

# The Dawn Project

## Tesla Full Self-Driving Safety Analysis

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### Purpose

The goal of this study is to analyze the driving ability and safety of Tesla's Full Self-Driving (FSD) beta program and answer the following questions:

- Does Tesla's FSD currently meet an acceptable level of safety?
- If the safety of FSD is not yet acceptable:
  - How quickly is FSD safety improving over time?
  - How long might it take for FSD to reach an acceptable level of safety?

### Methodology

21 YouTube videos, totaling over 7 hours of drive time, from customers test driving Tesla's FSD Beta program were analyzed for driving quality and safety. The videos analyzed in this study included FSD Beta major versions v8 (released December 2020) and v10 (released September 2021).

Each analyzed video was downloaded and saved for offline use.

### Video Selection

Videos with significantly positive or negative titles were avoided in an attempt to reduce bias.

There was an effort to analyze videos from as many unique YouTube channels as possible. As a result, the analyzed videos contain a variety of driving conditions, with varying times of day, weather conditions, traffic patterns, and locations.

The following table shows the number of YouTube videos found and analyzed for each FSD version included in the analysis:

| FSD Version   | Videos Found | Videos Analyzed | Percent Analyzed |
|---------------|--------------|-----------------|------------------|
| 8.0           | 10           | 6               | 60%              |
| 10.0          | 5            | 2               | 40%              |
| 10.2          | 15           | 9               | 60%              |
| 10.3          | 6            | 2               | 33%              |
| 10.3.1        | 18           | 2               | 11%              |
| <b>Totals</b> | <b>54</b>    | <b>21</b>       | <b>39%</b>       |

### Grading

Each video was graded according to the California DMV's Driving Performance Evaluation, an exam that every driver must pass to receive a driver's license.

The exam typically lasts 20 minutes, and drivers must have 15 or fewer Scoring Maneuver Errors and 0 Critical Driving Errors to pass.

Scoring Maneuver Errors are minor errors that include, but are not limited to:

- Failing to accelerate, brake, or turn smoothly with control
- Causing confusion to other drivers or impeding traffic flow
- Failing to use turn signals when changing lanes
- Maintaining a safe distance from other moving vehicles

Critical Driving Errors are major errors that include, but are not limited to:

- Making contact with an object when it could have been avoided
- Disobeying traffic signs or signals
- Disobeying safety personnel or safety vehicles
- Making a dangerous maneuver that forces others to take evasive action

The DMV provides a sample scoring sheet for the evaluation [1], as well as detailed explanations of the scoring criteria [2].

The grading in this analysis was not performed by a trained driving instructor.

In addition to the Driving Performance Evaluation criteria, an attempt was made to quantify the number of collisions FSD would have caused, were it not for driver intervention. In this study, a likely collision will be defined as a situation where, without intervention, FSD would have almost certainly made contact with an object such as a vehicle, pedestrian, cyclist, pole, gate, or sign.

## Results

The following tables show the grading results of each video in the analysis:

FSD Beta v8

| Video Date | FSD Version | Video Length | Scoring Maneuver Errors | Critical Driving Errors | Likely Collisions |
|------------|-------------|--------------|-------------------------|-------------------------|-------------------|
| 12/25/20   | 8.0         | 0:27:26      | 5                       | 7                       | 1                 |
| 12/27/20   | 8.0         | 0:31:24      | 8                       | 4                       | 2                 |
| 12/27/20   | 8.0         | 0:11:09      | 2                       | 0                       | 0                 |
| 12/27/20   | 8.0         | 0:07:14      | 0                       | 0                       | 0                 |
| 12/29/20   | 8.0         | 0:33:09      | 19                      | 12                      | 3                 |
| 12/30/20   | 8.0         | 0:25:51      | 10                      | 10                      | 3                 |

## FSD Beta v10

| Video Date | FSD Version | Video Length | Scoring Maneuver Errors | Critical Driving Errors | Likely Collisions |
|------------|-------------|--------------|-------------------------|-------------------------|-------------------|
| 9/11/21    | 10.0        | 0:30:01      | 7                       | 2                       | 0                 |
| 9/11/21    | 10.0        | 0:09:55      | 1                       | 0                       | 0                 |
| 10/11/21   | 10.2        | 0:47:48      | 14                      | 7                       | 2                 |
| 10/11/21   | 10.2        | 0:30:16      | 5                       | 6                       | 0                 |
| 10/11/21   | 10.2        | 0:22:02      | 7                       | 2                       | 1                 |
| 10/11/21   | 10.2        | 0:09:34      | 2                       | 2                       | 1                 |
| 10/11/21   | 10.2        | 0:10:47      | 2                       | 0                       | 0                 |
| 10/11/21   | 10.2        | 0:22:28      | 8                       | 3                       | 0                 |
| 10/11/21   | 10.2        | 0:24:23      | 10                      | 2                       | 0                 |
| 10/13/21   | 10.2        | 0:22:35      | 17                      | 4                       | 2                 |
| 10/15/21   | 10.2        | 0:10:36      | 6                       | 3                       | 2                 |
| 10/24/21   | 10.3        | 0:09:37      | 4                       | 0                       | 0                 |
| 10/25/21   | 10.3        | 0:07:20      | 2                       | 0                       | 0                 |
| 10/26/21   | 10.3.1      | 0:18:43      | 4                       | 1                       | 0                 |
| 10/26/21   | 10.3.1      | 0:15:13      | 5                       | 2                       | 0                 |

## Analysis

The following table shows the number of driving errors for each FSD Beta version, and compares them to the pass/fail criteria in California DMV's Driver Performance Evaluation:

|  | v8      | v10     |
|--|---------|---------|
| Videos Analyzed                                    | 6       | 15      |
| Total video time                                   | 2:16:13 | 4:51:18 |
| Scoring Maneuver Errors                            | 44      | 94      |
| Critical Driving Errors                            | 33      | 34      |
| Likely Collisions                                  | 9       | 8       |
| Average time to failure by Scoring Maneuver Errors | 0:49:32 | 0:49:35 |
| Average time to failure by Critical Driving Error  | 0:04:08 | 0:08:34 |
| Average time to Likely Collision                   | 0:15:08 | 0:36:25 |

## Current State of FSD

On average, FSD Beta v10 commits 16 Scoring Maneuver Errors in 49:35.

On average, FSD Beta v10 commits a Critical Driving Error every 8:34. FSD v10 would fail a driving test most of the time due to these mistakes.

According to AAA [3], drivers in the US average about 48 minutes of driving per day, or 337 minutes per week.

FSD Beta v10 committed one likely collision every 36:25, or 475 per year. This is 8,506 times higher than the average accident rate for human drivers used by the auto insurance industry, which is one accident every 17.9 years.

To calculate the human driver accident rate another way, the US Bureau of Transportation reported that in 2019, there were roughly 3.26 trillion miles driven in the US and 6,756,000 crashes [4]. On average, that is one crash every 483,000 miles driven. If the average driving speed is 30 miles per hour, then one crash occurs every 16,100 hours. By this metric, FSD Beta v10's likely collision rate is 26,546 times higher than that of a human driver.

### Future of FSD

FSD Beta v8 and Beta v10 were released roughly 9 months apart. In that time, there was a negligible change in the Scoring Maneuver Error rate. However, the Critical Driving Error rate decreased by 52% and the potential collision rate decreased by 58%.

If Tesla continues to reduce the potential collision rate at 58% every 9 months, it will take another 7.8 years (per AAA data) to 8.8 years (per Bureau of Transportation data) to achieve the accident rate of a human driver.

### References

1. <https://www.dmv.ca.gov/portal/uploads/2020/05/Driving-Performance-Evaluation-Score-Sheet-Sample-.pdf>
2. <https://www.dmv.ca.gov/portal/handbook/driving-test-criteria/driving-performance-evaluation-dpe-scoring-criteria/>
3. <https://newsroom.aaa.com/2016/09/americans-spend-average-17600-minutes-driving-year/>
4. <https://www.bts.gov/content/motor-vehicle-safety-data>