Summer Internship Report

Department of Civil Engineering

Indian Institute of Technology, Guwahati

Topic: Comparative Analysis of ADAS Warnings in Real-World Driving Scenarios

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Acknowledgement

We would like to express our sincere gratitude to the **Department of Civil Engineering, Indian Institute of Technology Guwahati**, for providing us the opportunity to undertake this internship in the field of **Transportation Engineering**.

We are deeply thankful to **Professor Dr. Nipjyoti Bharadwaj Sir** for his valuable support, encouragement, and insightful guidance throughout the internship. It was an enriching experience to work under his mentorship, which significantly enhanced our understanding of intelligent transportation systems.

We also wish to express our heartfelt thanks to **Mr. Ritesh Rao**, Ph.D. Scholar, for his continuous assistance and technical support during the internship. His expert suggestions and patient feedback were instrumental in helping us navigate the complexities of the project, particularly during the data analysis and interpretation stages.

This internship has provided us with a practical perspective on real-world transportation safety challenges and has allowed us to develop critical skills in data handling, analysis, and reporting. We are grateful for the academic and professional exposure we have received through this experience.

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Abstract

The internship, conducted from **23rd May to 16th July**, was undertaken in the domain of **Transportation Engineering** under the guidance of **Professor Dr. Nipjyoti Bharadwaj** and Ph.D. Scholar **Mr. Ritesh Rao** at the **Department of Civil Engineering, IIT Guwahati**.

The primary objective of the internship was to evaluate the effectiveness of **Advanced Driver Assistance Systems (ADAS)** in real-world driving conditions. For this purpose, a series of controlled trips were carried out using a test vehicle equipped with dashcams. Each trip was conducted twice — once with ADAS enabled and once without — by different drivers. These trips were recorded, and the resulting video footage served as the primary data source for our analysis.

We were tasked with extracting key information from the videos, including the **type of warning issued (e.g., LDW, SDW, PCW)**, **timestamp**, **validity of the warning (true/false positive)**, **type of vehicle ahead**, and the **driver's reaction** to each warning. This data was meticulously compiled into structured Excel sheets, categorized driver-wise.

Subsequently, we performed **paired t-tests** to analyze statistical differences in the frequency and nature of warnings with and without ADAS. Additionally, a **speed-bin-wise analysis** was conducted to understand the variation in warning occurrences under different driving conditions. Through comparative visualizations and statistical evaluations, we assessed the impact of ADAS in enhancing driver awareness and reducing false warnings.

This internship provided hands-on experience in **data extraction**, **statistical analysis**, and **driver behavior assessment**, contributing to a deeper understanding of intelligent transportation systems and their practical implementation.

Introduction

In recent years, **Advanced Driver Assistance Systems (ADAS)** have emerged as a pivotal innovation in the field of transportation engineering, aimed at enhancing road safety, minimizing human error, and assisting drivers in dynamic traffic conditions. ADAS uses a combination of sensors, cameras, and algorithms to monitor the vehicle's surroundings and provide timely alerts or interventions to the driver. These systems are an essential step toward the development of semi-autonomous and autonomous vehicles.

Among the many features offered by ADAS, several key warning systems play a crucial role in preventing potential accidents:

- **Lane Departure Warning (LDW):** Alerts the driver when the vehicle unintentionally drifts out of its lane without using turn signals.
- **Safe Distance Warning (SDW):** Notifies the driver when the vehicle is too close to the one ahead, help maintaining a safe following distance.
- **Pedestrian Collision Warning (PCW):** Detects pedestrians in the vehicle's path and alerts the driver to prevent collisions.

This internship focused on evaluating the effectiveness of these ADAS warnings by analyzing driving behavior in both ADAS-enabled and non-ADAS conditions. Real-world trips were conducted and recorded using dashcams installed in a test vehicle. For each trip, data was manually extracted from the video footage, including the **timestamp**, **type of warning**, **warning validity (true or false positive)**, **type of vehicle detected**, and the **driver's reaction** to the warning.

The collected data was systematically organized in Excel sheets, categorized by driver and warning type. A series of statistical analyses were then conducted, including **paired t-tests** and **speed-bin-wise comparisons**, to assess differences in the frequency and nature of warnings with and without ADAS assistance.

This report documents the methodology, observations, and insights derived from the study, offering a deeper understanding of how ADAS influences driver behavior and warning occurrence patterns in real traffic scenarios.

Internship Objectives

The primary objective of this internship was to gain practical exposure in the domain of **Transportation Engineering**, with a specific focus on the analysis of **Advanced Driver Assistance Systems (ADAS)** and their effectiveness in real-world driving scenarios. The internship aimed to bridge theoretical understanding with hands-on data collection, interpretation, and analysis.

The specific objectives were as follows:

1. **To understand the functionality and application of ADAS** in enhancing vehicle and road safety through real-time driver alerts.
2. **To extract and classify warning data** from dashcam footage of test vehicle trips conducted in both ADAS-enabled and non-ADAS conditions.
3. **To categorize each warning event** based on:
    - Type of warning (LDW, SDW, PCW)
    - Time of occurrence (timestamp)
    - Validity (true or false positive)
    - Type of object or vehicle detected
    - Driver response to the warning
4. **To organize and structure the extracted data** in Excel sheets for systematic analysis, grouped by driver and warning type.
5. **To perform statistical analysis**, including paired t-tests, to compare the frequency and nature of warnings in ADAS versus non-ADAS conditions.
6. **To analyze warning behavior across speed bins**, helping to assess how vehicle speed influences the generation and effectiveness of warnings.
7. **To develop skills in video-based data analysis, data handling, and statistical interpretation**, relevant to modern intelligent transportation systems.

This structured approach helped in evaluating the real-time performance of ADAS and understanding driver interaction with assistive technologies under varying traffic conditions.

Methodology

The methodology adopted during this internship was designed to systematically evaluate the behavior and effectiveness of **Advanced Driver Assistance Systems (ADAS)** in actual road environments. The process involved real-world data collection, manual extraction, classification, and statistical analysis to assess the influence of ADAS on driving performance and safety alerts.

1. Data Collection Through Test Drives

To ensure a controlled comparison, multiple drivers participated in a series of test drives. Each driver completed two trips:

- **One with ADAS enabled**, allowing for active driver assistance and warnings.
- **One without ADAS**, serving as a control condition.

These trips were recorded using **dashcams** installed in the test vehicle, capturing both the forward view of the road and the driver's behavior. The test environments were kept as similar as possible in terms of time of day, traffic density, and route to minimize external variability.

2. Video-Based Data Extraction

The recorded videos were reviewed manually to extract warning-related information. Each warning event was identified and classified based on the following attributes:

- **Timestamp** of occurrence
- **Type of warning:** Lane Departure Warning (LDW), Safe Distance Warning (SDW), or Pedestrian Collision Warning (PCW)
- **Validity of warning:** whether it was a true positive or false positive
- **Type of object or vehicle** in front of the test vehicle at the time of the warning
- **Driver's reaction** to the warning (e.g., braking, steering correction, or no action)

3. Data Organization and Compilation

All the extracted data was entered into structured **Excel spreadsheets**, with each sheet corresponding to an individual driver. Within each sheet, warnings were further grouped based on warning type and ADAS condition (enabled or disabled). This structured format allowed for easier comparison and statistical computation.

4. Statistical Analysis

To determine whether ADAS had a statistically significant effect on the number and type of warnings, the following analyses were performed:

- **Paired t-tests:** Conducted separately for LDW, SDW, and PCW warnings to compare the difference in counts between ADAS-enabled and non-ADAS trips. This helped assess whether the changes observed were due to chance or indicative of a real impact of ADAS.
- **Speed Bin Analysis:** Warnings were also grouped based on vehicle speed ranges (speed bins). The distribution of warnings within each speed category was analyzed to study whether higher or lower speeds influenced warning frequency and type.

5. Visualization

To aid interpretation, multiple graphs were generated, including:

- **Bar charts** comparing average warning counts across drivers and warning types.
- **Driver-wise comparison plots** to show variation in performance.
- **Line charts** for visualizing trends across drivers under different ADAS conditions.

This step-by-step methodology enabled a thorough and empirical assessment of how ADAS affects driver behavior and warning patterns, offering practical insights into the potential and limitations of such systems in real-world traffic conditions.

Data Analysis and Results (Introduction)

The data analysis primarily focused on comparing the **number of warnings generated during trips with and without ADAS** support for different drivers. This comparison helped assess whether ADAS effectively reduced the frequency of warnings across varied driving styles and behaviors. After driver-wise comparisons, a more detailed **speed-bin-wise analysis** was performed, where the total number of warnings was categorized based on speed intervals such as **0–10 km/h, 10–20 km/h, 20–30 km/h**, and so on. This segmentation provided insights into how the **frequency and risk associated with warnings changed at higher speeds**, highlighting the potential severity of warnings triggered at faster driving conditions.

ADAS Warning Analysis

Filtered Dataset Overview

The table below shows the warning counts for each driver with and without ADAS (excluding Himanshu and Pankaj):

Drivers	LDW with adas	LDW without adas	SDW with adas	SDW without adas	PCW with adas	PCW without ADAS
Krishna	29	35	12	10	23	74
Mrignabh	20	31	28	20	50	37
Aditya	14	15	6	9	9	12
Tarun	17	24	4	14	2	17
Nitin	14	12	4	5	20	16
Manjil	22	16	11	3	27	65
Chakradhar	23	29	11	26	72	61
Prithvee	24	20	9	19	36	49
Stanley	20	21	19	20	59	60
Mayank	15	11	10	14	35	29
Sourabh	12	3	23	12	11	11
Disheet	36	9	17	3	21	14

T-Test Results (Filtered)

Paired t-tests were conducted to compare warning counts with and without ADAS after removing Himanshu and Pankaj.

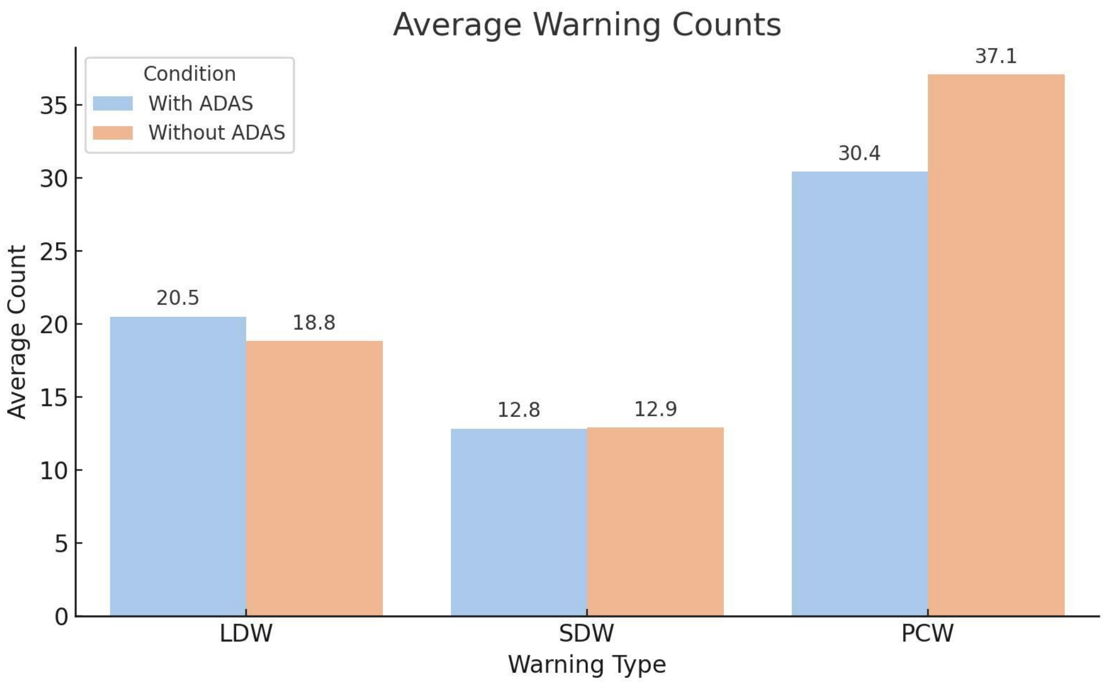
Warning Type	T-statistic	P-value
LDW	0.5793	0.5741
SDW	-0.0319	0.9751
PCW	-1.1671	0.2678

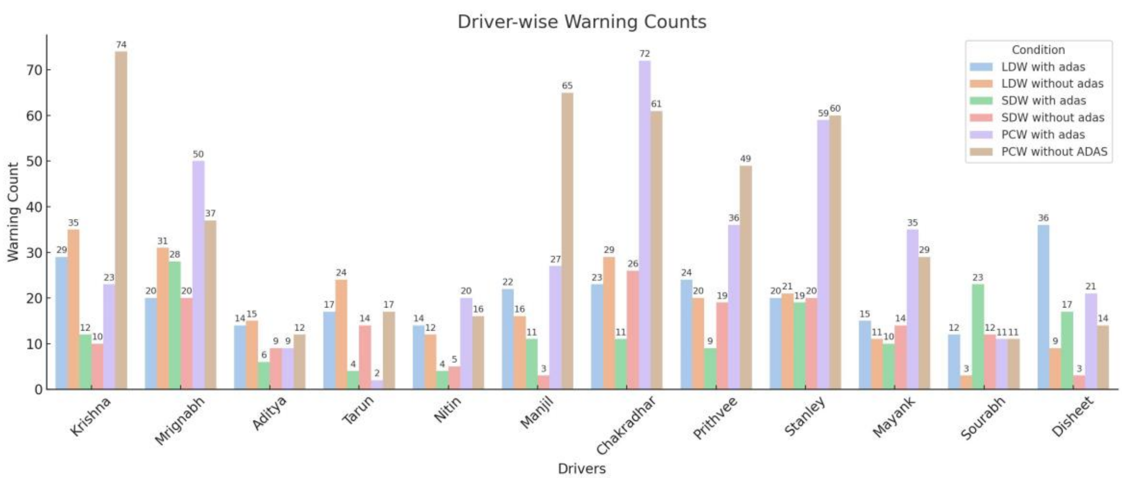
Interpretation of Results (Filtered)

The paired t-test was conducted to compare the number of warnings issued with and without ADAS support across three types: Lane Departure Warning (LDW), Speeding Warning (SDW), and Pedestrian Collision Warning (PCW). The p-values for all warning types were greater than 0.05, indicating that the differences in warning counts are not statistically significant. This implies that the presence of ADAS did not lead to a statistically meaningful reduction or increase in these warnings based on the current dataset. However, individual driver behavior and compliance could still influence the results.

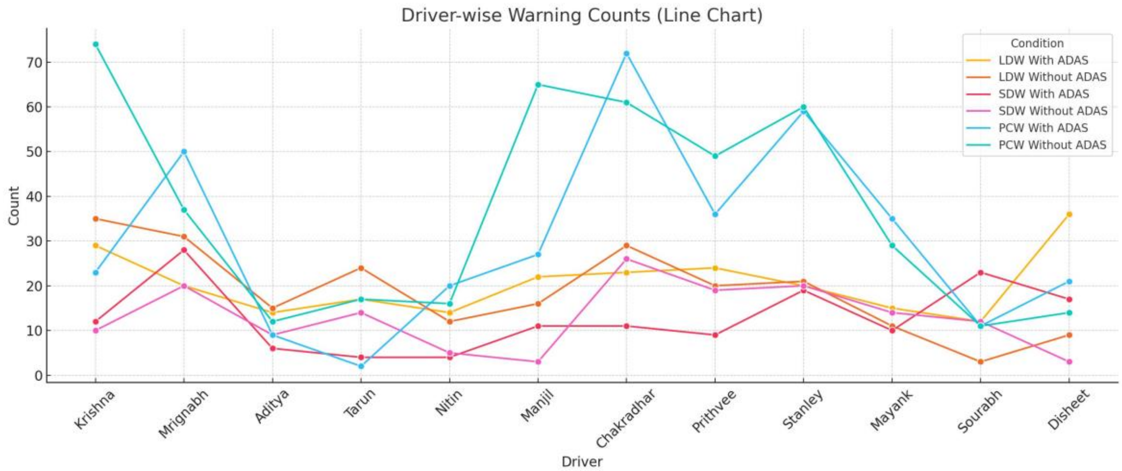
Visualizations (Filtered)

Bar Chart: Average warning counts with and without ADAS (Filtered)





Line Chart: Driver-wise warning counts (Filtered)



REASONS WHY IN SOME CASES THE NUMBER OF WARNIINGS WITH ADAS IS MORE THAN THAT WITHOUT ADAS:

1. **Low Driver Compliance with ADAS**

- **ADAS is only as effective as the driver's willingness to engage with it.**
- Some drivers may ignore or override ADAS alerts, intentionally or unintentionally.
- If a driver disregards warnings (e.g., keeps drifting despite LDW alerts), the system may **issue multiple repeated warnings**, increasing the total count.
- Poor seatbelt usage, eye tracking failures, or incorrect system calibration can also reduce ADAS effectiveness.

2. **Greater Sensitivity of ADAS**

- ADAS systems are programmed to detect and alert on **more subtle deviations** than a human observer might notice.
- Without ADAS, certain borderline behaviors may go unflagged, but with ADAS, **every small deviation** can trigger a warning.

3. **Increased Driver Dependency**

- Some drivers become **over-reliant** on ADAS, reducing their own vigilance.
- This "automation complacency" can lead to **more frequent violations**, which are then caught and warned against by the system.

4. **Variation in Driving Conditions**

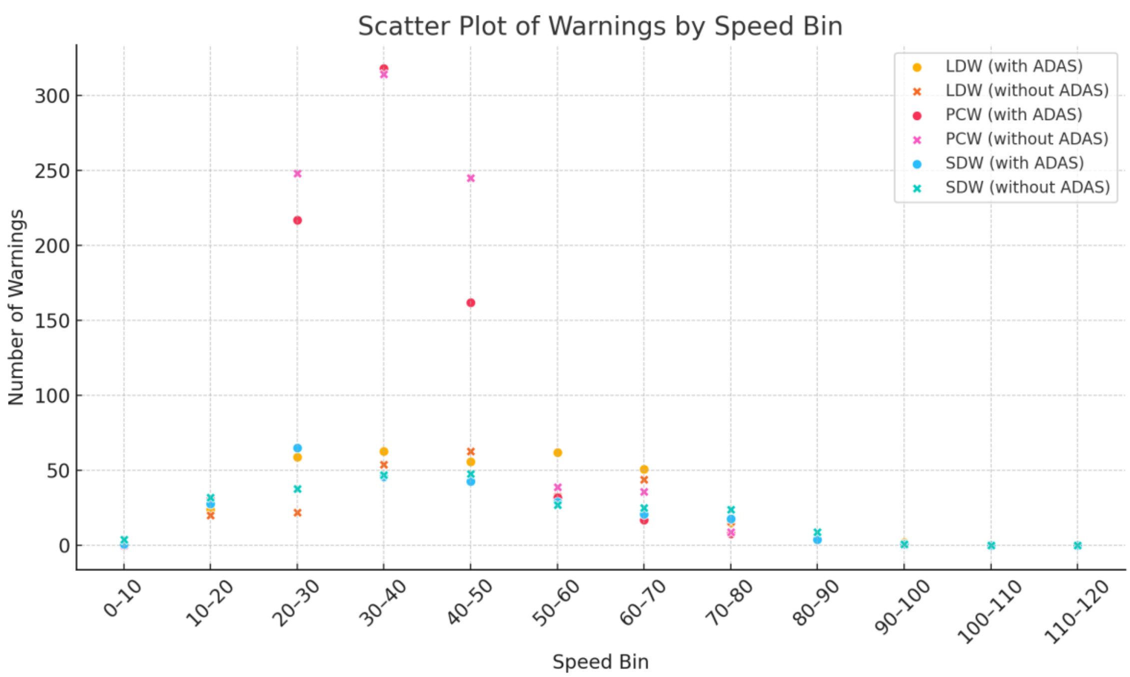
- If a driver drove in more challenging conditions (night driving, heavy traffic) **while ADAS was active**, more warnings could be expected simply due to situational complexity.

Speed Bin Wise Analysis

Consolidated Warning Table by Speed Bin

Speed Bin	No. of LDW with ADAS	No. of LDW without ADAS	No. of SDW with ADAS	No. of SDW without ADAS	No.of PCW with ADAS	No.of PCW without ADAS
0–10	0	0	1	4	0	0
10–20	24	20	28	32	31	29
20–30	59	22	65	38	217	248
30–40	63	54	46	47	318	314
40–50	56	63	43	48	162	245
50–60	62	33	29	27	32	39
60–70	51	44	21	25	17	36
70–80	15	16	18	24	8	9
80–90	4	5	4	9	5	4
90–100	2	0	1	1	1	0
100–110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Scatter Plot of Warnings by Speed Bin



T-Test Analysis of Driver Warnings

This report analyzes the difference in the number of warnings generated with and without ADAS across three warning types: LDW, PCW, and SDW. A t-test was conducted to determine statistical significance.

T-Test Results

Warning Type	t-statistic	p-value
LDW	0.639	0.529
PCW	-0.242	0.811
SDW	0.01	0.992

A p-value greater than 0.05 in all tests indicates no statistically significant difference in warning counts between vehicles with and without ADAS.

Scatter Plot Analysis

The scatter plot illustrates the number of warnings generated across various speed bins for each warning type (LDW, PCW, SDW), both with and without ADAS. Below are key insights drawn from the plot:

• Warning counts peak in the 30–50 km/h range, especially for PCW and LDW types, indicating high activity in urban driving zones.

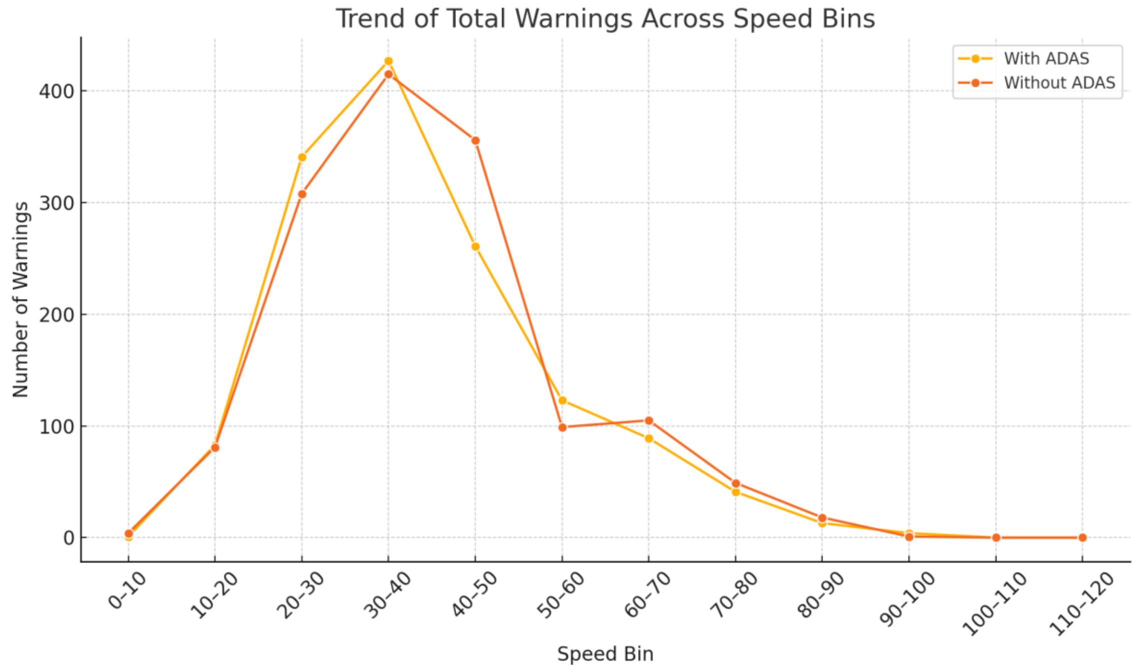
• Although warnings are less frequent at higher speeds (70+ km/h), the potential danger is significantly greater due to reduced reaction time and increased impact severity.

• Patterns for ADAS and non-ADAS vehicles are closely aligned, suggesting ADAS mirrors human driving behaviors rather than fully preventing warnings.

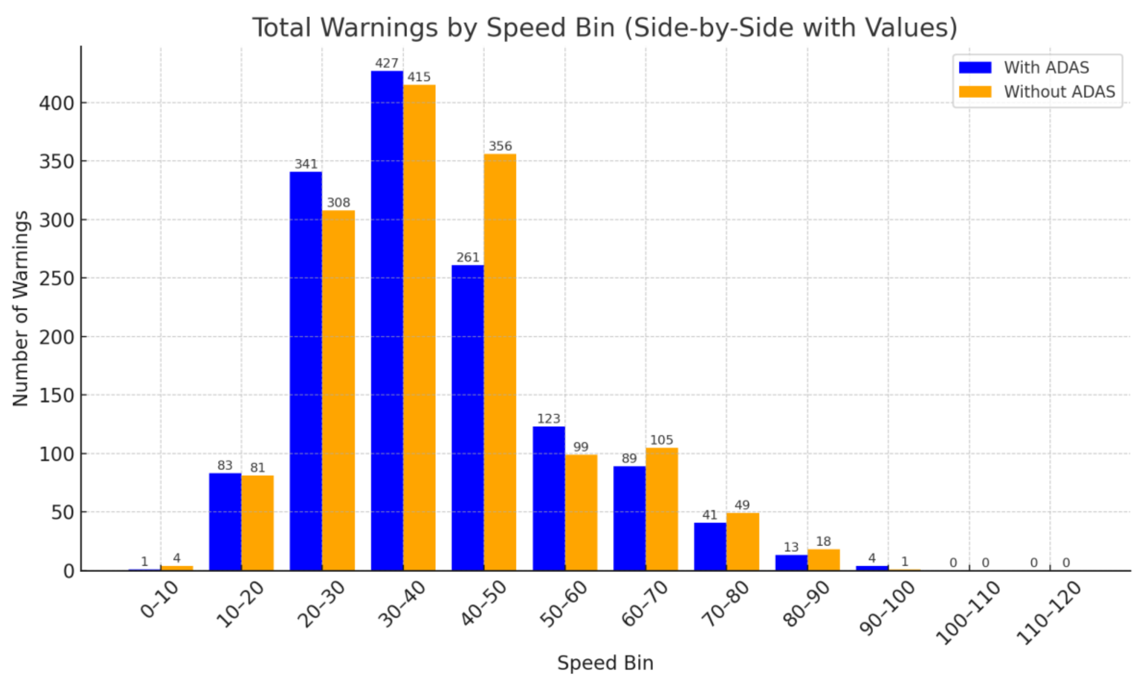
• SDW warnings spike in moderate traffic speeds (30–50 km/h), often due to dense vehicle presence and reduced following distances.

• Speed bins over 70 km/h should be flagged as high risk per event despite low warning volume.

Line Chart: Trend of Total Warnings Across Speed Bins



Bar Chart: total Warnings by Speed Bin



Driver – Wise Reports

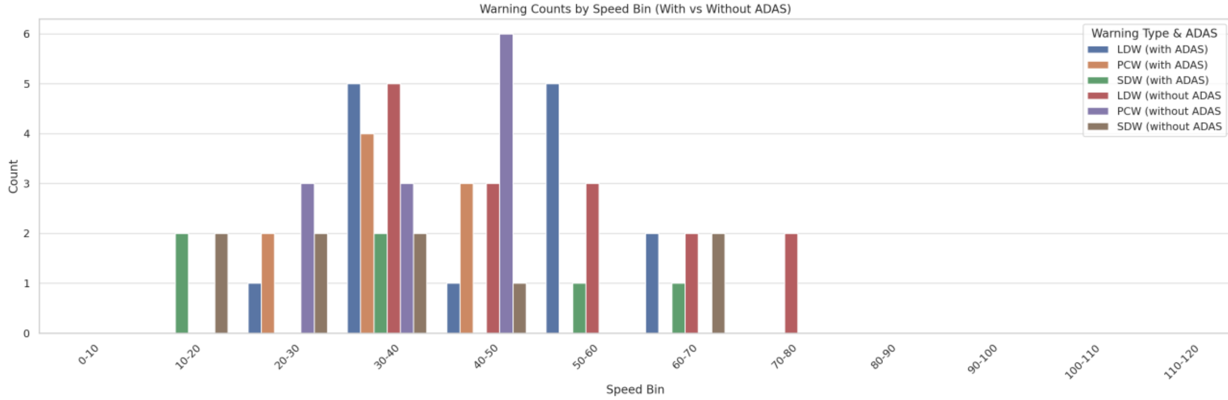
ADAS Impact Analysis: Aditya Dataset

This report presents a comparative analysis of three types of driver warnings—LDW (Lane Departure Warning), SDW (Speed Deviation Warning), and PCW (Potential Collision Warning)—across different speed ranges for vehicles equipped with and without ADAS (Advanced Driver Assistance Systems). The data is categorized into speed bins of 10 km/h intervals, and statistical analysis was conducted to determine the impact of ADAS on warning frequency.

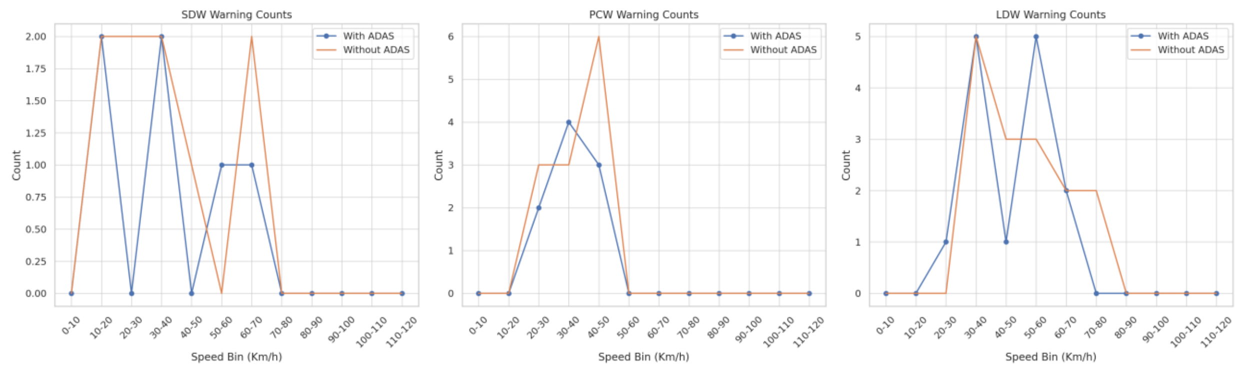
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS	PCW (without ADAS	SDW (without ADAS
0-10	0	0	0	0	0	0
10-20	0	0	2	0	0	2
20-30	1	2	0	0	3	2
30-40	5	4	2	5	3	2
40-50	1	3	0	3	6	1
50-60	5	0	1	3	0	0
60-70	2	0	1	2	0	2
70-80	0	0	0	2	0	0
80-90	0	0	0	0	0	0
90-100	0	0	0	0	0	0
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: Warning Counts for LDW, SDW, and PCW



T-Test Analysis

To evaluate the statistical significance of differences in warning counts between vehicles with and without ADAS, independent two-sample t-tests were performed for each warning type. The results are as follows:

Warning Type	t-statistic	p-value
SDW	-0.692	0.497
PCW	-0.358	0.724
LDW	-0.113	0.911

The p-values for all warning types (LDW: 0.911, SDW: 0.497, PCW: 0.724) are greater than the standard significance level of 0.05. This indicates that there is no statistically significant difference in the warning frequencies between vehicles equipped with ADAS and those without it. While some speed bins show visible differences in the graphs, the overall variation is not strong enough to confirm a consistent or significant impact.

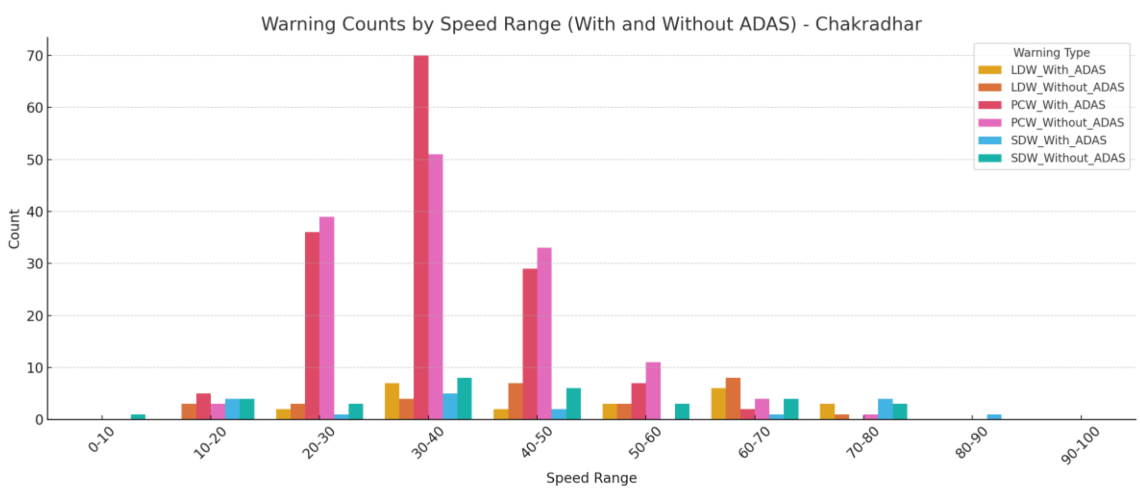
ADAS Impact Analysis: Chakradhar Dataset

This report presents a comparative analysis of three types of driver warnings—LDW (Lane Departure Warning), SDW (Speed Deviation Warning), and PCW (Potential Collision Warning)—across different speed ranges for vehicles equipped with and without ADAS (Advanced Driver Assistance Systems). The data is categorized into speed bins of 10 km/h intervals, and statistical analysis was conducted to determine the impact of ADAS on warning frequency.

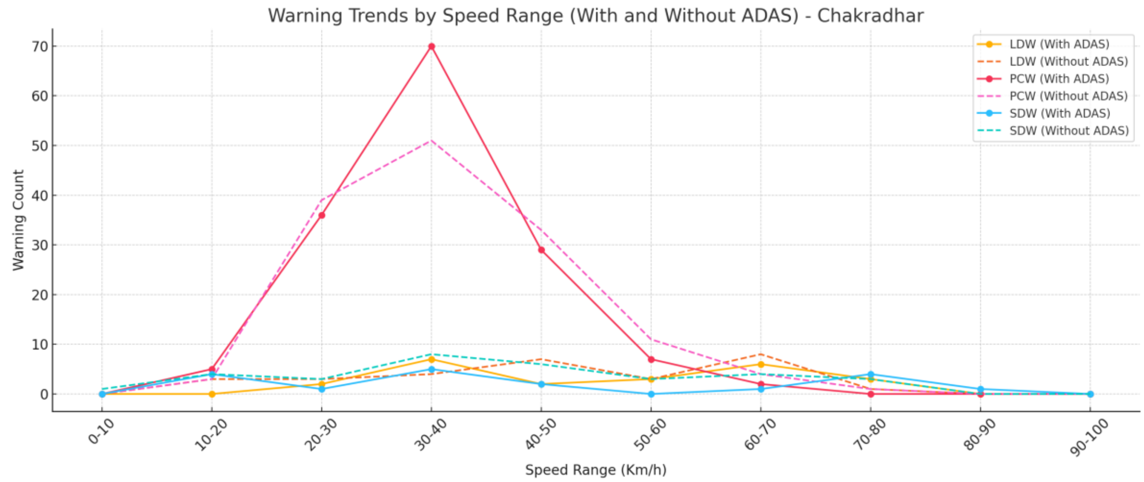
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	1
10-20	0	5	4	3	3	4
20-30	2	36	1	3	39	3
30-40	7	70	5	4	51	8
40-50	2	29	2	7	33	6
50-60	3	7	0	3	11	3
60-70	6	2	1	8	4	4
70-80	3	0	4	1	1	3
80-90	0	0	1	0	0	0
90-100	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: Warning Counts for LDW, SDW, and PCW



T-Test Analysis

To evaluate the statistical significance of differences in warning counts between vehicles with and without ADAS, independent two-sample t-tests were performed for each warning type. The results are as follows:

Warning Type	t-statistic	p-value
LDW	-0.497	0.625
PCW	0.073	0.943
SDW	-1.406	0.178

Based on the t-test results, none of the warning types show statistically significant differences between the ADAS and non-ADAS conditions ($p > 0.05$). While the visual data indicates some differences in trends across speed ranges, the differences are not strong enough to be confirmed statistically. Further data collection or segmentation may be needed for deeper analysis.

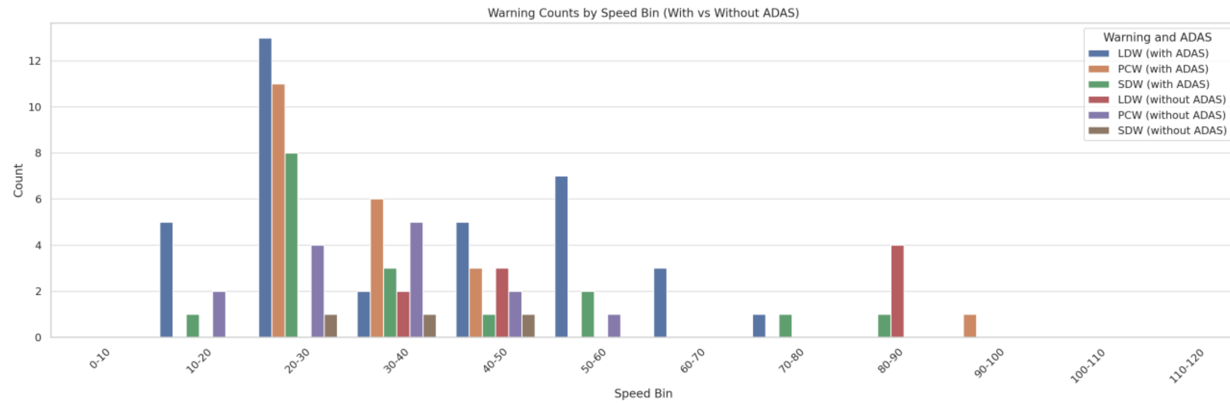
ADAS Impact Analysis: Disheet Dataset

This report analyzes the effect of Advanced Driver Assistance Systems (ADAS) on warning frequencies for the driver Disheet. Warnings considered include Lane Departure Warning (LDW), Speed Deviation Warning (SDW), and Potential Collision Warning (PCW). Data has been grouped by 10 km/h speed bins from 0 to 120 km/h.

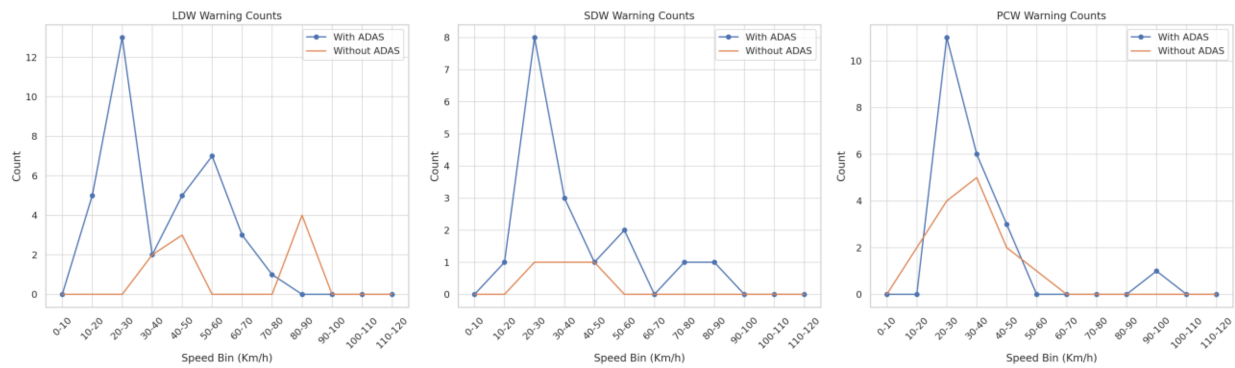
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	0
10-20	5	0	1	0	2	0
20-30	13	11	8	0	4	1
30-40	2	6	3	2	5	1
40-50	5	3	1	3	2	1
50-60	7	0	2	0	1	0
60-70	3	0	0	0	0	0
70-80	1	0	1	0	0	0
80-90	0	0	1	4	0	0
90-100	0	1	0	0	0	0
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: LDW, SDW, PCW Warning Counts



T-Test Analysis

Independent t-tests were conducted to evaluate statistical differences in warning counts with and without ADAS for each type. The results are displayed below:

Warning Type	t-statistic	p-value
SDW	1.743	0.107
PCW	0.523	0.608
LDW	1.845	0.087

All p-values exceeded 0.05, indicating no statistically significant difference between driving with and without ADAS in terms of SDW, PCW, or LDW warnings. However, there is a trend of reduced warnings with ADAS—particularly for LDW—though it is not statistically conclusive.

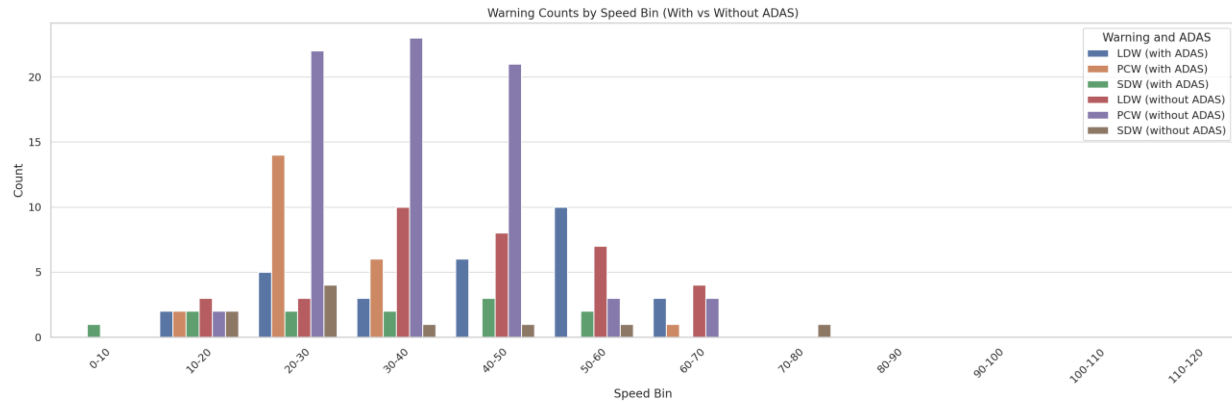
ADAS Impact Analysis: Krishna Dataset

This report presents an analysis of the impact of Advanced Driver Assistance Systems (ADAS) on the occurrence of Lane Departure Warning (LDW), Speed Deviation Warning (SDW), and Potential Collision Warning (PCW) events for the driver Krishna. The data is segmented by speed bins from 0 to 120 km/h in 10 km/h increments, comparing the frequency of warnings with and without ADAS.

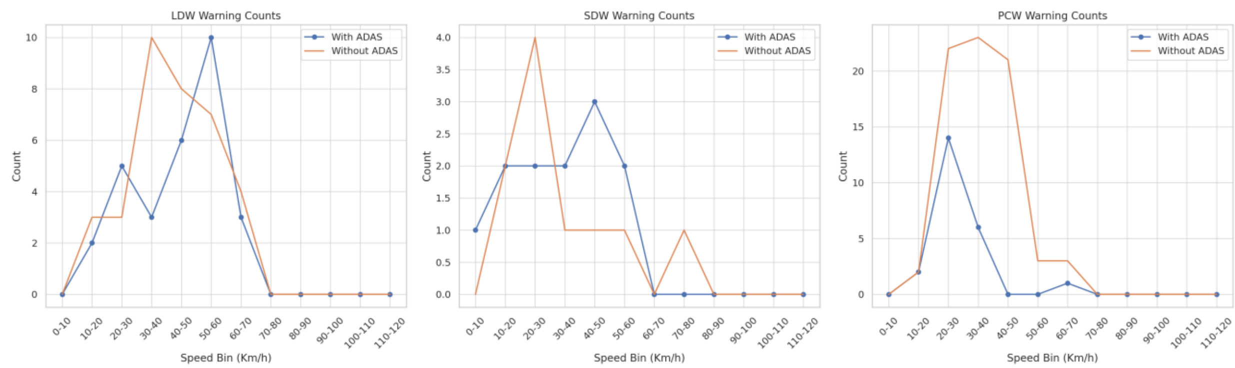
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	1	0	0	0
10-20	2	2	2	3	2	2
20-30	5	14	2	3	22	4
30-40	3	6	2	10	23	1
40-50	6	0	3	8	21	1
50-60	10	0	2	7	3	1
60-70	3	1	0	4	3	0
70-80	0	0	0	0	0	1
80-90	0	0	0	0	0	0
90-100	0	0	0	0	0	0
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: LDW, SDW, PCW Warning Counts



T-Test Analysis

Independent t-tests were conducted for each warning type to determine whether the presence of ADAS significantly impacts the number of warnings. The statistical results are provided below:

Warning Type	t-statistic	p-value
SDW	0.352	0.729
PCW	-1.402	0.181
LDW	-0.358	0.724

The p-values for all warning types (SDW: 0.729, PCW: 0.181, LDW: 0.724) exceed the 0.05 threshold for statistical significance. This suggests that there is no strong evidence to indicate that the presence of ADAS significantly changes the frequency of these warnings for the driver Krishna. While visual differences exist, especially for PCW, they are not statistically supported.

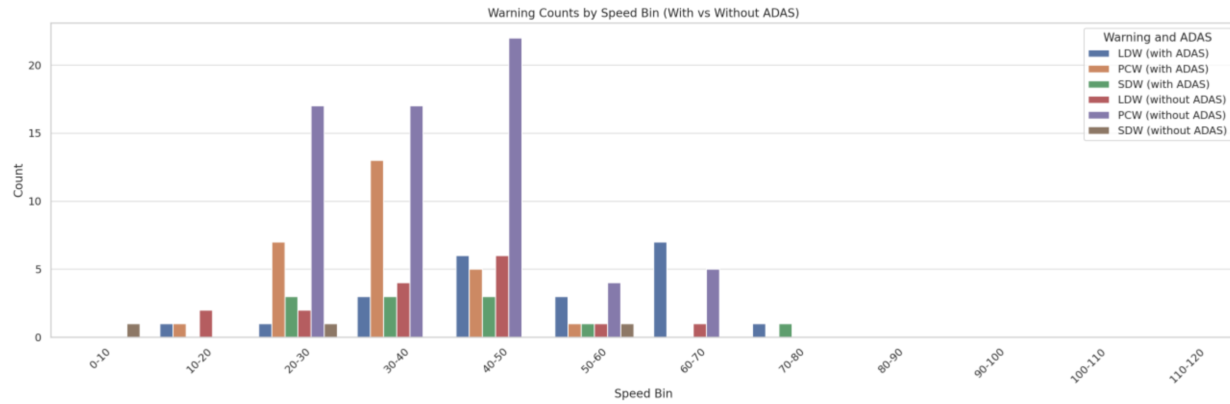
ADAS Impact Analysis: Manjil Dataset

This report analyzes the effect of Advanced Driver Assistance Systems (ADAS) on warning frequencies for the driver Manjil. Warnings considered include Lane Departure Warning (LDW), Speed Deviation Warning (SDW), and Potential Collision Warning (PCW). Data has been grouped by 10 km/h speed bins from 0 to 120 km/h.

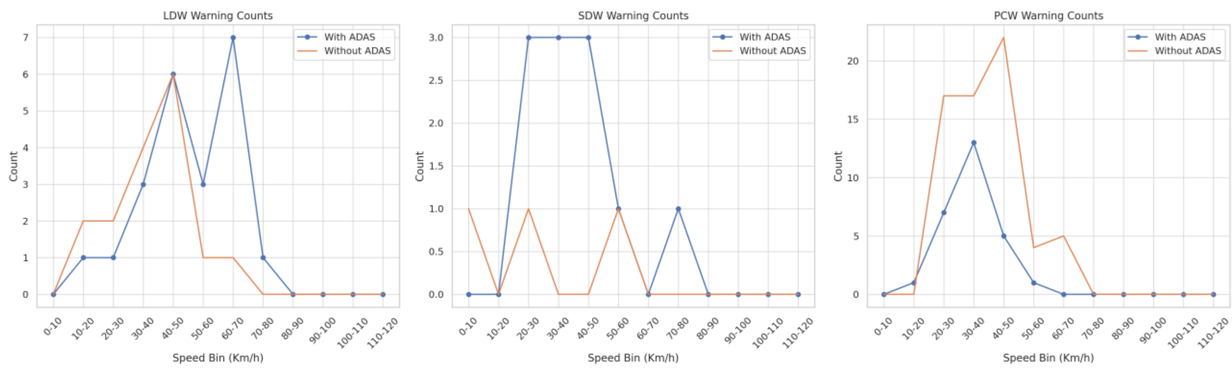
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	1
10-20	1	1	0	2	0	0
20-30	1	7	3	2	17	1
30-40	3	13	3	4	17	0
40-50	6	5	3	6	22	0
50-60	3	1	1	1	4	1
60-70	7	0	0	1	5	0
70-80	1	0	1	0	0	0
80-90	0	0	0	0	0	0
90-100	0	0	0	0	0	0
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: LDW, SDW, PCW Warning Counts



T-Test Analysis

Independent t-tests were conducted to evaluate statistical differences in warning counts with and without ADAS for each type. The results are displayed below:

Warning Type	t-statistic	p-value
SDW	1.665	0.119
PCW	-1.190	0.251
LDW	0.557	0.583

All p-values exceed 0.05, indicating no statistically significant difference between driving with and without ADAS in terms of SDW, PCW, or LDW warnings. While there are differences in raw counts—particularly for PCW—these are not statistically significant under a 95% confidence level.

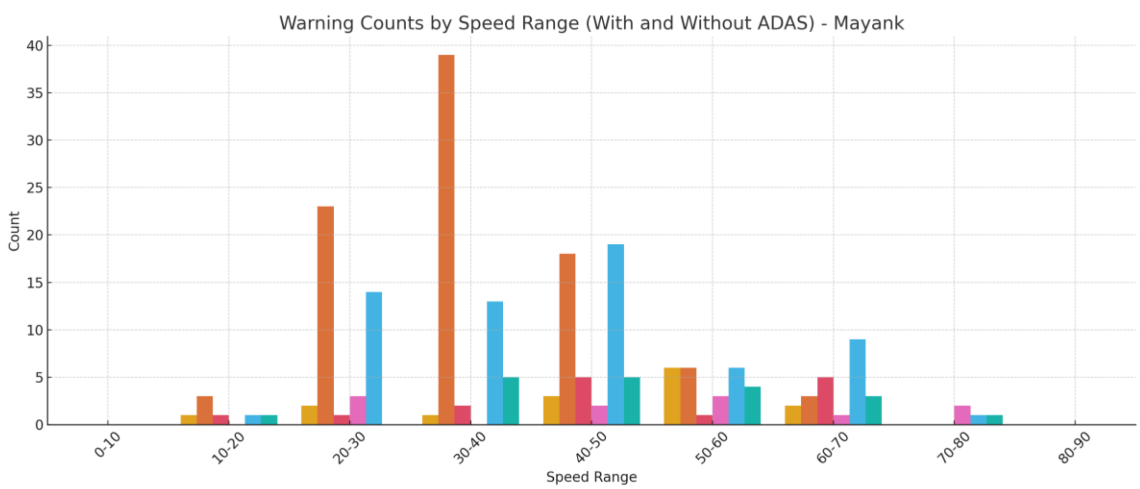
ADAS vs Non-ADAS Analysis - Mayank

Warning Counts by Speed Range

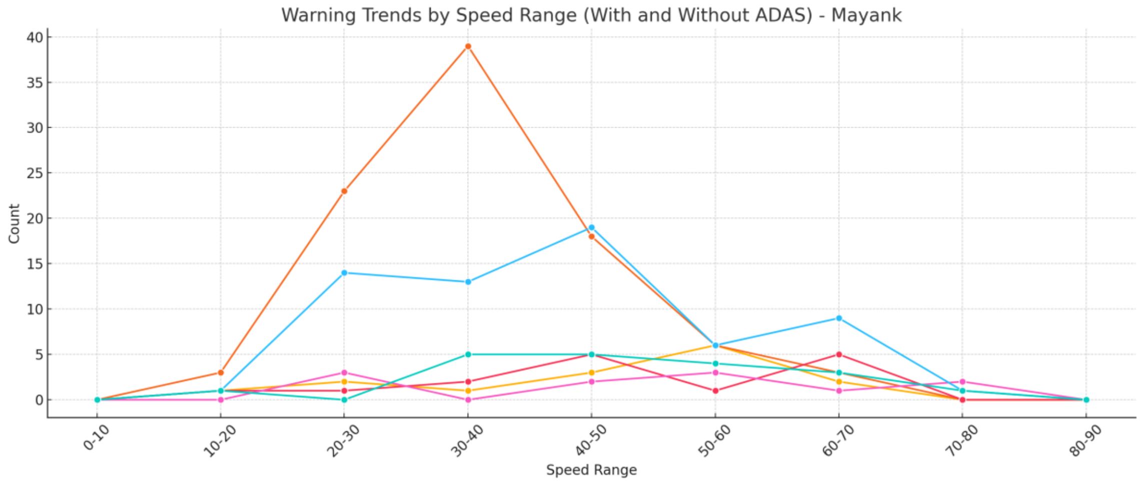
Speed Range	LDW (With ADAS)	PCW (With ADAS)	SDW (With ADAS)	LDW (Without ADAS)	PCW (Without ADAS)	SDW (Without ADAS)
0-10	0	0	0	0	0	0
10-20	1	3	1	0	1	1
20-30	2	23	1	3	14	0
30-40	1	39	2	0	13	5
40-50	3	18	5	2	19	5
50-60	6	6	1	3	6	4
60-70	2	3	5	1	9	3
70-80	0	0	0	2	1	1
80-90	0	0	0	0	0	0

Visualizations

Bar Chart:



Line Chart:



T-Test Results

Warning Type	t-statistic	p-value	Interpretation
LDW	-0.372	0.714	No significant difference
PCW	-2.761	0.007	Statistically significant difference
SDW	0.291	0.773	No significant difference

Interpretation Summary

PCW (Pedestrian Collision Warning) is significantly reduced when ADAS is enabled, indicating that the system effectively helps in avoiding pedestrian-related risks. LDW (Lane Departure Warning) and SDW (Safe Distance Warning) did not show statistically significant differences. This suggests ADAS has the strongest impact in assisting with pedestrian-related warnings for Mayank.

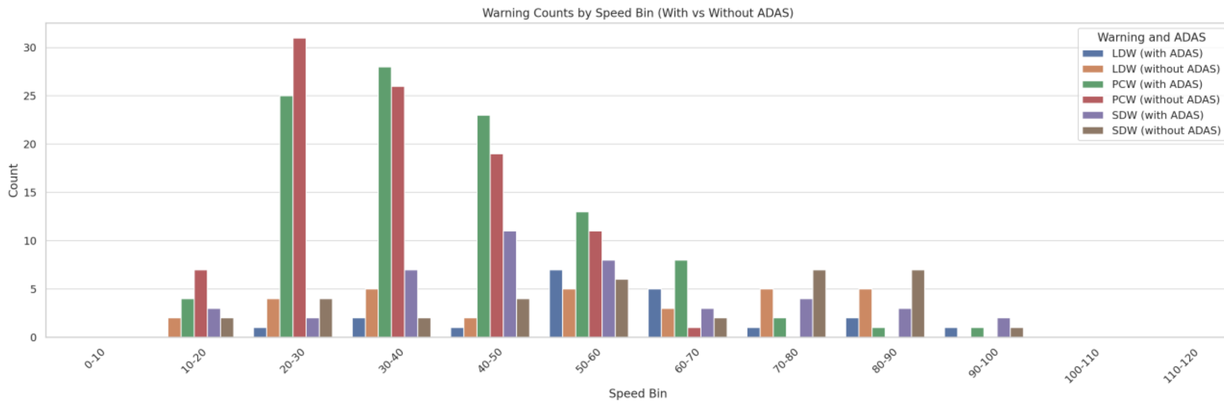
ADAS Impact Analysis: Mrighnabh Dataset

This report presents an analysis of the effect of Advanced Driver Assistance Systems (ADAS) on driving behavior using data from Mrighnabh. The data includes three types of warnings: Lane Departure Warning (LDW), Potential Collision Warning (PCW), and Speed Deviation Warning (SDW). The results are grouped into 10 km/h speed bins for comparison between driving with and without ADAS.

Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	LDW (without ADAS)	PCW (with ADAS)	PCW (without ADAS)	SDW (with ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	0
10-20	0	2	4	7	3	2
20-30	1	4	25	31	2	4
30-40	2	5	28	26	7	2
40-50	1	2	23	19	11	4
50-60	7	5	13	11	8	6
60-70	5	3	8	1	3	2
70-80	1	5	2	0	4	7
80-90	2	5	1	0	3	7
90-100	1	0	1	0	2	1
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: LDW, SDW, PCW Warning Counts

Warning Type	t-statistic	p-value
LDW	-1.025	0.317
PCW	0.185	0.855
SDW	0.531	0.601

Interpretation

All p-values are greater than the standard significance level of 0.05, indicating that there is no statistically significant difference in the frequency of these warnings between ADAS and non-ADAS conditions for Mrighnabh. Although visual trends may suggest minor differences, these are not statistically supported.

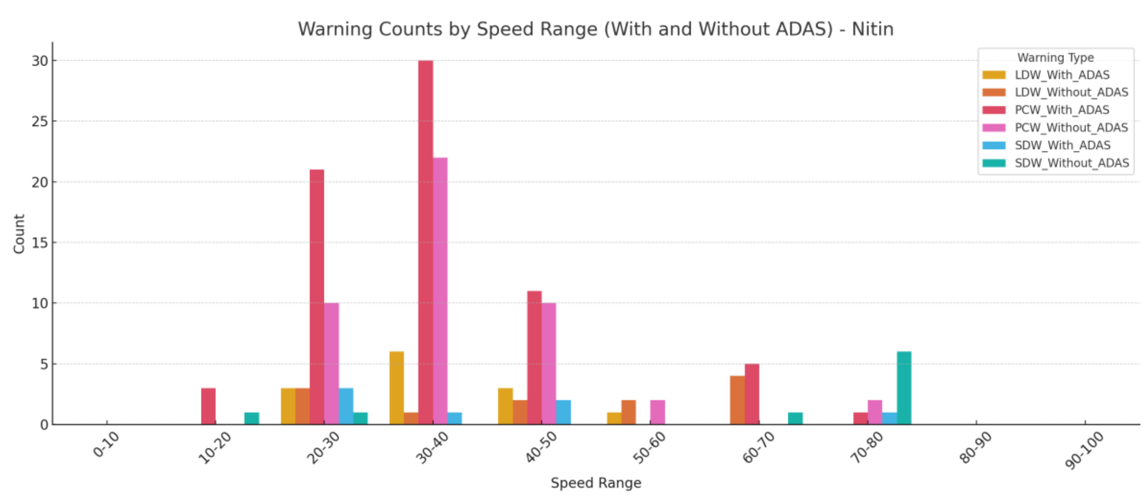
ADAS Impact Analysis: Nitin Dataset

This report presents a comparative analysis of three types of driver warnings—LDW (Lane Departure Warning), SDW (Speed Deviation Warning), and PCW (Potential Collision Warning)—across different speed ranges for vehicles equipped with and without ADAS (Advanced Driver Assistance Systems). The data is categorized into speed bins of 10 km/h intervals, and statistical analysis was conducted to determine the impact of ADAS on warning frequency.

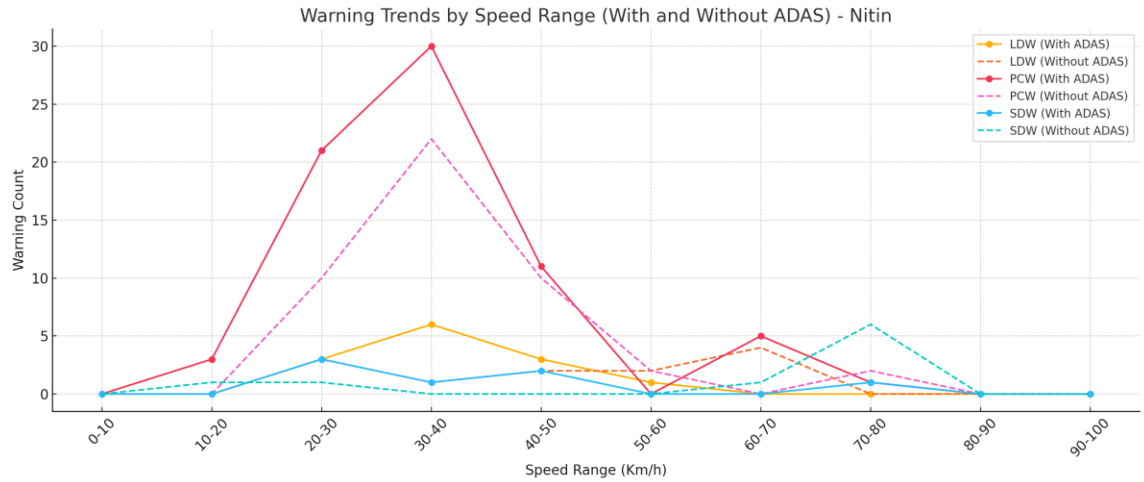
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	0
10-20	0	3	0	0	0	1
20-30	3	21	3	3	10	1
30-40	6	30	1	1	22	0
40-50	3	11	2	2	10	0
50-60	1	0	0	2	2	0
60-70	0	5	0	4	0	1
70-80	0	1	1	0	2	6
80-90	0	0	0	0	0	0
90-100	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: Warning Counts for LDW, SDW, and PCW



T-Test Analysis

To evaluate the statistical significance of differences in warning counts between vehicles with and without ADAS, independent two-sample t-tests were performed for each warning type. The results are as follows:

Warning Type	t-statistic	p-value
LDW	0.125	0.902
PCW	0.618	0.545
SDW	-0.296	0.771

Based on the t-test analysis, none of the warning types (LDW, PCW, SDW) show a statistically significant difference between the ADAS and non-ADAS conditions. This indicates that for Nitin's driving data, the use of ADAS did not result in significantly different warning frequencies overall, although visual differences exist in certain speed ranges.

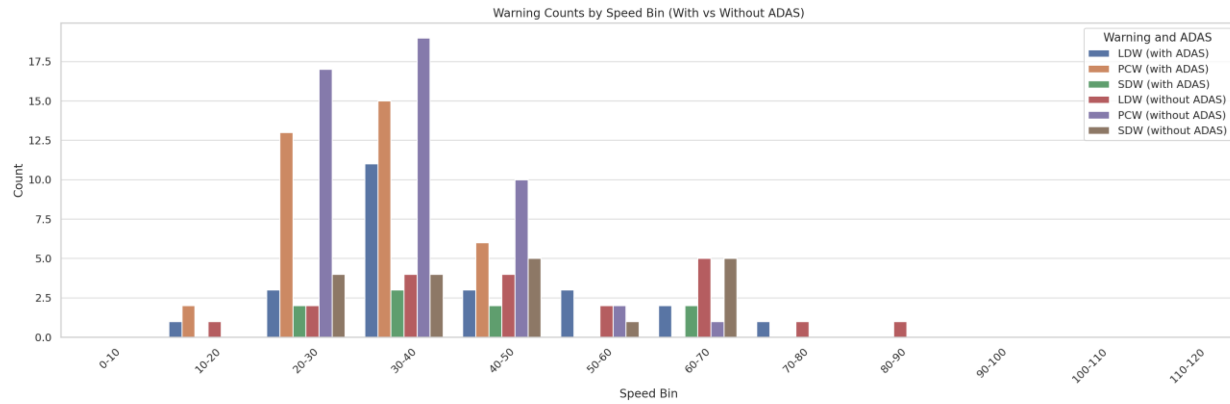
ADAS Impact Analysis: Prithvee Dataset

This report analyzes the influence of Advanced Driver Assistance Systems (ADAS) on the frequency of various driving warnings, including Lane Departure Warning (LDW), Speed Deviation Warning (SDW), and Potential Collision Warning (PCW), for the driver Prithvee. Data is categorized into 10 km/h speed bins ranging from 0 to 120 km/h.

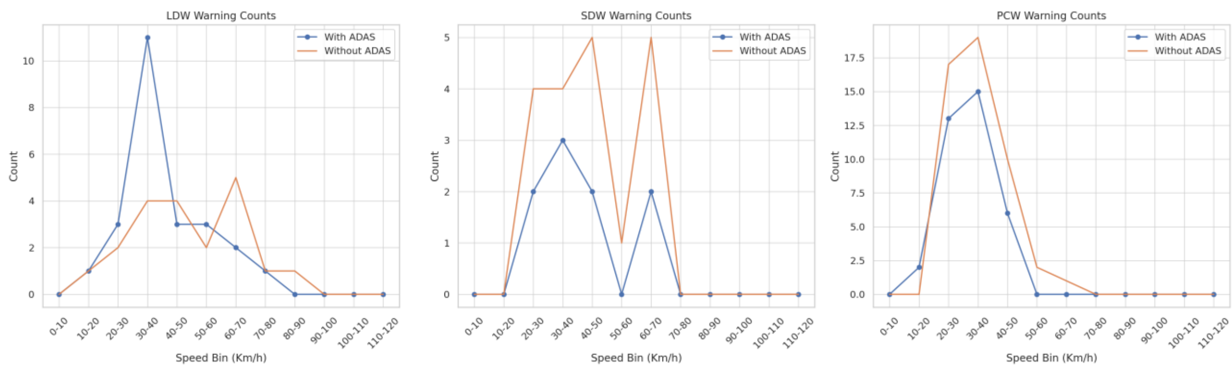
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	0
10-20	1	2	0	1	0	0
20-30	3	13	2	2	17	4
30-40	11	15	3	4	19	4
40-50	3	6	2	4	10	5
50-60	3	0	0	2	2	1
60-70	2	0	2	5	1	5
70-80	1	0	0	1	0	0
80-90	0	0	0	1	0	0
90-100	0	0	0	0	0	0
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: LDW, SDW, PCW Warning Counts



T-Test Analysis

To assess the impact of ADAS, independent t-tests were conducted on each warning type. The results are summarized in the table below.

Warning Type	t-statistic	p-value
SDW	-1.168	0.259
PCW	-0.419	0.679
LDW	0.323	0.751

The t-tests for all warning types (SDW, PCW, and LDW) yield p-values greater than 0.05, indicating no statistically significant difference in warning frequency between driving with and without ADAS for Prithvee. Thus, ADAS appears to have no measurable effect on warning reduction in this specific dataset.

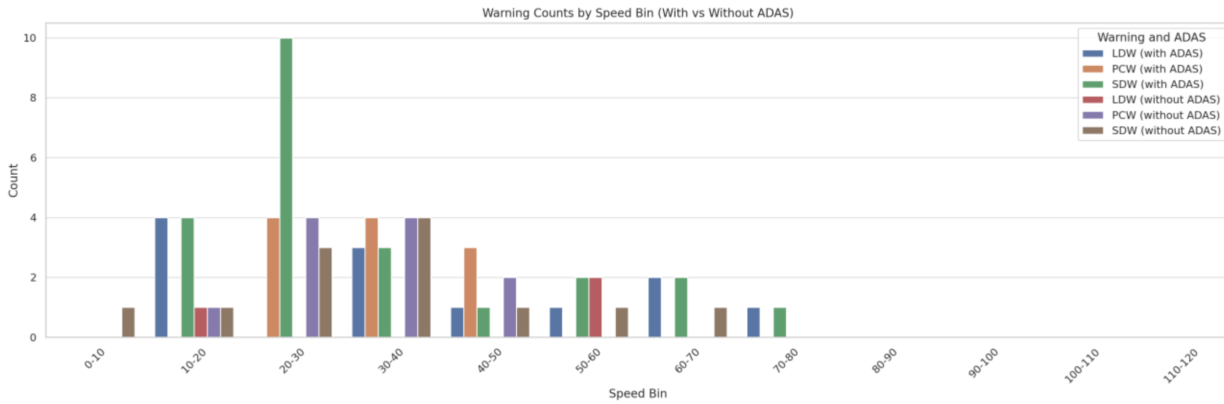
ADAS Impact Analysis: Sourabh Dataset

This report analyzes the effect of Advanced Driver Assistance Systems (ADAS) on warning frequencies for the driver Sourabh. Warnings considered include Lane Departure Warning (LDW), Speed Deviation Warning (SDW), and Potential Collision Warning (PCW). Data has been grouped by 10 km/h speed bins from 0 to 120 km/h.

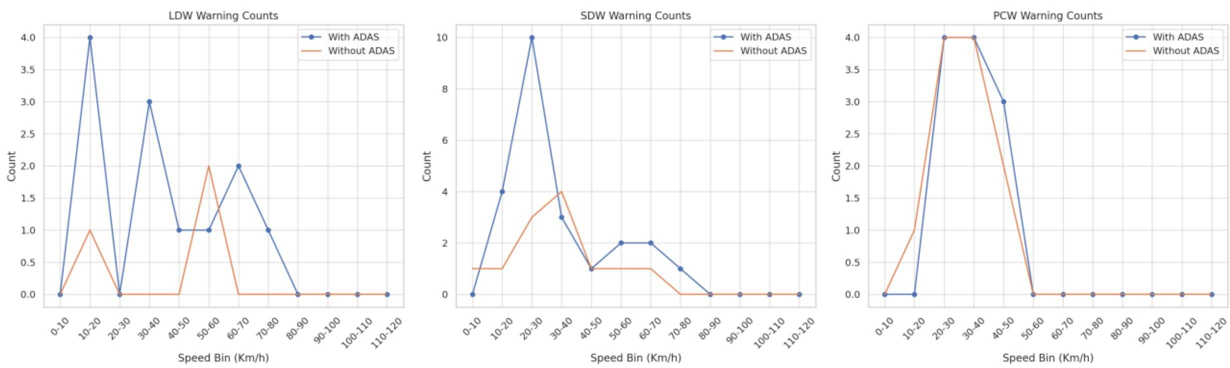
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	1
10-20	4	0	4	1	1	1
20-30	0	4	10	0	4	3
30-40	3	4	3	0	4	4
40-50	1	3	1	0	2	1
50-60	1	0	2	2	0	1
60-70	2	0	2	0	0	1
70-80	1	0	1	0	0	0
80-90	0	0	0	0	0	0
90-100	0	0	0	0	0	0
100-110	0	0	0	0	0	0
110-120	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: LDW, SDW, PCW Warning Counts



T-Test Analysis

Independent t-tests were conducted to evaluate statistical differences in warning counts with and without ADAS for each type. The results are displayed below:

Warning Type	t-statistic	p-value
SDW	1.009	0.329
PCW	0.000	1.000
LDW	1.750	0.100

All p-values exceed 0.05, indicating no statistically significant difference between driving with and without ADAS in terms of SDW, PCW, or LDW warnings. However, LDW showed a possible trend toward reduction with ADAS, though not conclusively significant.

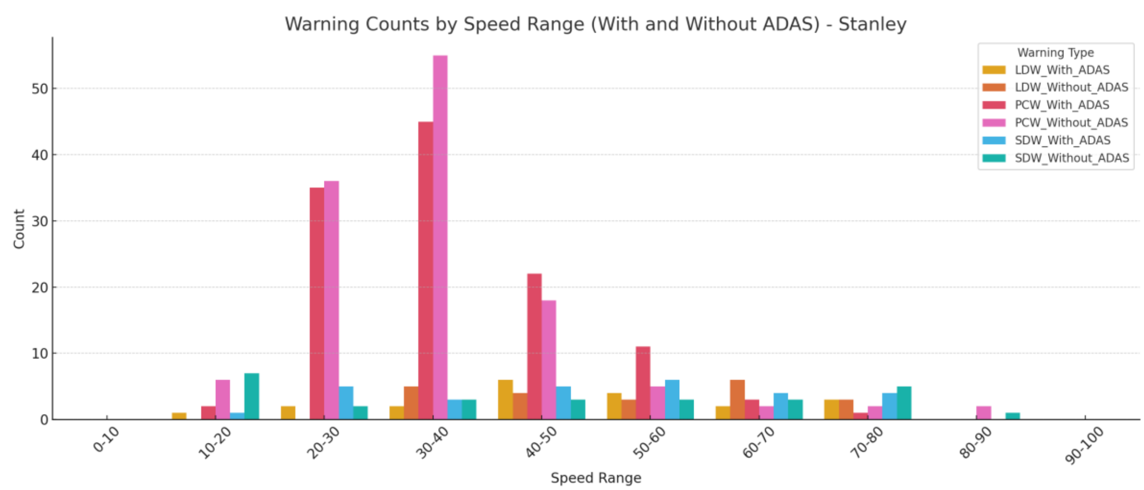
ADAS Impact Analysis: Stanley Dataset

This report presents a comparative analysis of three types of driver warnings—LDW (Lane Departure Warning), SDW (Speed Deviation Warning), and PCW (Potential Collision Warning)—across different speed ranges for vehicles equipped with and without ADAS (Advanced Driver Assistance Systems). The data is categorized into speed bins of 10 km/h intervals, and statistical analysis was conducted to determine the impact of ADAS on warning frequency.

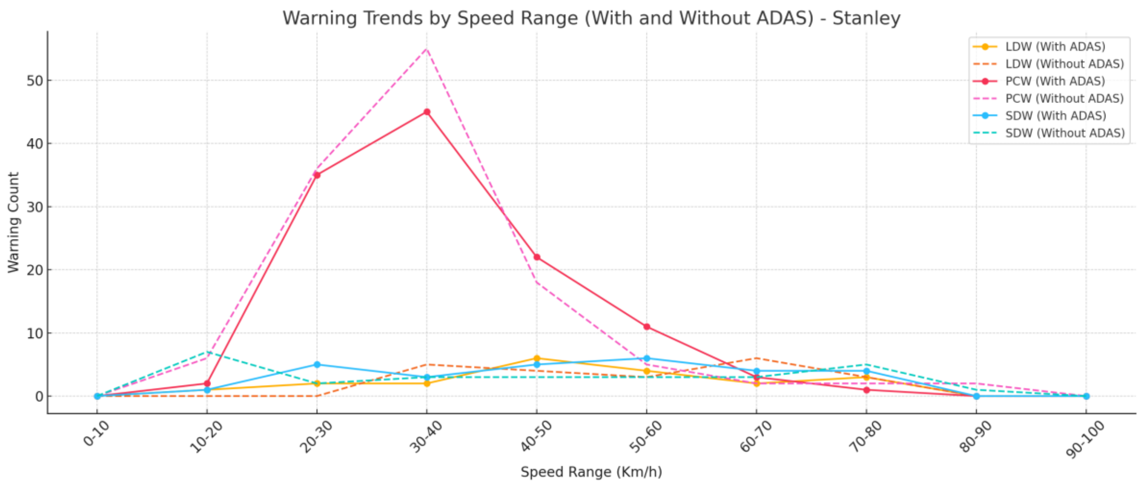
Warning Counts by Speed Bin

Speed Bin	LDW (with ADAS)	PCW (with ADAS)	SDW (with ADAS)	LDW (without ADAS)	PCW (without ADAS)	SDW (without ADAS)
0-10	0	0	0	0	0	0
10-20	1	2	1	0	6	7
20-30	2	35	5	0	36	2
30-40	2	45	3	5	55	3
40-50	6	22	5	4	18	3
50-60	4	11	6	3	5	3
60-70	2	3	4	6	2	3
70-80	3	1	4	3	2	5
80-90	0	0	0	0	2	1
90-100	0	0	0	0	0	0

Bar Chart: Warning Counts by Speed Bin



Line Charts: Warning Counts for LDW, SDW, and PCW



T-Test Analysis

To evaluate the statistical significance of differences in warning counts between vehicles with and without ADAS, independent two-sample t-tests were performed for each warning type. The results are as follows:

Warning Type	t-statistic	p-value
LDW	-0.103	0.919
PCW	-0.089	0.930
SDW	0.099	0.922

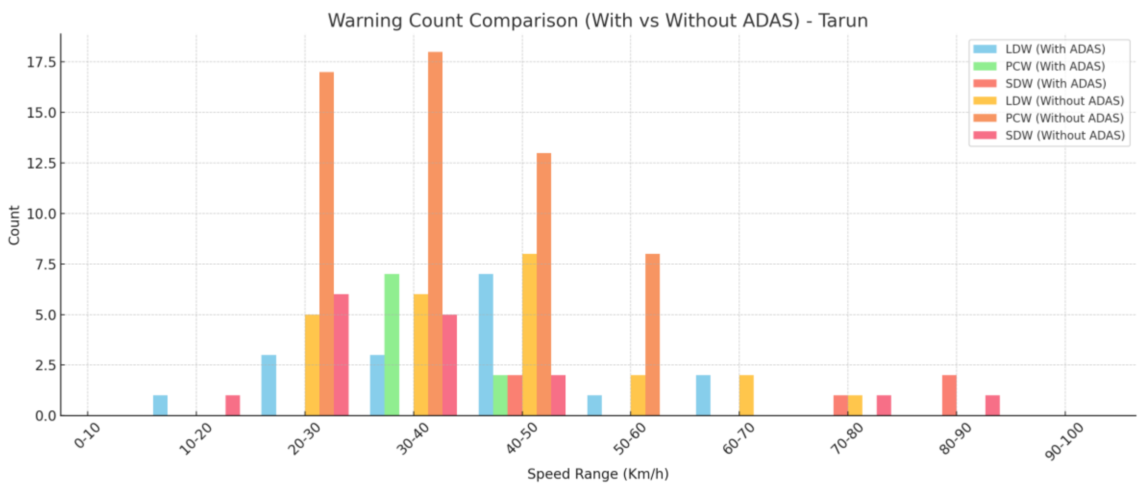
All p-values are above the significance threshold of 0.05, indicating that there is no statistically significant difference in warning frequency between vehicles equipped with and without ADAS. Visual trends may show variation across speed bins, but these are not statistically validated under standard confidence levels.

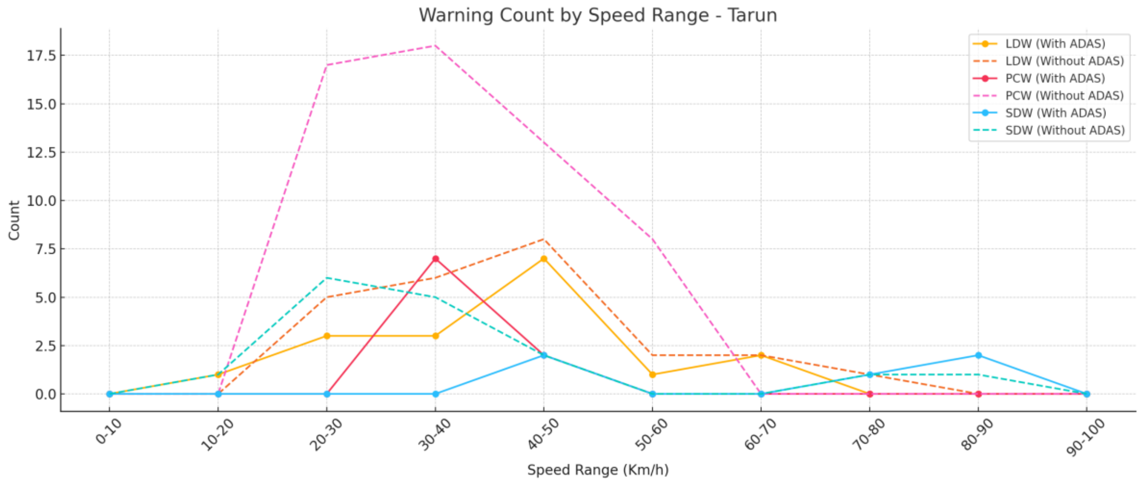
ADAS vs Non-ADAS Warning Analysis - Tarun

Speed Range Warning Count Comparison

Speed Range	LDW (With ADAS)	LDW (Without ADAS)	PCW (With ADAS)	PCW (Without ADAS)	SDW (With ADAS)	SDW (Without ADAS)
0-10	0	0	0	0	0	0
10-20	1	0	0	0	0	1
20-30	3	5	0	17	0	6
30-40	3	6	7	18	0	5
40-50	7	8	2	13	2	2
50-60	1	2	0	8	0	0
60-70	2	2	0	0	0	0
70-80	0	1	0	0	1	1
80-90	0	0	0	0	2	1
90-100	0	0	0	0	0	0

Visualizations





T-Test Results

LDW: t-statistic = -0.60, p-value = 0.553 - Not Significant

PCW: t-statistic = -1.86, p-value = 0.092 - Not Significant

SDW: t-statistic = -1.49, p-value = 0.162 - Not Significant

Interpretation

The t-test results indicate that there is no statistically significant difference in the number of LDW, PCW, and SDW warnings between the ADAS and Non-ADAS conditions for Tarun. The PCW warnings show a trend toward significance ($p \approx 0.09$), suggesting that with a larger sample size, the difference might become significant.

Discussion

The results of this study provide valuable insights into the behavior of drivers and the role of Advanced Driver Assistance Systems (ADAS) in real-world driving conditions. While the analysis revealed fluctuations in the number of warnings issued across different drivers and speed bins, the overall statistical evaluation indicated **no significant difference** between ADAS-enabled and non-ADAS trips in terms of total warning counts.

1. Interpreting the Results

The **paired t-tests** for all three warning types—**Lane Departure Warning (LDW)**, **Safe Distance Warning (SDW)**, and **Pedestrian Collision Warning (PCW)**—showed p-values greater than 0.05. This suggests that the presence of ADAS did not result in a statistically meaningful change in the number of warnings issued. Although some drivers experienced fewer warnings with ADAS, others recorded more, leading to inconclusive aggregate effects.

The **speed-bin-wise analysis** revealed that most warnings were concentrated in the **30–50 km/h** range, which corresponds to typical urban traffic conditions. These zones likely involved more interactions with pedestrians, lane changes, and speed fluctuations, increasing the probability of triggering warnings. Interestingly, while **fewer warnings occurred at higher speeds**, those that did are inherently more dangerous due to **shorter reaction times and greater impact forces**.

2. Behavioral Observations

Several behavioral trends were evident during data review:

- Some drivers appeared to **disregard ADAS alerts**, continuing to drive in ways that triggered repeated warnings.
- Others may have become **over-reliant on ADAS**, exhibiting less vigilance, which in turn could lead to more system-flagged infractions.
- The **effectiveness of ADAS was partially dependent on the driver's compliance** with the system's feedback, reinforcing the idea that technology alone cannot ensure safety without active human participation.

3. Limitations of the Study

While the study methodology was robust, several limitations must be acknowledged:

- **Limited sample size** of drivers restricts the generalizability of the findings.
- **Variations in traffic conditions**, such as congestion or weather, could not be fully standardized across trips.
- **Manual video review** may introduce some degree of subjectivity in labeling warnings as true or false.
- The analysis focused only on **three ADAS warning types**, leaving out other assistive functions such as adaptive cruise control or emergency braking.

4. Implications and Future Directions

The findings underscore the complexity of integrating ADAS technologies into real-world environments. While the system is capable of detecting potential hazards, its practical impact depends on the **driver's engagement**, **traffic environment**, and **system tuning**.

Future studies should consider:

- **Larger and more diverse driver samples**
- Use of **automated data logging tools** for precision and efficiency
- Incorporation of **driver monitoring systems** (e.g., eye tracking, distraction analysis)
- Longitudinal studies to observe behavior over extended periods

Conclusion

This internship provided an in-depth opportunity to explore the application and impact of **Advanced Driver Assistance Systems (ADAS)** in real-world driving environments. Through systematic video-based data extraction, organization, and statistical evaluation, we assessed the frequency and nature of warnings generated with and without ADAS across multiple drivers and varying speed conditions.

The core of the analysis focused on comparing **driver-wise warning counts** and conducting **speed-bin-wise assessments** to determine the relationship between speed, driver behavior, and warning occurrences. While the presence of ADAS introduced consistent alerting mechanisms, the statistical results indicated that the differences in warning counts between ADAS-enabled and non-ADAS trips were **not significant**. Additionally, the highest warning density was observed in the **30–50 km/h speed range**, emphasizing the complexity of urban driving environments.

Beyond the technical analysis, the internship facilitated hands-on experience in **video data interpretation**, **statistical testing using t-tests**, and **data visualization**, all of which are crucial skills in modern transportation research. It also provided practical insights into the limitations of ADAS technologies, particularly the importance of driver compliance and the variability introduced by real-world conditions.

Overall, the internship not only strengthened our understanding of transportation systems and safety technologies but also highlighted the challenges and opportunities in the deployment of intelligent driving aids. The experience gained through this project lays a strong foundation for future work in traffic behavior analysis, data-driven policy evaluation, and the development of smarter, safer mobility solutions.

Appendices

Appendix A: Sample Extracted Data (From Excel File)

The table below is a sample from the raw dataset used in the analysis. Each entry corresponds to a warning event recorded during an ADAS-enabled trip.

Time Stamp	Warning Type	True/False	Front Vehicle	Vehicle in Opposite Lane	Speed (km/h)	Speed Reduction	Lateral Shift	Time of Reduction/Shift
01:02:34	LDW	True	2W	-	54	NO	YES	01:02:37
01:03:06	LDW	True	-	-	68	NO	NO	NO
01:03:10	SDW	False	2W	-	71	NO	NO	NO
01:03:34	SDW	False	CAR	-	61	NO	NO	NO
01:03:39	SDW	False	-	-	60	NO	NO	NO

Note: "2W" = Two-Wheeler; LDW = Lane Departure Warning; SDW = Speed Detection Warning

Appendix B: Data Fields Description

Column Name	Description
Time Stamp	Time when the warning occurred (from video)
Warning Type	Type of ADAS warning (LDW, SDW, etc.)
True/False	Indicates whether the warning was a valid (true) or false positive
Front Vehicle	Type of vehicle directly in front of the test vehicle (e.g., 2W, CAR)

Vehicle in Opposite Lane	Vehicle detected in the opposite lane (if any)
Speed (Km/h)	Approximate speed of the test vehicle at the time of warning
IF SPEED REDUCTION	Whether the driver reduced speed in response to the warning
Lateral Shift (if any)	Whether a lane shift was observed (for LDW/PCW scenarios)
Time of Reduction or Shift	Timestamp of any response action after the warning

Appendix C: Notes on Data Extraction

- All data was manually extracted by reviewing dashcam video footage.
- Driver reactions were observed visually and interpreted based on observable maneuvers.
- Speed readings were taken from the in-video HUD (if available) or inferred from context.
- Data was entered into structured Excel sheets per driver, with consistent column formatting for comparability.