Tesla Model 3 Reliability in Driver Alerting: Assessing Human-Autonomy Interaction in Driving Assist Settings

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The Conundrum of Partial Autonomy

Level 2+

Driving

Computer

Humans

Top-down reasoning

Uncertainty

Expert

Knowledge

Rule

Skill

STOP

Bottom-up reasoning

The Conundrum of Partial Autonomy

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Driving

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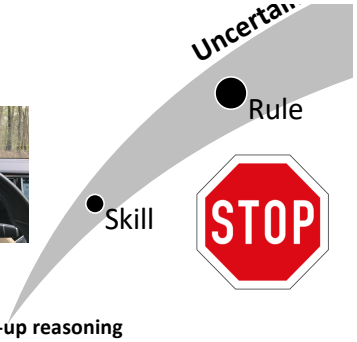
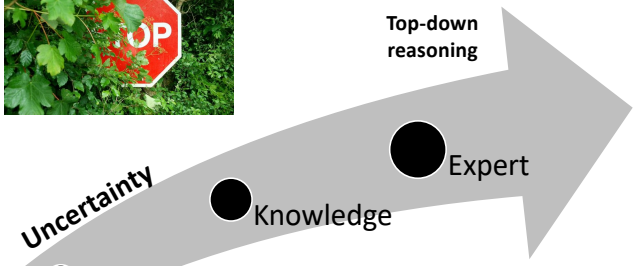
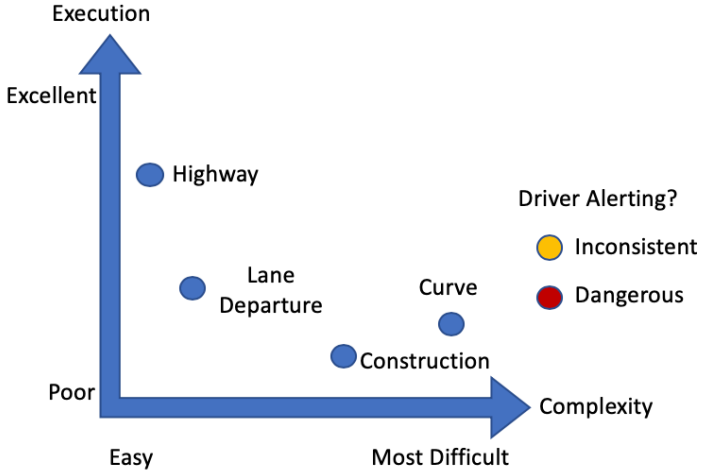


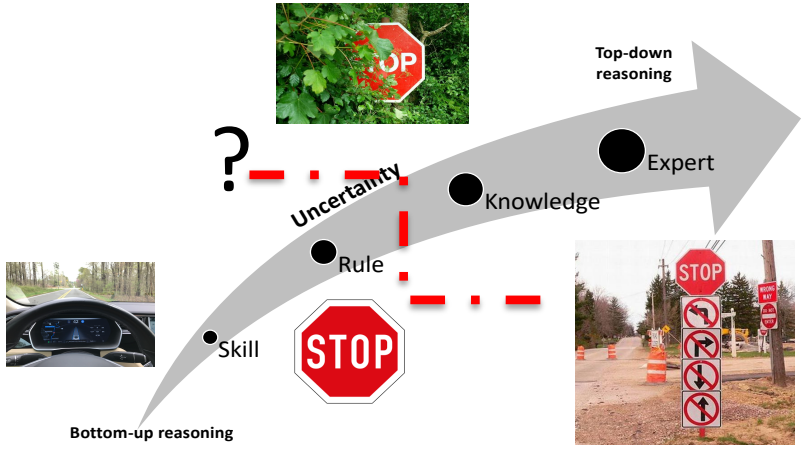
Need consistent and timely handover alerting to maintain continuity



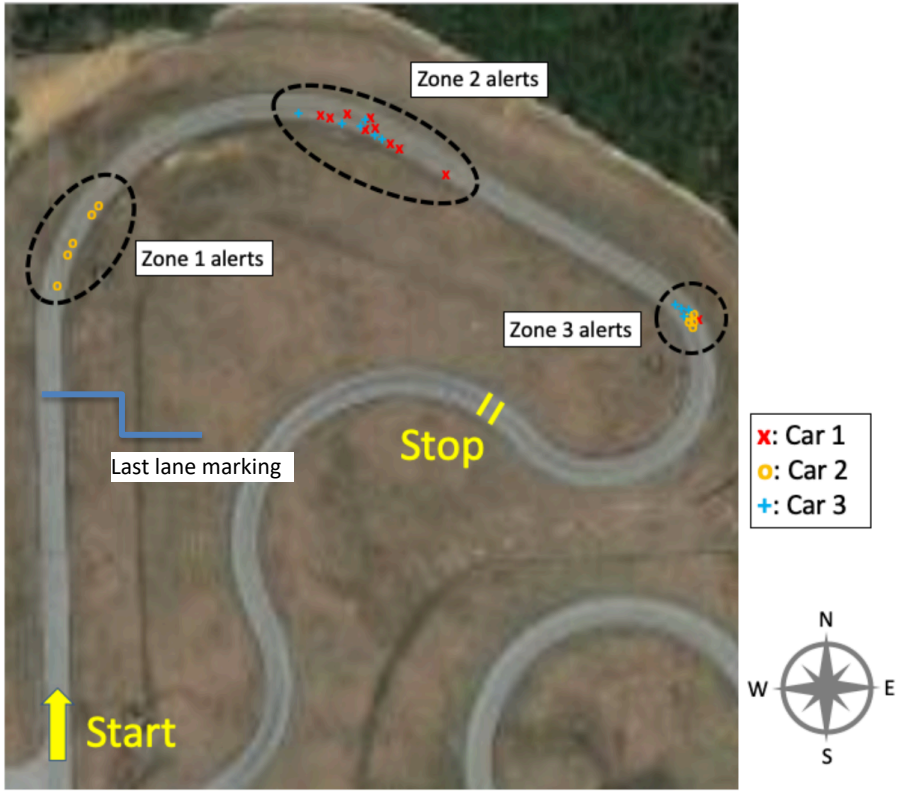
Test Outline

- 4 tests
  - Curve
  - Construction
  - Lane departure
  - Highway
- NCCAR track
- Three 2018 Tesla Model 3s randomly selected
  - 10 randomized runs each
  - 1 driver w/ 1 assistant
  - Confound between the car and the software version.
  - Could only control some internal settings
  - 6 hour window (11am-5pm in March)





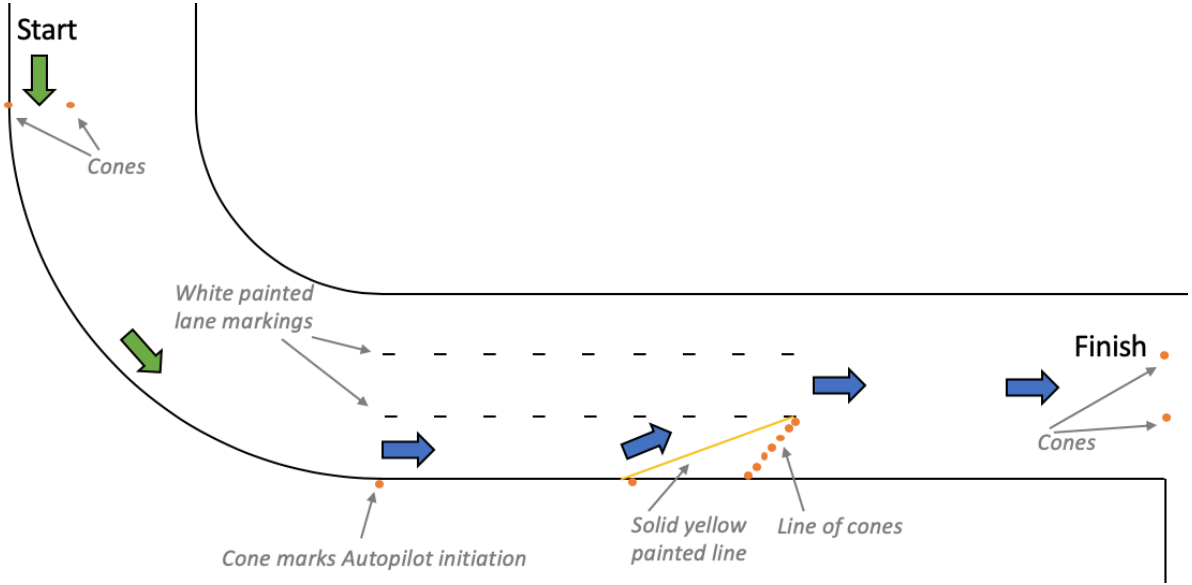
Curve Test



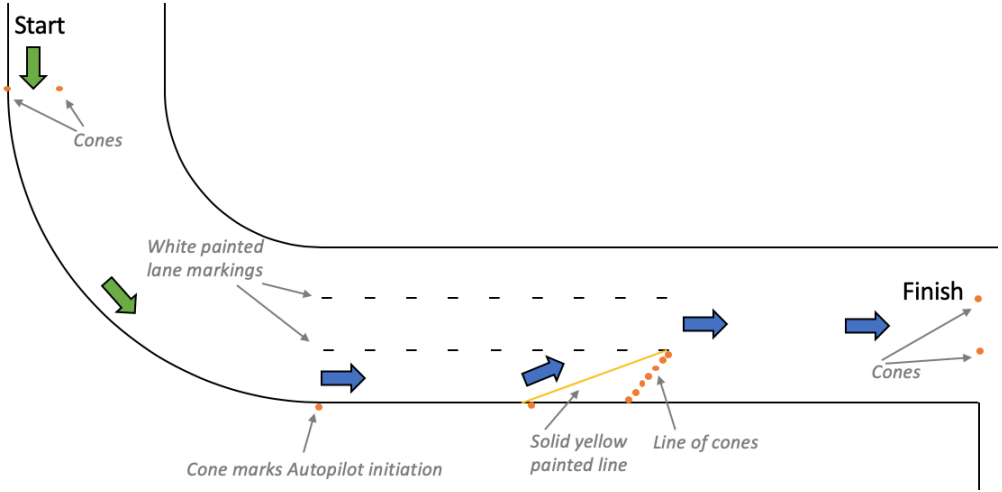
- Autopilot safely stopped the cars in all 30 trials.
- High variability for receiving 1st takeover alert (3 distinct clusters), but once initiated, consistent timing for 2nd and 3rd
- In 30% of trials, cars travelled 26s beyond LLM before warning the driver.
- Distances between LLM & initial alert could be as short as 43 ft (13 m), as late as 1255 ft (383 m)
  - Very inconsistent
- Some evidence that sun angle and brightness may influence perception systems

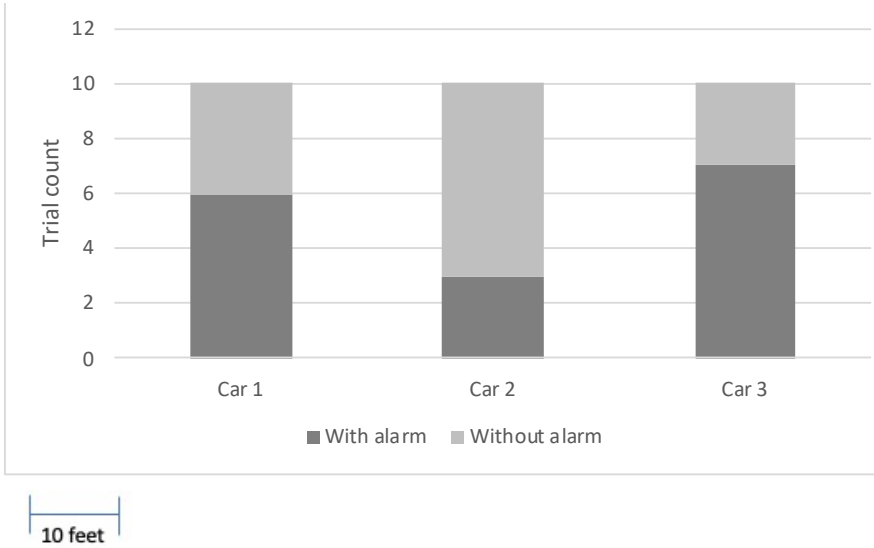
Test 2 Environment

- Same 3 Teslas
  - Disabled Car 2's FSD visualization
  - Same times of day
- 10 runs each
  - Randomized
- 25 mph
- Autopilot initiated at lane lines
- 7 cones, painted yellow line

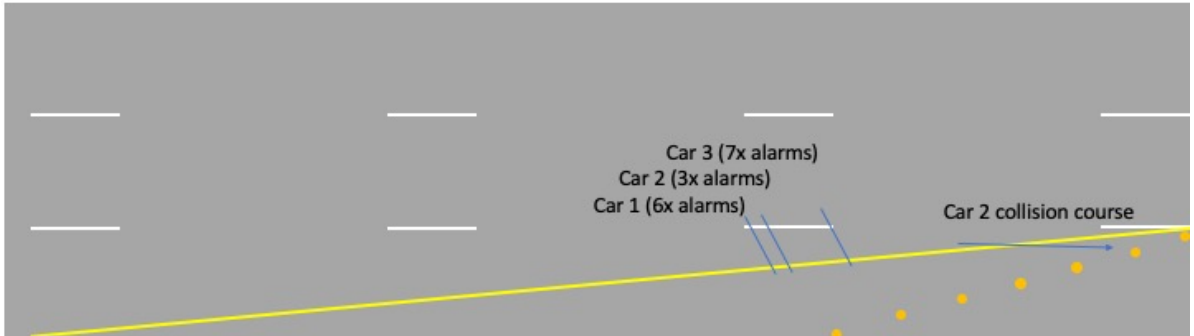


Construction Zone Test



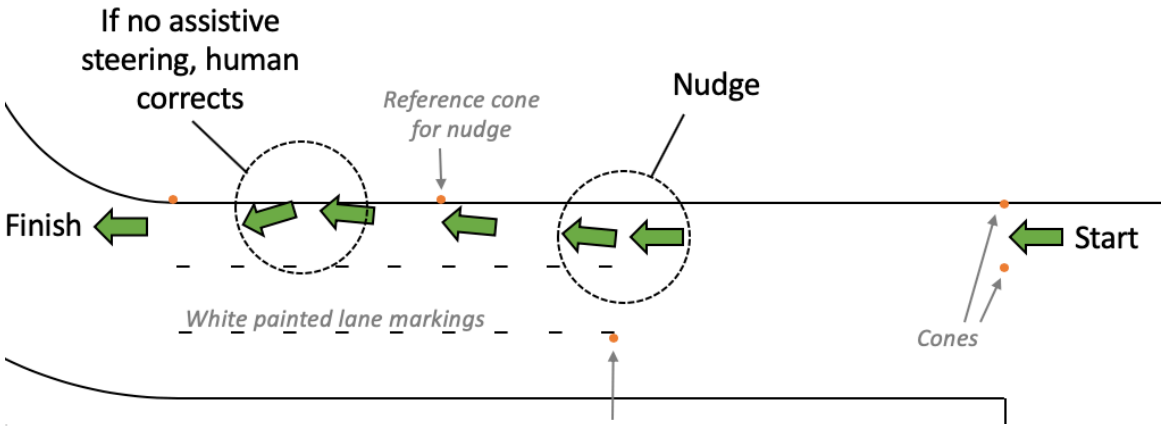


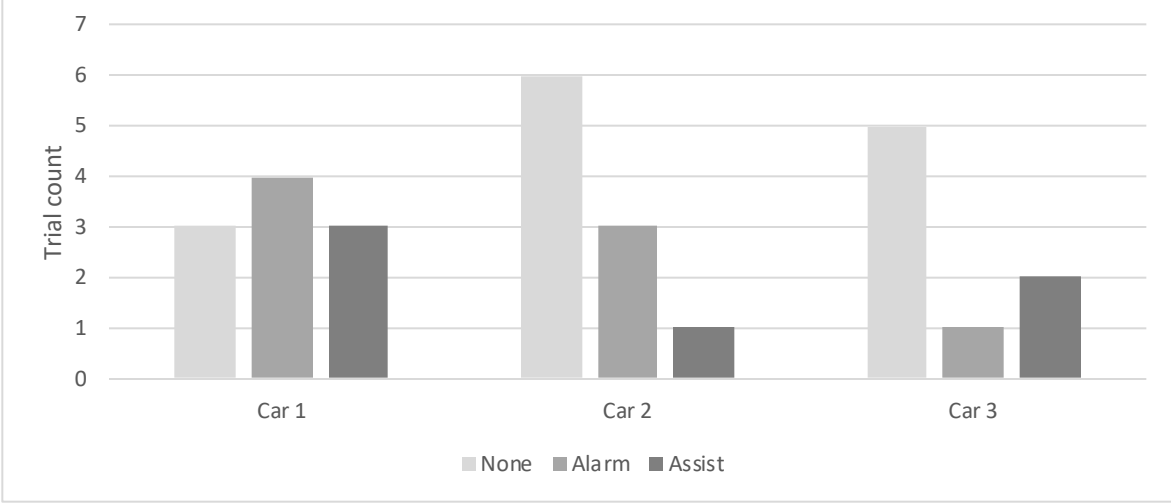
Car 2 was *full self-driving*



Emergency Road Departure Test

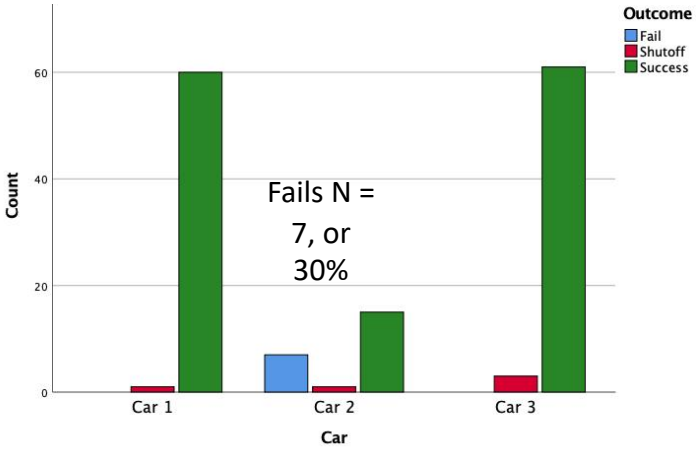
- Angle of wheel rotation measured from cameras, ANOVA with car & outcome (none/alarm/assist) as predictors. No statistical difference in wheel angle inputs.
- 50% trials would have ended with distracted driver off the road, only 21% had any active emergency steering.

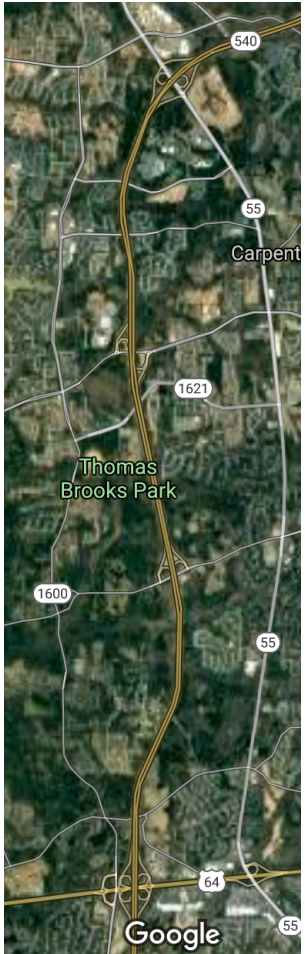




Highway Driver Monitoring Test

- 162 total events
  - FSD car was a problem
- Success, shutoff, failure
  - Driver responds to alert and autopilot continues
  - Driver responds to alert and autopilot shuts off unexpectedly
    - 3.6% of successful trials
  - Driver never alerted, car makes unsafe move
    - A failure ended that trial for safety

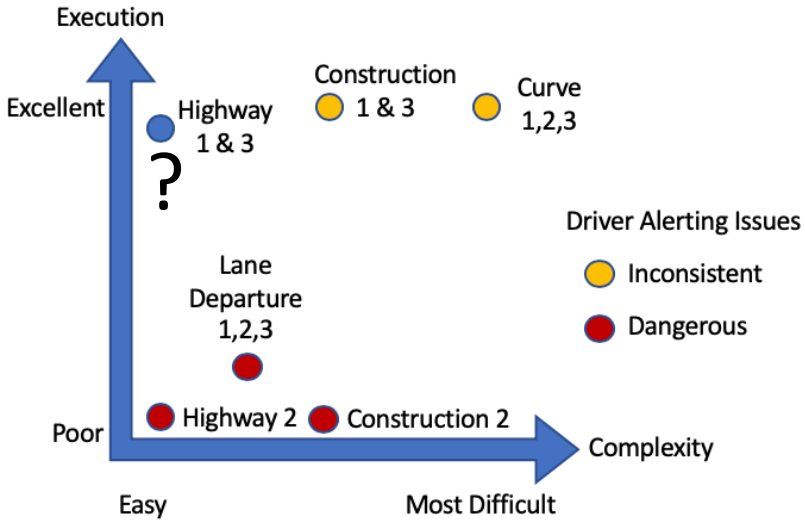




- While hands off alerting was generally consistent, 30s is a long time to not be paying attention at 70mph
  - Car 3: 43.8s at ~55mph & Car 1: 43.4s at ~63mph
  - Time to clear each alarm was consistent

Meta-analysis

- Perception systems for Cars 1 & 3 seemed consistent across tests
  - Sometimes good (const. & hwy), sometimes bad (lane departure)
- Autopilot handover alerting was all over the place for all 3 cars
  - Unexpected handovers can be critical under time pressure – mode confusion



- Driving monitoring system mostly consistent
  - Completely failed in 30% of Car 2 trials
  - Is linear time between hands-off notifications a good idea?
- Car 2 performance a mystery
  - Performed best in most difficult scenario, consistent in successful highway trials (roughly 1/3 of other cars) but was unsafe in 3 of 4 tests
  - Problems with software OTA updates could be a significant albatross
  - Are drivers being used for beta testing?

Questions?