on track to begin mass production of its Tesla Semi trucks by the end of 2024, but 2026 might be more realistic. It wouldn’t be surprising if the cost of ownership for a Tesla Semi is more than double the original \$180,000 estimate, and its driving range is likely to be much lower than Tesla’s 500-mile claim. Tesla delivered 36 trucks to PepsiCo last December but notably kept the focus of conversation on electrification rather than autonomous driving.

### Aurora’s Commercial Launch Timeline

- “I have paid [a deposit] of \$200,000 to have 10 Tesla Semis reserved. They were \$20,000 each [for the reserve deposit]. The reservation fee is fully refundable. I think reservations are closed now.”
- “I will have to hire drivers at some point, I assume. [But it will be attractive] if you can have the driver out most of the time and halve the fuel costs and have much lower maintenance costs and less downtime for maintenance. There are small profit margins in the trucking business, but [those things combined] just completely change the equation. The driver is something like 40% of your costs.”
- “The demand [for autonomous trucking] is huge because it’s about money. Trucking companies stand to make so much more money [from autonomous trucks] until the rates start to drift down, which will probably happen, and that will result in more consolidation because the little guys won’t be able to afford it.”
- “Driving on the highway is so much simpler than driving on local roads, and I think we’re basically there [with autonomous technology]. It seems realistic to me [that Aurora will have driverless trucks on the road by the end of next year].”
- “I imagine it’s going to be along the lines of you stay in the right lane, you go 60 miles an hour, tops.”
- “My question about Aurora is whether they will do transfer points where you get off the highway. There are businesses which are building yards for just that, to have transfer points between autonomous and human-driven trucks. You basically pull right in off the highway, and a driver takes over.”
- “For your average run then, it becomes about how many miles are on the highway vs. between the exit and the warehouse. So many companies are chomping at the bit for this because of the money you can save, at least on the highway.”
- “I think having really good remote operators will be a major enabler of vehicle autonomy. A bunch of companies are already doing this with things like forklifts and farm machinery. The latency is dropping, and I think that technology is basically there, too, [for] trucking. A truck could put out a signal indicating it doesn’t know how to handle a situation, and within seconds someone can remote in and either pull the truck over or [change speed, etc.]”

“Having really good remote operators will be a major enabler of vehicle autonomy.”

Entrepreneur planning to launch a trucking business with Tesla Semi trucks

### Competitive Landscape

- “I imagine the pricing [for a Tesla truck] will be much higher than what [the company] originally said. It was originally \$150,000 for the 300-mile-range version and \$180,000 for the 500-mile range. Those prices are ridiculously low. [Comparable] trucks are going for something like \$400,000 now and have much lower range.”
- “Tesla announced the truck in 2017; I think they were promising delivery in 2019 then. It’s always a year and a half away. I reserved [my trucks] in September 2020, and I remember thinking it’s going to be a year and a half [before



delivery]. Maybe six months ago, Elon [Musk, Tesla's founder] made a remark that [Tesla] was hoping to produce 50,000 in the year 2024, and then he amended that to say they'll begin mass production at the end of 2024. I'll be shocked if that actually happens."

- "I'm hoping I'll get some [trucks] in 2025 and thinking 2026 might be more realistic. I've stopped estimating. When Elon Musk says something is going to happen, there's a good chance that it will; it's just going to be triple the amount of time, or more."
- "[PepsiCo is currently deploying 36 Tesla Semis](#)—15 in Modesto and 21 in Sacramento [California]. The company expects to take delivery of the 100 Tesla Semi trucks it ordered by the end of 2023. This was done with a huge grant from the California Air Resources Board."
- "Interestingly, the focus has been switched away from autonomous vehicles and is staying on the electric angle. But [Tesla's vice president of supply chain, Mike O'Connell] said that the trucks [have the hardware for autonomous driving](#), but it had not yet been activated, and that autonomous features could be added in the future as an additional capability."
- "In an earnings call a couple of years ago, analyst Gene Munster asked Elon Musk whether the Semi trucks could benefit from all the data that's being gathered by [Tesla] cars. He said yes; you just have to tell it that it's in a different model [vehicle]. He basically confirmed that the truck would be able to use Tesla's [existing] self-driving software."
- "I'm hoping that's true, and I think Tesla's at an advantage because they've got all these millions and millions of miles that cars have driven. And no one else has those real-world miles. Not even close. They would have to do a lot of simulation, and it's just not as good."

#### Key Industry Issues

- "I think [Tesla's] ecosystem is going to include insurance, because they're doing that with their cars. I'm assuming they will have truck insurance as well. However, I also assumed they'd give me a 2.5% loan, which turns out not to be true."
- "What I learned from attending congressional hearings into autonomous vehicles is that China figures very large in the government's willingness to approve autonomous vehicles. They don't want China to get ahead of us. [For proponents of autonomous vehicles], that's awesome. It's good to have a boogeyman."

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Additional research by Eva Cahen, Emily Carr, and Marianne Weaver.

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