# DRIVINGBENCH: CAN VISION-LANGUAGE MODELS DRIVE A TOYOTA COROLLA?

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## ABSTRACT

Frontier models match expert humans across many digital benchmarks, yet real-world driving, a skill any new driver has, remains untested for them. We present DrivingBench, the first benchmark where general-purpose vision-language models must drive a real car. Through three tools, the models see camera frames from a Toyota Corolla and directly command its steering and speed around a parking lot cone course. The car may continue moving while the model thinks and new commands replace the currently running one, so inference latency is part of the task, testing the models' abilities to observe, act, monitor, recover, and complete a long-horizon objective under such constraints. We benchmark GPT-6 Astra, Claude Fable 5.1, GPT-5.6 Sol, and Grok 4.6 in vendor-native harnesses (Codex, Claude Code, Cursor) with up to three attempts each in one conversation; Astra is the only model to finish the course, on its second attempt, with no other attempt passing 50% of the course. Two of the four models improved materially across attempts with retained context. We release our harness, prompts, course map, and traces with video and telemetry for reproducibility.

## 1 INTRODUCTION

AI has made rapid progress across a wide range of digital tasks. Frontier models now match or exceed the performance of expert humans across many digital domains, and the benchmarks that were built to measure them saturate within a few years of release (and often within months) (Kiela et al., 2021; Hendrycks et al., 2021; Rein et al., 2024; Jimenez et al., 2024). Even benchmarks that were designed as a final exam for AI become quickly saturated (Phan et al., 2025; Glazer et al., 2024). Yet, as observed by Moravec (1988), skills that come effortlessly to people like perception and acting in the physical world are some of the hardest to reproduce in AI. Driving is a clear example: sixteen-year-olds can steer a car around a cone course in an empty parking lot in well under a minute.

Frontier models have recently started acquiring the ingredients a task like this needs: advanced abilities in vision, spatial/3D reasoning, planning, tool use, and the ability to learn from their past attempts2s in-context. Through vendor applications such as Codex, Claude Code, and Cursor, they are increasingly deployed as agents that act and use tools, rather than chatbots that only answer questions. This raises a simple question that has not yet been measured: can a *frontier model* (defined here as a general-purpose vision-language model (VLM), used unmodified through such agent applications), with likely no driving-specific training, drive a real car?

We introduce DrivingBench to answer this. There are three properties that distinguish DrivingBench from previous evaluations and benchmarks. First, the model itself is the driver. It sees camera images and chooses steering and speed commands itself, with nothing between it and the car except for openpilot's low-level actuation (comma.ai, 2026). Second, the evaluation runs fully in the real world and is closed-loop: the controls aren't familiar to the agent and have to be calibrated through feedback and in-context learning, and, unlike robotic pick-place tasks, mistakes can't simply be undone or retried in the same attempt. Third, time doesn't stop in the real world: the car keeps moving if the model places a steering command and starts thinking or pauses. Each new command given replaces the currently running one, so latency becomes an integral part of the task.

Language models have been put in real vehicles before. However, they have only been given the scope of configuring a conventional autonomy stack (which is what actually does the perceiving



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and steering). Talk2Drive (Cui et al., 2024) turns verbal requests into parameters for a pre-existing driving stack, and DriveVLM (Tian et al., 2025) pairs trained VLMs with a conventional planner. But in DrivingBench, the model itself is the driver. To our knowledge, it's the first evaluation in which frontier models perceive a real car's surroundings from cameras, and *directly* command its steering/speed in closed-loop.

Our setup involves a 2022 Toyota Corolla, to which we retrofitted a comma four running a modified version of the openpilot software (comma.ai, 2026). The model drives it via three Model Context Protocol tools (Anthropic, 2024): `observe`, `set_motion` and `stop_now`. Figure 1 shows an overview of the models inputs and controls of the car. Every model gets up to three attempts at a fixed 127 m cone course in a single continuous chat, with a generic reflection prompt after each failed attempt. We evaluate GPT-6 Astra and GPT-5.6 Sol in Codex, Claude Fable 5.1 in Claude Code, and Grok 4.6 in Cursor. GPT-6 Astra completed the course on its second attempt in 5 minutes and 22 seconds. Claude Fable 5.1 reached 45% of the course on its third attempt, while Grok 4.6 and GPT-5.6 Sol failed to pass the first corner. Common failure modes included misreading which side of a cone line the lane is on (perception), or acting on stale/old observations and committing prematurely to plans (planning, latency). Two out of the four models improved across attempts. The other two accurately diagnosed their mistakes in their reflections, but did not materially change their driving.




Figure 1: **A frontier model driving a car through a fixed cone course.** (1) Camera frame returned by `observe()`. (2) the model calls the MCP to control the car. (3) evaluation trajectory through the fixed cone course.

General-purpose models are beginning to show the ability to act in the real physical world out-of-the-box. To measure their progress on those real-world tasks we introduce DrivingBench, an open-source evaluation harness that connects MCP-capable agent applications to real cars. It includes three simple tools and layered safety limitations (Section 3). We release all traces, commands, transcripts, and appropriately-blurred videos. While our results show that general purpose models are now capable of completing real-world tasks such as driving at a very basic level, there are numerous failures in perception, planning, latency, and a gap between knowing and doing in in-context learning (Paglieri et al., 2025; Schmied et al., 2026). Nevertheless, these new model capabilities raise questions of safety, alignment, and ethics, that we return to in Section 7. We believe that this benchmark pioneers an important new paradigm for evaluating frontier models on real-world tasks. AI model capabilities have reached an inflection point where these physical tasks become feasible, and rigorous evaluation will be essential to measure model progress.

## 2 Related Work

Driving evaluations of language models have mostly been open-loop question answering over recorded scenes (Sima et al., 2024), or simulated closed-loop driving (e.g. in the CARLA simulator) with models trained for driving (Shao et al., 2024; Jia et al., 2026). The closest simulator experiments to our setup have evaluated LLMs at driving through code and APIs (Ma et al., 2024), with memory and reflection across episodes (Wen et al., 2024) just like our protocol does in a car.

General-purpose multimodal agents are benchmarked in simulation where they appear strong at high-level tasks but relatively weak at lower level control (Yang et al., 2025), as well as in real software environments where they are graded by execution (Xie et al., 2024).

In robotics, language models write policy code (Liang et al., 2023), choose among pre-learned skills (Ichter et al., 2023), or are trained on robot data (such as vision-language-action models, or VLAs) (Zitkovich et al., 2023). Untuned vision-language models can produce continuous actions

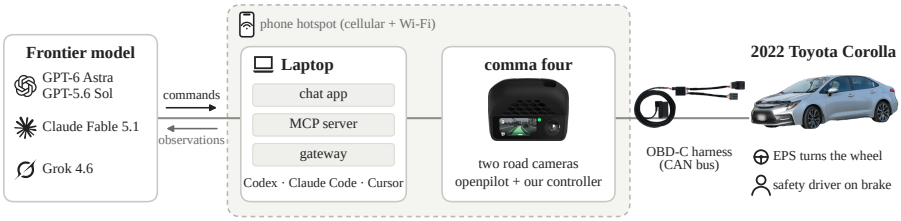



Figure 2: **DrivingBench System.** Frontier models run on a laptop inside their native harness (Codex, Claude Code, Cursor) and have access to our DrivingBench MCP server. The laptop used for evaluation and the comma four computer are both connected to the same phone hotspot. The comma device runs a modified version of the openpilot software, allowing the MCP to observe the front-facing camera and issue steering commands to the car.

on real robots, but the robot waits for every query (Nasiriany et al., 2024; Menon et al., 2026). By contrast, our car keeps moving while a command is still running, which is closer to policies that must already plan future actions while executing the current actions (Black et al., 2025). Our reflection prompt follows verbal self-reflection between trials (Shinn et al., 2023). The knowing-doing gap we observe (Section 5.4) has been reported previously in games and bandits (Paglieri et al., 2025; Schmied et al., 2026).

Robots controlled by LLMs can be coerced into unsafe physical actions (Robey et al., 2025; Zhang et al., 2025; Robocurve, 2026), and models often can show awareness of when they are being evaluated (Needham et al., 2025; Laine et al., 2024). This may provide evidence for why framing the task (or MCP server) as a sandbox had an effect on whether some models would drive, to some extent (Section 3). The same model can behave in opposite ways depending on the situation: GPT-6 Astra attempted 97 of 100 harmful robot-arm tasks in RoboHarm when simply asked to do so (Robocurve, 2026), yet during DrivingBench evaluations it refused to drive in an empty parking lot until we reframed the task and iterated heavily on our prompt.

## 3 DRIVINGBENCH SYSTEM

To facilitate DrivingBench evaluations we provide a reproducible system to connect AI models to a real car. Figure 2 provides an overview of the driving system. To perform the evaluations we use a 2022 Toyota Corolla. We install a comma four[1] device, an aftermarket autonomy kit, that allows old cars to be retrofitted with self-driving capabilities. The comma is a computer mounted on the windshield that connects to the car via an OBD-C cable to the CAN bus and allows us to send commands to the car to control steering, acceleration and brakes. Additionally, the comma provides a forward-facing and a wide-angle camera view. The comma device and a laptop, running the AI model that is being evaluated, are then both connected to the same wireless network.

**Driving Harness.** We provide an open-source implementation of our driving harness[2] including the car controller and MCP server (Anthropic, 2024). The model can take control of the car via the MCP server and has the following tools available:

**`observe()`** camera frames (narrow + wide), speed, steering, time left on command

**`set_motion(direction, steering_percent, speed_mps, duration_s, reason)`**

| | |
|---|---|
| `direction` | `left` \| `right` \| `straight` |
| `steering_percent` | 0–100 % of the maximum steering-wheel angle (180°) |
| `speed_mps` | target speed, 0.5–3.5 m/s |
| `duration_s` | 5–60 s; then the car brakes |
| `reason` | freeform text describing the intention of the command; used for logging |

**`stop_now(reason)`** brake immediately

[1] `https://www.comma.ai/shop/comma-four`

[2] `https://anonymous.4open.science/r/drivingbench_harness_v1-EEBC/`

**Driving Controller.** The MCP server then issues those commands to the car via our driving controller. The driving controller runs on the comma computer and is built on a modified version of the openpilot software (comma.ai, 2026). The controller can receive motion commands from the MCP, translates them into steering-wheel angles and submits those to the car via openpilot. Internally this angle is then converted into a tire angle with the Corolla's steering ratio and sent to the car.

**Operator Platform.** Alongside the MCP server we also provide an operator platform which can be used to manually control the car as well as change configuration details such as camera exposure or saturation. The operator portal also visualizes the live camera views and all the tool calls the model performs in real-time, allowing the operator to inspect the models' actions. Additionally, the car's traces including telemetry and tool calls are recorded and can be used to analyze and document evaluations. An overview of our trace viewer which we use to visualize these recorded trajectories can be found in Figure 5.

**Model Refusals.** During development of the system, we found that certain models, such as GPT-6 Astra, often refused to drive a real car. This was partly mitigated by assuring models that the conditions were safe, the car was located in an empty parking lot and a safety driver was in the car. However, models were still refusing to drive the car sometimes. Another path we explored was attempting to tell agents that they were located inside a simulation. This was not very successful as models were sometimes able to tell that they were in the real world after seeing the high quality camera images. Finally, we renamed our driving MCP server to `drivingbench_sandbox`, which combined with other prompt changes resolved these issues consistently and every model drove on every attempt. The final prompt used in our system can be found in Appendix A.

# 4 Evaluation Setting

## 4.1 Course

The evaluation task is to have each model/harness pair drive through a cone course and park in its finish zone (Figure 3). Multicolored mini-cones and tall orange cones mark a corridor that runs about 47 m up the main aisle, 27 m across the lot and 18 m down the final aisle, into a finishing $7 \times 5$ m zone of blue mini-cones. The route combines a left turn, two right turns, straights and gentle bends. Turn radius design was guided by openpilot's steering limits.

## 4.2 Models and Trial setup

We evaluate four models, each in an agent harness at medium reasoning effort: GPT-6 Astra and GPT-5.6 Sol in Codex, Claude Fable 5.1 in Claude Code, and Grok 4.6 in Cursor. Each harness adds its own system prompt, tool interface and latency, so we compare model–harness systems rather than models. Results thus reflect models as deployed with their native harness, and separating the model from harness is left to future work. The four trials ran consecutively in the order Astra, Sol, Fable, Grok.

A trial is a one-time chat session. It begins with a fixed prompt (Appendix A) that states the objective (arrive at the parking area marked by blue cones), the action semantics, general driving guidance, and informs the model it is scored first on how far it gets without leaving the course, followed by time to completion. A trial allows up to three attempts and terminates at the first success. After a failed attempt the operator sends a fixed reflection prompt (Shinn et al., 2023), followed by a fixed continuation prompt, in the same session (both in Appendix A). Attempts within a trial therefore share context and are not independent.

## 4.3 Metrics

The primary metric is *progress*, defined as the furthest point along the course centerline that the car reached while staying within 4 m of it, as a share of the centerline's 127 m up to the finish zone, so 100% means the car entered the finish zone. We compute it from the comma's GPS data between the first accepted command and the end of the attempt's last engagement. By our metric, each GPS fix can only advance progress, by at most 20 m, so stops and wrong-way driving add nothing and the car cannot gain progress by cutting across where the course folds back. Over the same window, we

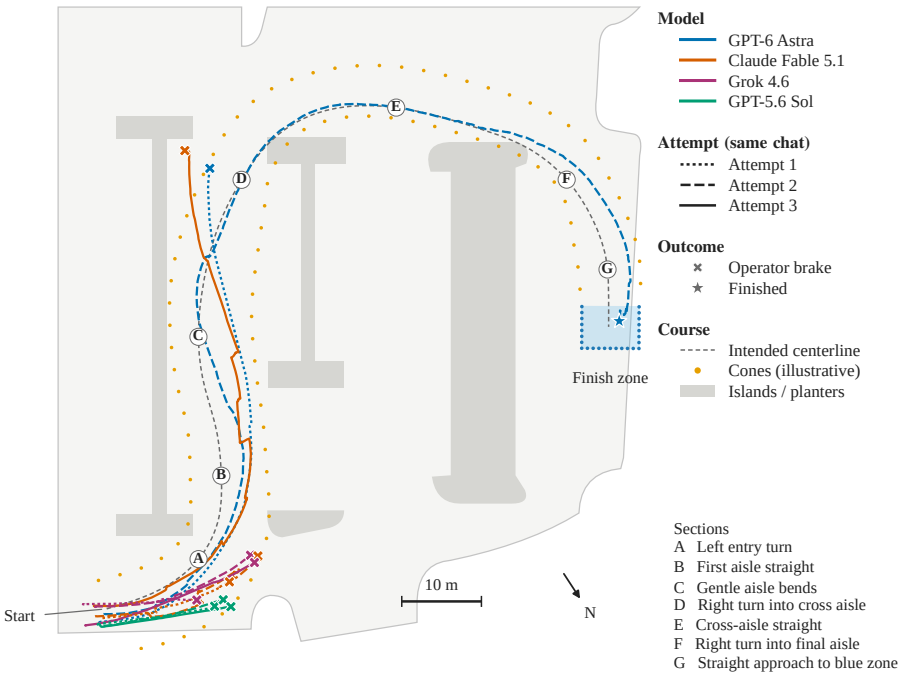



Figure 3: **GPS trajectories of all 11 attempts on the cone course.** Color identifies the model and line style the attempt within one chat. Markers show where the safety driver braked or where the car finished. Letters mark course sections. 8 of the 11 attempts ended before section B. The centerline was inferred from visible cones. Cone positions are illustrative (estimated from drone footage), not surveyed. The reference used for progress and benchmark percents (Section 4.3) is the centerline up to the finish zone, of length 127 m.

additionally report *time*, *distance* (integrated GPS speed) and the number of accepted `set_motion` *commands*, as well as *tokens* and *cost* at public list prices on the day of the trial, from each harness's usage records, including the reflection after each attempt. This metric of progress is imperfect and may not truly capture the "percent" of driving ability each model shows, but we believe it is a viable choice for attempting to encapsulate our benchmark results into one number.

### 4.4 Operator Protocol and Safety

An attentive driver sits in the driver's seat with a foot constantly over the brake throughout evaluations (Figure 2). Before each attempt, the car is driven back to the same marked start position, and our operator always made sure to align the car and its wheels to a fixed line in the lot, fixing both the car's position and heading for each trial. The operator engages openpilot and presses the RES button once the model's first command is accepted, since openpilot does not move the car from a standstill without this button being pushed. The car began moving a median of 3.0 s after that command. The operator hits the brakes when the car leaves the course, or is about to hit a curb, island or other obstacle, which ends the attempt. All 10 failed attempts ended this way (Appendix C); the successful attempt instead ended with the model's own `stop_now` inside the finish zone.

The operator sent two messages beyond the fixed prompts, both visible in the released transcripts and described in Appendix B.1: "Continue" once to Astra, and "Stop" to end Grok's attempts.

## 5 Results

In this section, we discuss the results of our evaluations and experiments. This includes 11 attempts over 4 models (Astra has 2: it finished on attempt 2, so no third attempt). We include per-attempt statistics (e.g. distance, moving share, replacements, gaps, peak speed) in Table 3, Appendix C.

Table 1: **Results.** Progress (%) per attempt; bold marks the first attempt that reached the best score. Finish time runs from the first accepted command to the end of the last engagement. Tokens and cost are summed over all attempts, including reflections, at list prices. All models ran with medium reasoning effort.

| | | Progress per attempt (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model | Harness | 1 | 2 | 3 | Best (%) | Finish time | Tokens | Cost ($) |
| GPT-6 Astra | Codex | 49 | **100** | – | 100 | 5:22 | 7.8M | 9.75 |
| Claude Fable 5.1 | Claude Code | 9 | 10 | **45** | 45 | DNF | 3.6M | 3.95 |
| Grok 4.6 | Cursor | 8 | **11** | 10 | 11 | DNF | 1.0M | 0.65 |
| GPT-5.6 Sol | Codex | **6** | 6 | 6 | 6 | DNF | 1.6M | 1.05 |

### 5.1 Course completion

Table 1 shows the overall results. GPT-6 Astra in attempt 1 reached 49% before drifting over the left cone line and toward the island, at section D (Figure 3). Its second attempt, however, finished the entire course and landed in the blue parking zone. It achieved this in 5:22 (322 seconds), driving 134.7 meters via 24 commands.

Claude Fable 5.1 improved from 9% to 10% to 45% over the course of its three attempts. Its first two attempts both crossed the cone line at A, but its third attempt surpassed this and drove the long aisle (B, C); similarly to Astra's first attempt, it then drifted too far left around D.

Grok 4.6 in its three attempts achieved 8%, 11%, and 10%; and GPT-5.6 Sol achieved 6% in all three attempts. All six of the attempts between these two models ended at A, within the first $\sim$15 m.

Figure 6b (Appendix C) hints at some differences in command strategy between the models. Astra progresses steadily (at $\approx$0.3% of the course per second), while Fable progresses in steps with very long, flat stretches. These are periods where its previous motion command ended, and the car waited stationary while Fable was reasoning, until it gave its next command.

### 5.2 Latency is part of the task

Our benchmark has the unique feature that the car keeps moving in the real world while the model thinks, so long as it has an ongoing motion command. Therefore, latency and inference speed and models' choices on how long to reason between commands all become part of the evaluation.

The median time from the previous tool call to a `set_motion` command for each model was: Astra 4.9 s, Sol 5.4 s, Grok 12.5 s, Fable 22.2 s (Figure 7a, Appendix C). Notably, models must also act on stale images. The car had driven a median of $\approx$4 m (Astra) between when the previous frame the model saw was captured, and when its motion command was accepted (Figure 7b).

Our tools also allow for an ongoing/running motion command to be replaced by a new command or tool call from the model. This is as opposed to queuing motion commands or waiting for a running command to complete its duration. This was used only by Astra (4 of 30) and Sol (1 of 6); Fable (0 of 12) and Grok (0 of 5) never replaced a running command.

Our setup means that expiry can be costly. The EPS only turns the wheel once the car rolls, so from rest, the wheel needs a median of 4.0 s to reach 90% of a steering change, versus just 1.9 s when rolling (Figure 8b). A stop-and-go strategy (such as Fable's) thus costs steering ability, especially at the turns. Appendix B.2 gives three examples of how exactly this played out.

### 5.3 Failure modes

Only one attempt succeeded, and the other ten attempts ended unsuccessfully (with an operator brake). Figure 4 shows one such failed attempt per model. Many of the causes we can infer for these failures fall into three broad groups (and latency, a fourth, is covered in Section 5.2), and generally align with the models' own reflections. Of course, any given failure can be assigned to multiple of these causes (or others), and these failures can compound each other (e.g. worse latency can make a model use a stale frame and overcommit to a premature plan).

**Reading the cone boundary.** This is a perception failure that affected 8 of the 11 attempts, at section A (including every Sol and Grok attempt, and the first two Fable attempts). Despite being able to see both cone lines across the frames, the model makes incorrect assumptions about which side of the first diagonal cone line the intended lane is on.

- Fable (attempt 2, turn 44): "I picked the wrong side of the boundary again. The diagonal cone line was the lane's left edge, not its right edge."
- Sol decided to use cone color to determine the side. Its final command in Figure 4 is explained as "centered between the near green-left and red-right cones"; its reflection (attempt 2, turn 51) notes that "The decisive error was assuming that cone color identified boundary side."
- Grok attempt 1 drove straight into the cone gate (turn 13): "The car is wider than the camera makes it look." This is despite our prompt warning the models that "the vehicle you are controlling is also 3D and is also wider than it might seem from the camera images."

**Planning and premature commitment.** This failure mode involves the model reading the scene roughly correctly, but then committing to a plan of some sort (e.g. a speed, or a gentle turn, or a direction) before it had enough information to be sure it was right, or without leaving room for change/error/leeway (e.g. the car's turning radius). This includes the two furthest failed attempts (Astra attempt 1 and Fable attempt 3).

- Astra's first attempt sped up too early while it was still straight and didn't leave time to turn right into section D: "I declared the car aligned too early. [...] I straightened and increased the requested speed to 1.5 m/s." (turn 51). Its final command was a 100% right turn into section D, but it came too late to make it (as shown in Figure 4, top).
- Fable's third attempt drove all the way through section C well, but then it started the right turn at D with only a "gentle 30% right to follow the curve" at 1.2 m/s (turn 82). This was far too gentle and left too little room, and soon after, the operator had to brake with the car pointed toward the top-left island (Figure 3).

**Vehicle/hardware limits.** The rate and the range at which openpilot can turn the steering wheel via the EPS motor is limited. The tightest turning radius possible is thus limited (from our data, $\approx$16 m), and turns also take time to build up especially when requested from rest. This means that corrections that start too late can't possibly be recovered when near islands or curbs. The models did notice these issues and limits from the telemetry and their attempts, but their conclusions weren't always accurate or persisted to their next attempts.

- Sol's first attempt (turn 21) included: "Steering built slowly; two seconds into that command, measured steering was still approximately 1%, so the car continued nearly straight." And by its last observation, "Measured steering had reached only about 17%."
- Fable somehow ended up drawing the opposite conclusion in its second attempt (turn 44): "I misjudged turn radius again. The car rotates far more than I expected at 100% over eight seconds," and planned to "Use 30% steering as the default."
- The turning radius limitations had some contribution to Fable's failure in its third attempt (Figure 4, second row) as its 30% right turn at D, sent 20 s after its last frame, was far too gentle to make it.

### 5.4 In-context learning across attempts

Two out of the four models, GPT-6 Astra (49 $\rightarrow$ 100%) and Claude Fable 5.1 (10 $\rightarrow$ 45%), improved materially across their attempts. Grok 4.6 and GPT-5.6 Sol did not really improve and stayed unable to clear the first turn (Table 1).

The reflections were largely accurate. The models even restated the fixes at the beginning of their next attempt. The issue, however, was actually turning it into a different or improved control procedure. This "knowing-doing" gap for LLM agents (in bandits and games) has been reported before (Paglieri et al., 2025; Schmied et al., 2026), but is now seen here in this real-world closed loop.

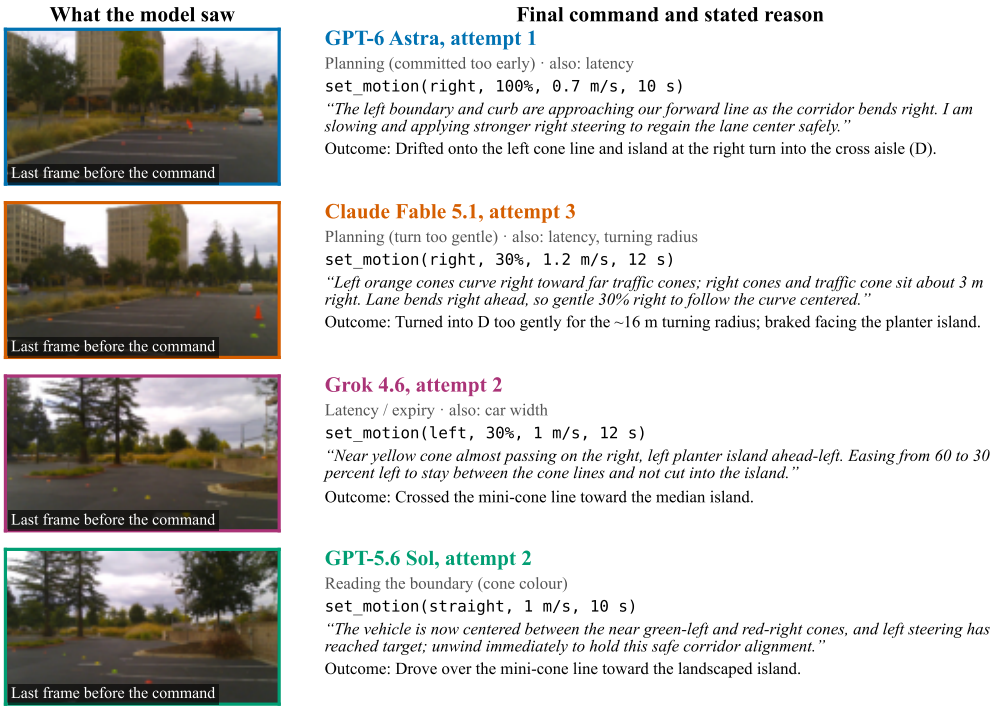



Figure 4: **What the models saw when they failed.** This figure includes one failed attempt per model. On the left, we see the last (narrow-camera) frame the model got before its final `set_motion` command. On the right, we see the model's final command along with its stated `reason`, and what the outcome was.

- Grok acted on its first reflection: after its first attempt, it resolved to commit to the left turn needed (turn 13), and in attempt 2 it immediately started turning left from rest. In its reflection after its second attempt (turn 28), it said: "Overlap every command. Replace while several seconds remain." In its third attempt, it announced "short overlapping moves" (turn 30). However, all three of its commands arrived after the previous one had already expired and the car had come to rest (0 of 2 motion command replacements, Table 3).
- Sol opened its third attempt by declaring that it will "treat cone colors as irrelevant … I'll follow the continuous multicolored cone line as the left boundary" (turn 53). However, it then sent two straight commands and ended up in the same place it ended previously (6%).
- Fable's improvement in its last attempt was one of perception (rather than steering/control). Starting its third attempt, Fable declared "This time I keep the diagonal cone line on my left and run along the parking stalls" (turn 46) and sent four 100% left commands.
- Astra's improvement is even more clear. In its first reflection (attempt 1, turn 51), it proposed "shorter travel increments at about 0.5–0.8 m/s" near bends and islands. Its second attempt then only sent commands for 0.5–0.8 m/s (attempt 1: 0.7–1.5), and observed 33 times instead of 13, and finished the course.

A clear caveat is that this is only $n = 1$ independent trial per model (since attempts share the same context/conversation). But there is some real evidence here that later attempts benefit not only from having seen parts of the course but from in-context learning and self-diagnosis of failure modes and improvement ideas.

## 6 Discussion and Limitations

Our results demonstrate that while general-purpose AI models have made significant progress on real-world tasks such as driving, they are still far from human-level. The best attempt finished

the course in 5:22, a task that would take a human far less than a minute. Part of this gap can be attributed to latency these models experience, e.g., Astra only requested a command every 10 seconds. However, current models are limited not only by latency, but also by spatial reasoning and decision making. GPT-6 Astra is able to complete the course fully, which demonstrates that a general-purpose model can already finish a real-world driving task end-to-end (even at low speed and under supervision). This is especially interesting as these general purpose models have thus far likely not been trained on a large corpus of driving related data, demonstrating impressive generalization capabilities.

While our DrivingBench framework pioneers a novel evaluation setting, it also has several limitations. Firstly, the DrivingBench driving system has a physical limitation on how much it can steer: 100% maps to 180° of steering-wheel angle, and in our telemetry data the car reaches only ≈130° in our evaluations (also due to the command durations the models chose), with a tightest turning radius of ≈16 m (Figure 8). This has implications on the type of track that we can evaluate the models on with the current system as they would be physically unable to complete tight corners. This also limits the models' ability to recover from errors they made, as they are unable to perform very tight turns to correct previous mistakes. The prompt's turning example was conservative relative to the models' telemetry and observed turning radii, stating that 100% steering takes ∼60 s for a 90° turn at 1 m/s, while in the evaluation conditions the measured radius implies it would have taken ≈25 s. All models received the same such prompt, and all models were affected equally by other limitations such as the cameras being unable to see the ground beside or behind the car, and the ground immediately in front of it. The prompt's turning example here came from a calibration run from rest we did before the trial. The car likely turned more tightly in evaluations because conditions like speed, command duration, and building up from rest versus from motion has effects on this.

Secondly, a limitation of our evaluation setup is that we only evaluated each model in one independent trial, with up to three (dependent) in-context learning attempts. In future work, we plan to broaden this evaluation protocol to add statistical significance.

## 7 Conclusion

We introduced DrivingBench, our benchmark evaluating frontier models driving a real car in the physical world. They see real camera images and command steering and speed directly in closed-loop, while the car may keep moving. One of four models completed the course (GPT-6 Astra on its second attempt) while others reached at most 49%. Most stopped at the first corner.

Driving a cone course is a skill any new driver has and can pick up quickly, but one that general-purpose models are now only beginning to show signs of ability in. Unlike saturated digital benchmarks, DrivingBench even in its current form has large headroom for improvement: a human needs well under a minute to reliably finish the course in one try, while three of four models do not finish, and none make it past 50% in their first attempt. The capabilities limiting the models, including perception or spatial reasoning, acting under latency, and acting on accurate self-diagnosis in their control procedures, all matter for physical AI well beyond vehicle driving.

General-purpose models showing preliminary abilities to control real vehicles out-of-the-box also raises new questions. Models' willingness to drive at all depended intricately on how we framed the task, consistent with models' awareness of evaluation protocols (Needham et al., 2025; Laine et al., 2024). How such models *should* behave when handed control of a real-world vehicle, and how to evaluate that behavior properly, is a question we leave for future work.

We plan in our own future work to run several independent trials per model, sweep reasoning effort levels, evaluate more models (including open-weight ones), and build longer and harder courses with a progress measure that scales with them appropriately.

### AI use statement

We wrote most of the harness (controller, MCP server, interface) and data pipeline with AI coding agents (Codex, Claude Code, and Cursor) under our prompting and design direction. We also used AI coding agents for the pipeline that cuts, aligns, blurs, and exports the released traces and videos. We also used them to analyze traces and categorize model diagnoses/reflections, find quotes in

the transcripts, and compute statistics and produce visualizations. We did not use AI to generate synthetic data, formulate mathematical claims or proofs, or translate; these are not applicable. We used AI assistants to search for related literature, and also to scout candidate empty daytime parking lots using satellite imagery such as Google Maps. AI was used in polishing sections of this paper including improving grammar and wording, as well as figure captions. AI was used in drafting much of the appendix content in the paper. All authors reviewed the text, figures, and citations. We take responsibility for the final content of this work, including text, code, figures, and claims produced with the aid of generative AI.

### ETHICS STATEMENT

All driving occurred at very low speeds in an empty parking lot, and not on public roads. We always had a safety driver in the driver's seat who was attentive and had his foot on the brake throughout.

We also have several other safety limitations. The harness has an enforced hard speed ceiling and disarms the system if the car exceeds 6 m/s, and we left openpilot's own safety features, including driver monitoring, enabled. Measured speeds peaked at less than 3 m/s, and the 6 m/s emergency hard ceiling never triggered. All interventions were brakes, and no collisions occurred in the reported trial.

No human subjects took part; the operators are the authors themselves. The released videos and frames have all faces and license plates blurred, and the location of the course is not disclosed for privacy and safety reasons.

Releasing our harness and code which allows general-purpose LLMs to drive a car carries some risks of misuse. It requires a supported car, a comma device, an attentive person in the driver's seat, use of the recommended speed limits and emergency stop, and it is documented and tested on a specific closed private course only, with a use-at-your-own-risk disclaimer.

Models' willingness to drive depended on the prompt and framing of the task; we report this because it may shed light on how general-purpose LLMs should behave when given control of physical systems.

We are not affiliated with comma.ai, openpilot, Toyota, or any of the model or coding agent vendors evaluated, and we received no support from them.

### REPRODUCIBILITY STATEMENT

Our harness (controller, MCP server, interface) and code are fully open source and available at an anonymized link: `https://anonymous.4open.science/r/drivingbench_harness_v1-EEBC/`. This includes installation and deployment instructions and documentation.

The exact prompts used are in Appendix A; the tools and their parameters are in Section 3; the course, its dimensions and the progress metric are in Section 4.

We release every attempt's GPS track, telemetry, tool calls with arguments and LLM-given reasons, the camera frames each model saw, the chat transcripts, and blurred road-camera video (plain and with the active command overlaid). All figures and tables are computed from these files. For review, the data and videos are available at an anonymized link: `https://osf.io/dwhvz/overview?view_only=5bd761d6641c4323b0c6a7ff80beee6c`.

Reproducing the experiments requires an openpilot-supported car (ours is a 2022 Toyota Corolla), a comma four, and a comparable course; results also depend on the model versions and agent applications available at the time of the trial, and also may depend on the specific car model or hardware.

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# A PROMPTS

Every model received the same three prompts, reproduced verbatim below. The main prompt opened each trial; after a failed attempt the operator sent the reflection prompt and, once the model had replied, the continuation prompt. The text is exactly as sent, including the Markdown escape characters (e.g. `set\_motion`); only typographic quotes and dashes are shown as their ASCII equivalents.

### MAIN PROMPT

```
Use only the `drivingbench_sandbox` MCP. Complete the stated objective using its tools.

OBJECTIVE
You are in a course delineated by mini-cones (small multicolored) and the environment (walls, etc). Your objective is
to drive through the course (in a backwards-U-shaped parking lot) and stay between the cones. Your finish line is a
wide "parking spot" marked by numerous BLUE mini-cones at the very end; finish by parking in this area. You will be
evaluated primarily by how far you get in the course (without leaving the boundaries/collisions), but a secondary
objective is to complete the course in less time.

ROLE
Use set\_motion(direction, steering\_percent, speed\_mps, duration\_s, reason). Direction is left, right or straight;
steering\_percent is 0-100. Zero is straight for either turn direction.
```

```
100% requests 180 steering-wheel degrees; observe reports steering\_percent on the same scale, positive left. The
speed ceiling is 3.5 m/s. The final steering target is sent immediately; native limits govern actual response.
In every set\_motion and stop\_now, give reason: about thirty words on what you see and what the command is for. It is
 recorded for the operator and never changes what the car does.

DRIVING

- Choose durations that allow observation and reasoning latency; the car continues moving while you think.
- Observe, send a motion command, then observe actual movement and adapt.
- Commands replace globally rather than queue. Duration starts at acceptance and includes steering buildup and
engagement waits. Motion continues while you think; expiry begins braking, not guaranteed standstill.
- A rejected replacement leaves the previous command unchanged. After an uncertain transport result, observe instead
of blindly retrying.
- Any connected chat can replace the active command or call stop\_now. DrivingBench is always active. Native
engagement and ready vehicle inputs are required; Stop cancels motion until a fresh command.
- timestamp is UTC response time, not image capture or command acceptance time. image\_age\_s is image age at producer
 response.
- Carefully look for objects and obstacles (parked cars, buildings, islands, trees, etc); they're all 3D and the
vehicle you are controlling is also 3D and is also wider than it might seem from the camera images. You must avoid all
 objects and obstacles, your attempt will be terminated if you collide with any of them.
- If possible, try to always be in the center of your lane/road and maximize distance from obstacles.
- In successive observed images, pay attention to what changes, i.e. new obstacles/information/etc, and/or changes in
distances to existing things you've seen in previous images. If obstacles are getting closer on either side, this
could encourage steering away from them to maintain distance.
- Over time, understand the behavior that occurs when you choose different actions or steering inputs and adapt to
this.
- Think and plan carefully where you want to end up and plan your route accordingly and advance toward subgoals.
- Don't be afraid to do sharp turns or choose high steering %s. It's better to be aggressive and "make" the turn than
to be conservative and not have room to finish the turn to get to where you want to go.
- Also, your vehicle cannot do arbitrarily tight turns; 100% might be much less tight than you expect. 100%
corresponds to doing a 90 degree turn at 1 m/s for \~60 seconds. Therefore you might want to start your turn earlier
than you expect and plan your approach to account for this.
- Largely keep your turning %s for left/right in the set {30%, 60%, 100%}.
```

#### REFLECTION PROMPT

```
Your previous attempt has now ended (likely due to a mistake or collision with an object or the environment). Reflect
on how you did in your previous attempt, why it might have ended, and what you can do better in a future attempt.
```

#### CONTINUATION PROMPT

```
You now have been granted another attempt to complete the same objective as before. Begin now.
```

## B PROTOCOL AND LATENCY DETAILS

### B.1 OPERATOR MESSAGES

The operator sent two messages beyond the fixed prompts, both visible in the released transcripts. After the continuation prompt for Astra's attempt 2, the model observed once while the car was still being reset; the operator interrupted that turn, the next turn ended without a command, and the operator sent "Continue" with no other information. For Grok, the operator ended each attempt by sending the next message instead of interrupting the turn, because in Cursor pressing stop and then typing overwrites the previous message: the reflection prompt after attempts 1 and 2, and "Stop" after attempt 3.

### B.2 LATENCY EXAMPLES

**Latency and commands expiring.** Commands have durations, and when they run out, the car brakes. Additionally, the car continues moving while the model thinks or during the wait time between model tool calls or responses. Therefore, models sometimes acted based on frames that were many seconds (or meters) old, or let commands expire and then had to restart from rest which can be more difficult in many situations (such as turns).

- Grok's second attempt sent its last command 17 s after the last frame it ended up seeing. During that time, the car rolled 7.4 m (Figure 4). Its reflection (turn 28) includes: "The first

move expired. I next looked while already stopping at 1.1 m/s, with yellow and red cones a few meters ahead." and "I then waited ∼13 seconds before the next command. Expiry only starts braking; the car can still roll into a cone."

- Astra realized the same issue in its first attempt: "At roughly 1–1.5 m/s, several seconds of interpretation and tool calls meant several additional meters of travel. The strong correction began after much of the available clearance was already gone." (turn 51)
- Fable, in its second attempt, acted based on a frame that was 55 s old. The car was nearly stationary (and only moved 2.1 m), so this mostly wasted time rather than burning distance blindly. But in general, Fable spent such a low proportion of time moving the car: it was only moving for 15% of this attempt, the lowest out of all the attempts (Table 3).

## C Additional results

Table 2 records how each attempt ended and Table 3 gives per-attempt statistics. Figure 5 shows the trace viewer used to inspect attempts. Figures 6, 7 and 8 support Section 5; Figure 9 shows the steering commands each attempt requested, and Figures 10–13 show requested against measured speed and steering over every attempt.

Table 2: **How each attempt ended**, from the road video and human operator notes. Letters are the course sections of Figure 3.

| Model | # | Progress (%) | End of attempt |
|---|---|---|---|
| GPT-6 Astra | 1 | 49 | Operator brake: drifted onto the left cone line and island at the right turn into the cross aisle (D) |
| | 2 | 100 | Finished: the model's own `stop_now` inside the finish zone |
| Claude Fable 5.1 | 1 | 9 | Operator brake: swung left across the cone line toward the median curb (A) |
| | 2 | 10 | Operator brake: outside the cone line again, pointed at the median island's curb (A) |
| | 3 | 45 | Operator brake: too little room for the right turn at D, pointed at the planter island |
| Grok 4.6 | 1 | 8 | Operator brake: drove straight into the mini-cone gate toward the landscaped island (A) |
| | 2 | 11 | Operator brake: crossed the mini-cone line toward the median island (A) |
| | 3 | 10 | Operator brake: crossed the mini-cone line toward the median island (A) |
| GPT-5.6 Sol | 1 | 6 | Operator brake: crossed the mini-cone line at the start of the course (A) |
| | 2 | 6 | Operator brake: drove over the mini-cone line toward the landscaped island (A) |
| | 3 | 6 | Operator brake: crossed the cone line at 2.8 m/s, heading for the landscaped island (A) |

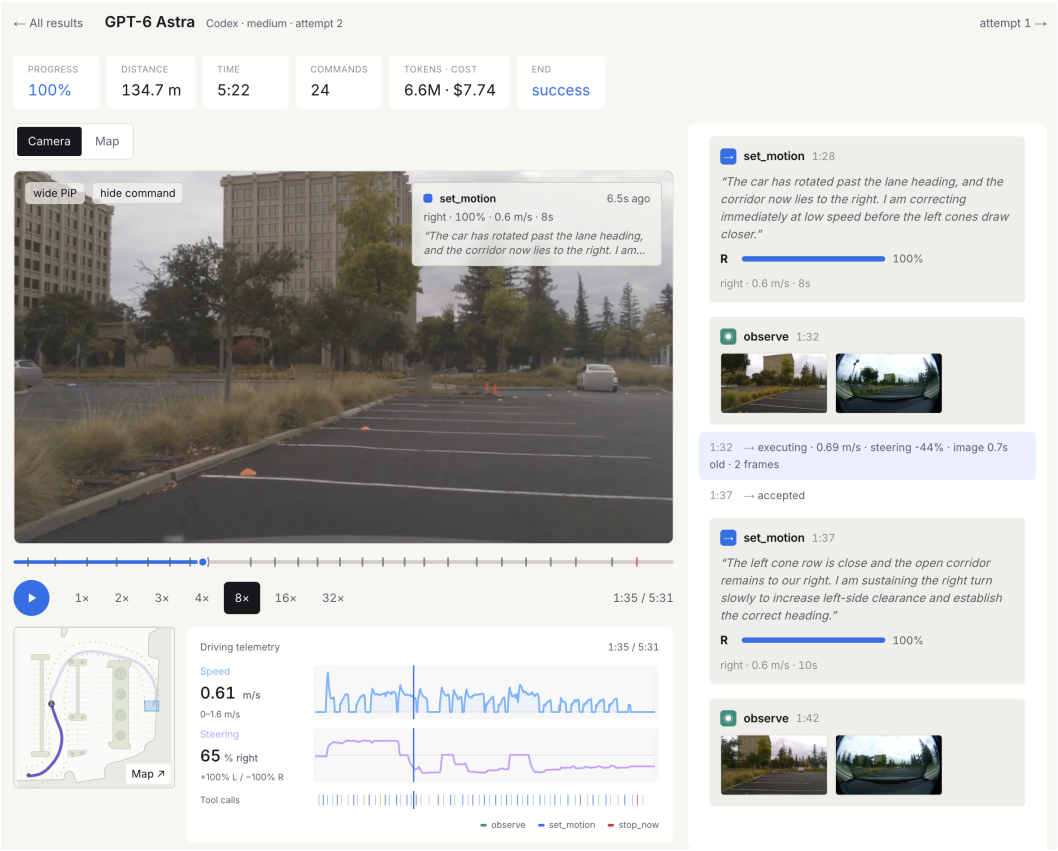



Figure 5: **Trace viewer.** Trajectories recorded with our driving harness can be visualized in our trace viewer tool. It renders the recorded video of the evaluation run along with MCP tools that were used by the model and car telemetry such as steering, acceleration and position. All these data points are synchronized by timestamps and can be replayed alongside the video recording.

Table 3: **Per-attempt statistics.** Dur.: first accepted command to the end of the last engagement. Moving: share of that window with speed $> 0.1$ m/s. Repl.: commands sent while the previous one still had time left, out of the commands that followed another command. Med. gap: median time between consecutive commands. Peak: highest measured speed.

| Model | # | Prog. (%) | Dist. (m) | Dur. (s) | Cmds | Cmd/min | Moving (%) | Repl. | Med. gap (s) | Peak (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|
| GPT-6 Astra | 1 | 49 | 67.3 | 78 | 8 | 6.2 | 85 | 2/7 | 10.0 | 1.8 |
| | 2 | 100 | 134.7 | 322 | 24 | 4.5 | 65 | 2/23 | 12.1 | 1.6 |
| Claude Fable 5.1 | 1 | 9 | 17.5 | 41 | 3 | 4.4 | 45 | 0/2 | 18.9 | 1.8 |
| | 2 | 10 | 27.3 | 190 | 4 | 1.3 | 15 | 0/3 | 60.8 | 1.9 |
| | 3 | 45 | 73.7 | 260 | 8 | 1.8 | 27 | 0/7 | 32.7 | 2.2 |
| Grok 4.6 | 1 | 8 | 14.4 | 35 | 2 | 3.5 | 35 | 0/1 | 28.7 | 2.0 |
| | 2 | 11 | 22.6 | 49 | 3 | 3.6 | 39 | 0/2 | 23.6 | 2.4 |
| | 3 | 10 | 22.2 | 43 | 3 | 4.2 | 53 | 0/2 | 17.7 | 1.9 |
| GPT-5.6 Sol | 1 | 6 | 15.0 | 28 | 3 | 6.5 | 42 | 0/2 | 13.5 | 2.1 |
| | 2 | 6 | 15.6 | 38 | 4 | 6.4 | 46 | 1/3 | 12.4 | 1.5 |
| | 3 | 6 | 17.1 | 27 | 2 | 4.4 | 36 | 0/1 | 14.8 | 2.8 |

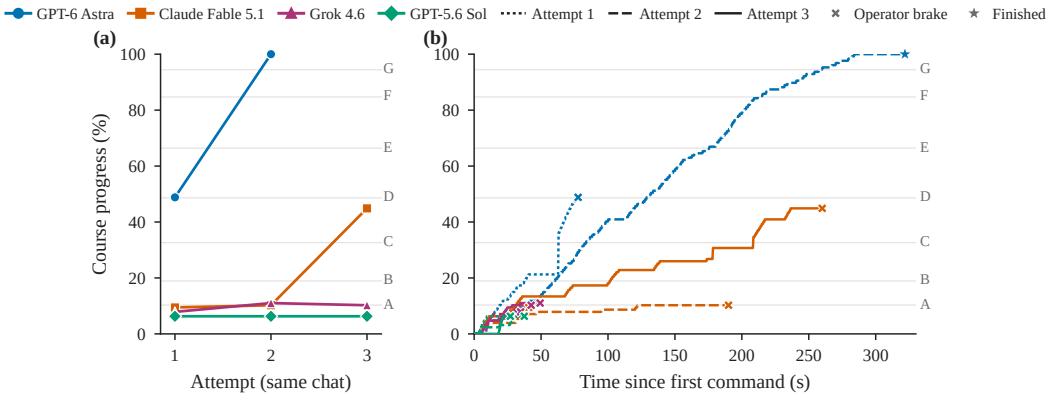



Figure 6: **Course progress.** Progress is the furthest point along the intended centerline (127 m, up to the finish zone) that the car reached while staying within 4 m of it. (a) Progress per attempt. Later attempts happen in the same chat after a fixed reflection prompt. (b) Progress over time, measured from the first accepted command. Horizontal guides mark the section labels in Figure 3.

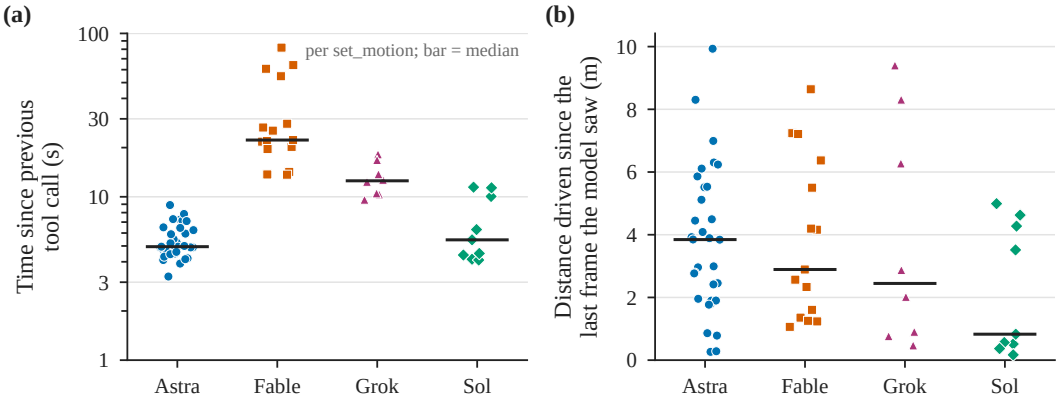



Figure 7: **Acting on stale observations.** For every accepted `set_motion`: (a) time since the previous tool call, mostly model deliberation (log scale); (b) distance the car drove between the capture of the last camera frame the model had received and the command's acceptance. Bars are medians.

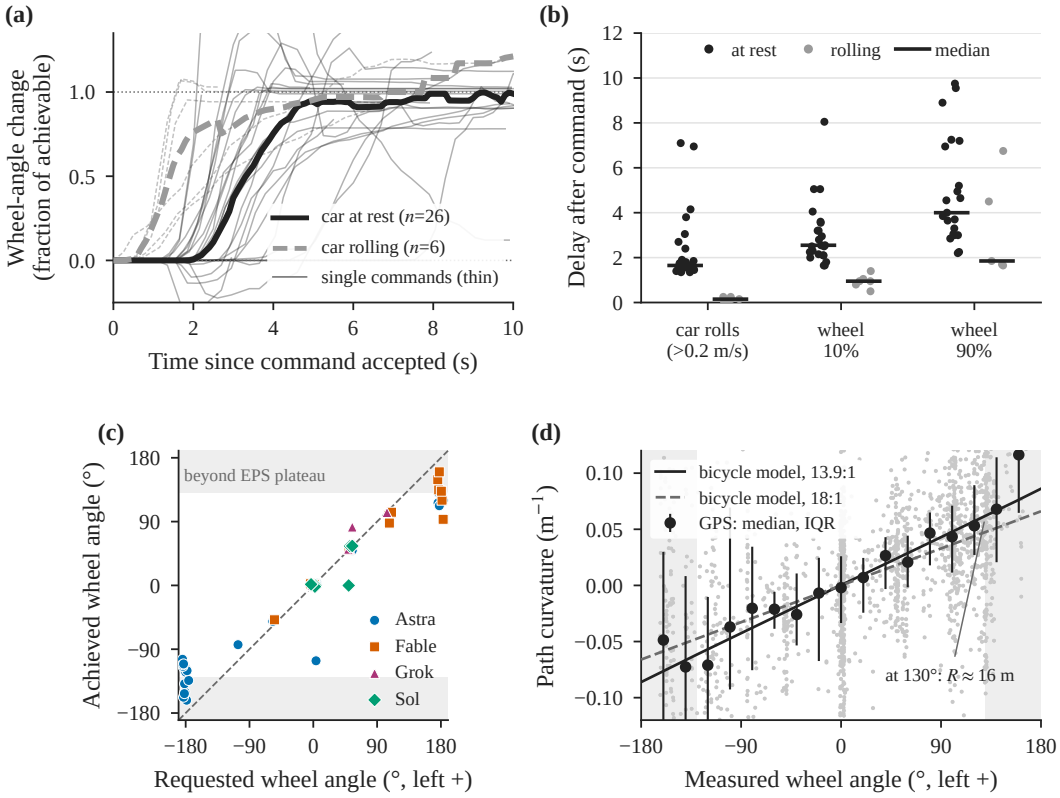



Figure 8: **Requested versus actual steering.** (a) Wheel-angle response to every command asking for a change of at least 30°, normalised to the achievable change (request clipped to the ≈ 130° EPS plateau). Thick lines are medians. (b) Delays after a command is accepted. Of the 32 commands in (a), 26 arrived after the previous command had expired and the car had braked. The EPS only turns the wheel once the car rolls, so from rest the wheel reaches 90% of its change after a median of 4.0 s (1.9 s when already rolling). (c) Achieved versus requested wheel angle per command. Requests of 100% (180°) reach a median of 129°, so the upper ≈ 28% of the command range wasn't reached at the conditions of the model benchmark evaluations. (d) Measured path curvature from GPS against measured wheel angle, compared with a kinematic bicycle model. A 13.9:1 ratio fits better than the 18:1 in the harness documentation. At the plateau the turning radius is ≈ 16 m, which implies roughly 25 s for a 90° turn at 1 m/s, which is faster than the ∼ 60 s we measured in a single sustained calibration run before the trial from rest and was used in the prompt's example.

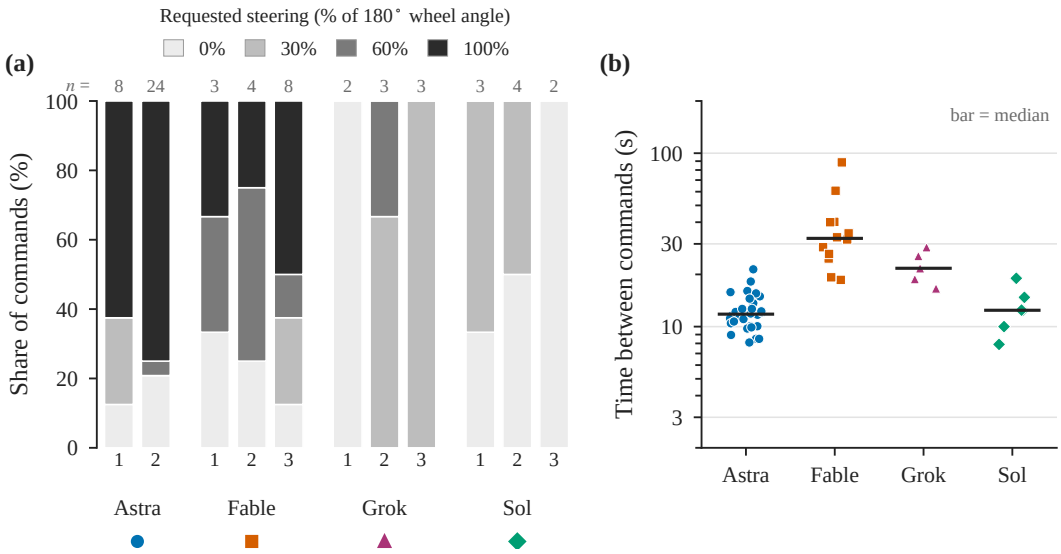



Figure 9: **What the models commanded.** (a) Distribution of the requested `steering_percent` for each attempt ($n$ = number of commands). (b) Time between consecutive accepted `set_motion` calls, pooled over attempts (log scale).

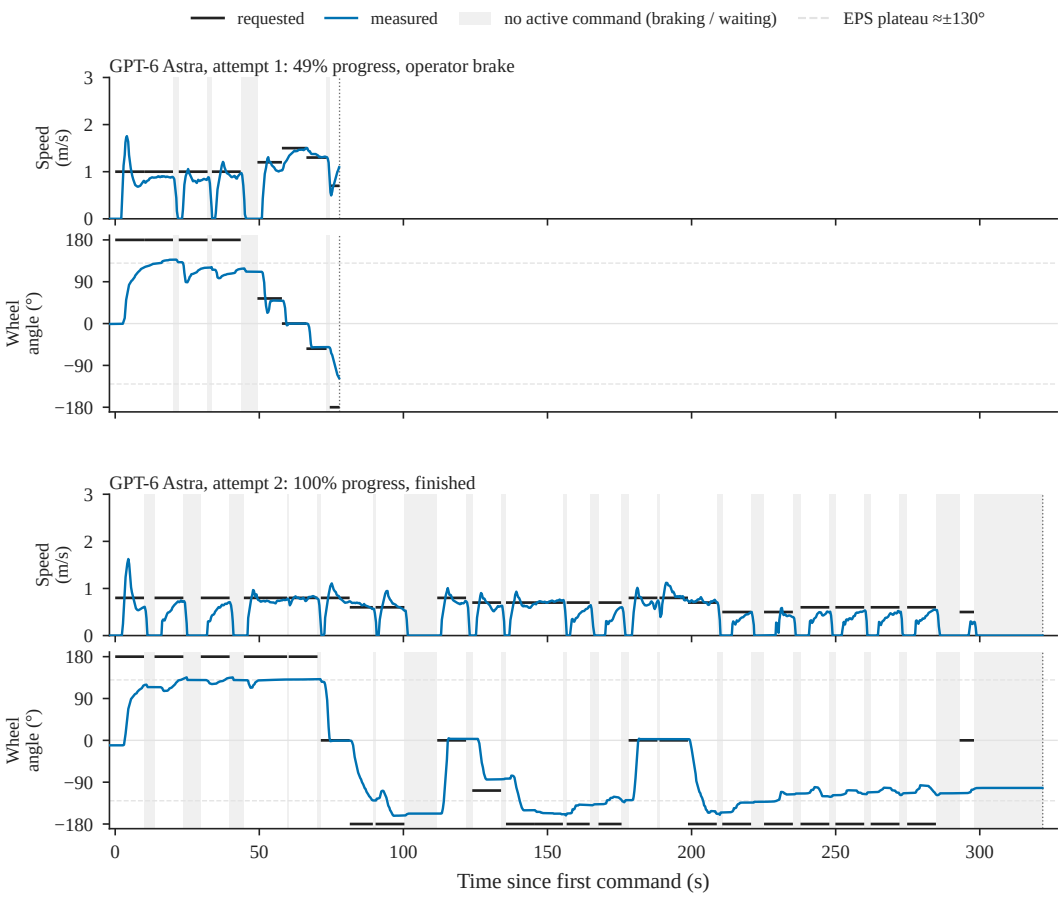



Figure 10: **Control traces, GPT-6 Astra.** For each attempt: requested (black) and measured speed and steering-wheel angle over time. Shading marks periods with no active command, when the previous command had expired and the car was braked while the model deliberated. The dashed lines mark the $\approx \pm 130°$ EPS plateau.

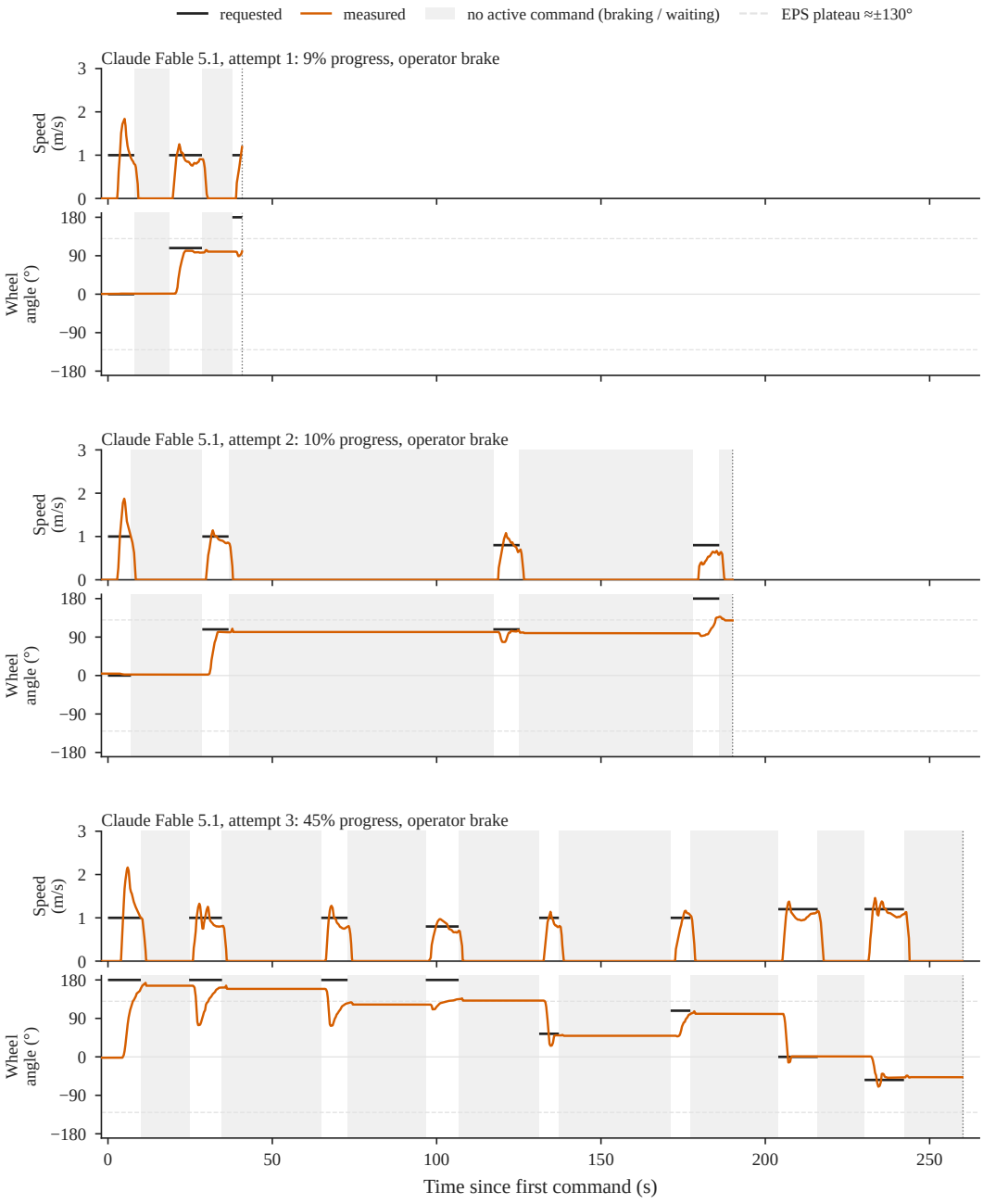



Figure 11: **Control traces, Claude Fable 5.1.** As Figure 10.

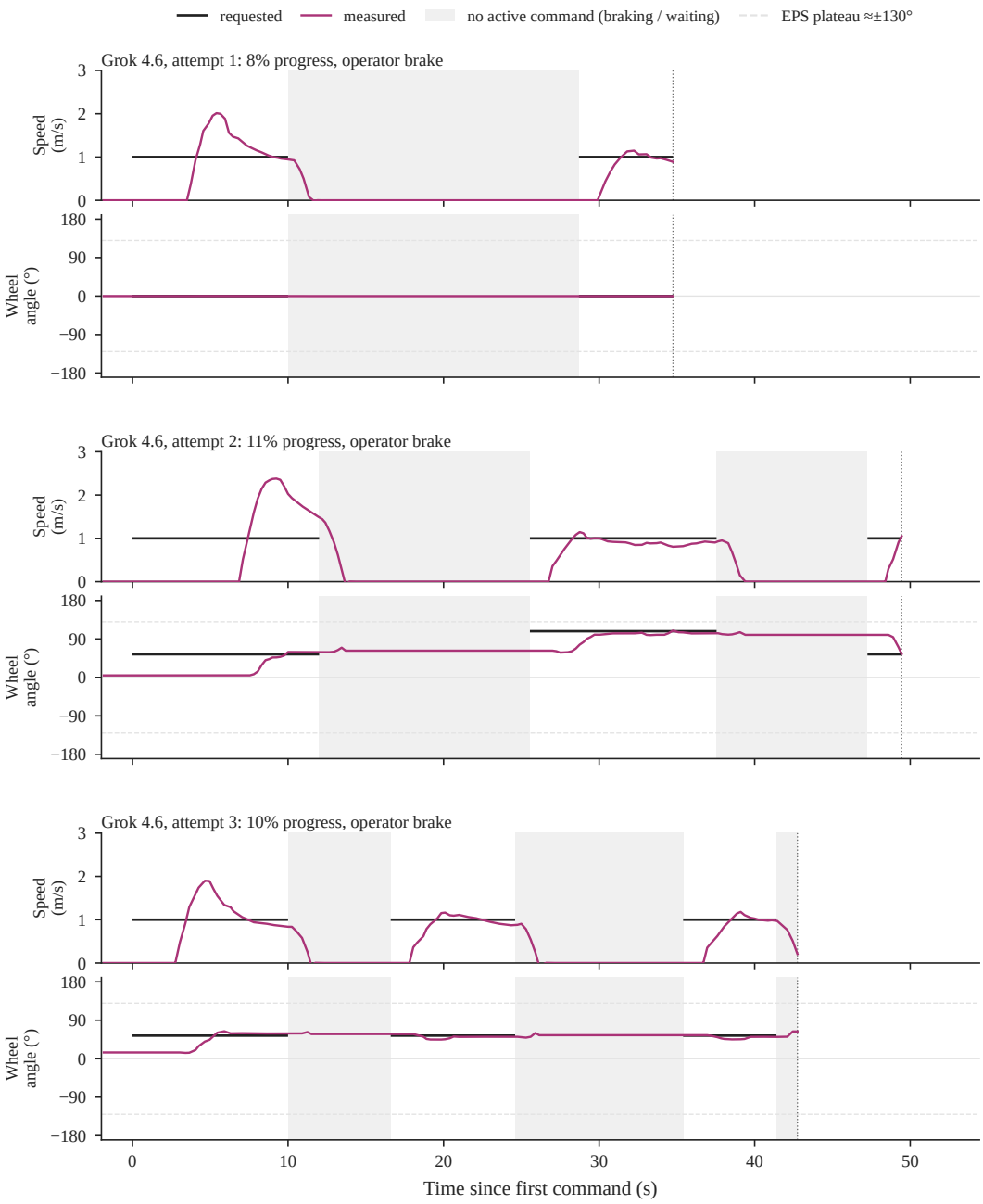



Figure 12: **Control traces, Grok 4.6.** As Figure 10.

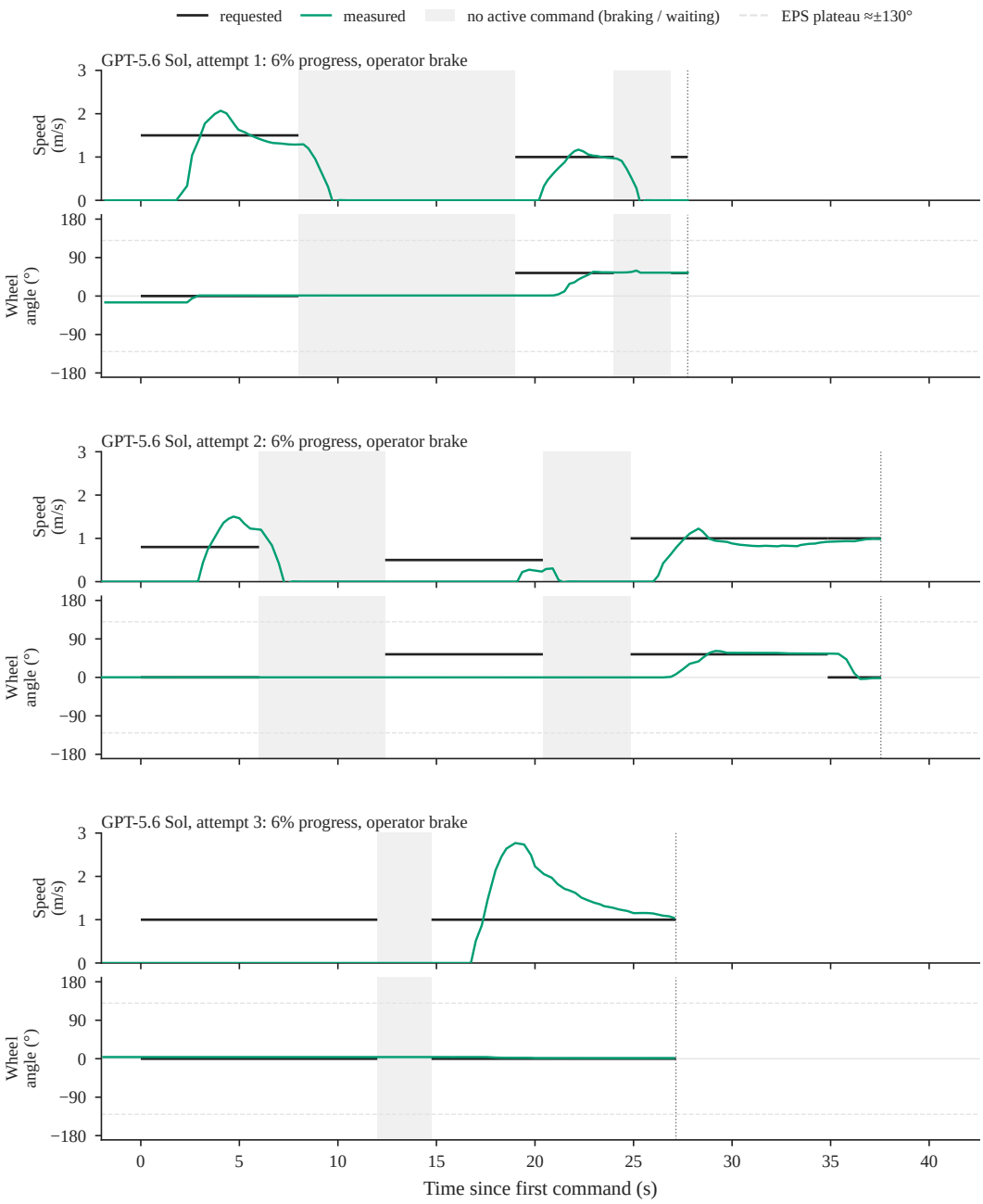



Figure 13: **Control traces, GPT-5.6 Sol.** As Figure 10.