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Driver Gap Acceptance And Passing Sight Distance Analysis On Rural Single-Carriageway Roads Using Field Video Observations

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Abstract

Overtaking maneuvers on rural single-carriageway roads represent one of the most critical sources of head-on collision risk due to limited passing sight distance (PSD) and opposing-lane exposure. This study investigates driver gap acceptance behavior and PSD characteristics under real traffic conditions using field video observations collected on single-carriageway roads. A total of 214 overtaking maneuvers were extracted and analyzed using descriptive statistics, correlation analysis, linear regression, and logistic regression modeling. The results demonstrated a significant inverse relationship between operational speeds and accepted overtaking gap, indicating adaptive driver risk-tolerance behavior at higher travel speeds. The developed regression model showed a strong positive relationship between speed and required passing sight distance (R^2=0.73), expressed as PSD=182.4+3.05V. The findings further revealed that many observed overtaking maneuvers were completed using shorter passing distances than those recommended by AASHTO guidelines, particularly under high-speed conditions. The study contributes to transportation safety research by integrating overtaking behavior, gap acceptance, and PSD analysis within a unified behavioral framework specifically focused on rural single-carriageway roads. The outcomes provide important implications for behavior-aware highway safety assessment and intelligent overtaking assistance systems.

Keywords: Overtaking behavior; Single-carriageway roads; Gap acceptance; Passing sight distance; Head-on collision risk.

1. Introduction

Rural single-carriageway roads constitute a major component of highway transportation networks in many developing countries. These facilities typically consist of one lane for each travel direction without physical median separation, requiring overtaking vehicles to temporarily enter the opposing traffic lane during passing maneuvers. Consequently, overtaking operations on single-carriageway roads are associated with elevated crash severity and increased head-on collision risk compared with divided highway facilities [1, 2]. The World Health Organization reported that road traffic crashes account for approximately 1.19 million deaths annually worldwide, with single-carriageway roads contributing disproportionately to severe and fatal head-on collisions. Unsafe overtaking maneuvers on single-carriageway roads are recognized as a major contributor to crash severity due to limited passing sight distance, opposing-lane exposure, and driver misjudgment during overtaking decision-making processes.

Unlike multilane highways, overtaking opportunities on single-carriageway roads are highly constrained by opposing traffic conditions, roadway visibility, geometric alignment, and driver judgment capability. Drivers must simultaneously estimate opposing vehicle speed, evaluate available overtaking distance, assess acceleration capability, and determine whether the maneuver can be completed safely before encountering oncoming traffic [3]. Failure to accurately evaluate these factors may lead to catastrophic head-on crashes, particularly under limited visibility conditions [4].

Overtaking-related crashes remain among the most severe accident types on single-carriageway roads because overtaking vehicles remain fully exposed to opposing traffic conflicts throughout the maneuver duration [5]. The absence of median separation substantially limits maneuver recovery opportunities once the overtaking vehicle occupies the opposing lane. Therefore, understanding overtaking decision-making behavior on rural single-carriageway roads is essential for improving traffic safety performance and geometric highway design [6].

Driver gap acceptance behavior represents one of the most important behavioral factors influencing overtaking safety. Gap acceptance refers to the minimum spatial or temporal separation that a driver considers sufficient to safely initiate and complete an overtaking maneuver. On single-carriageway roads, accepted gaps are directly related to opposing-lane exposure duration and head-on collision probability [7, 8 and 9].

1.1. Study Context

The present study was conducted on the Brak–Sebha Road, located in southern Libya. This roadway represents one of the principal intercity transport corridors connecting Brak Al-Shati and Sebha. The route carries a mixture of passenger cars, buses, freight vehicles, and service traffic. Several segments of the road are characterized by limited passing sight distance caused by horizontal and vertical alignment as well as surrounding desert terrain, making it an appropriate case study for investigating overtaking behaviour on rural single-carriageway roads.

Previous overtaking studies have investigated driver behavior using driving simulators, instrumented vehicles, radar monitoring systems, and roadside video observations. Several studies reported that drivers operating at higher speeds tend to accept shorter overtaking gaps, thereby reducing available safety margins during overtaking maneuvers. Such behavior is commonly interpreted as adaptive risk-tolerance behavior, where drivers dynamically modify their accepted risk levels according to traffic demand and perceived roadway capability [9].

Passing sight distance (PSD) is another critical parameter governing overtaking safety on rural single-carriageway roads. PSD represents the minimum visible roadway distance required for a driver to safely complete an overtaking maneuver without conflicting with opposing traffic. Conventional highway geometric design standards, including those developed by American Association of State Highway and Transportation Officials, AASHTO [10], define PSD values based on assumed driver behavior and idealized operational conditions. However, actual overtaking behavior under heterogeneous rural traffic environments may differ substantially from standard design assumptions [11, 12]

Although considerable research has been conducted on overtaking behavior and passing sight distance, several limitations remain evident in current literature. First, many previous studies focused on general overtaking behavior without specifically addressing the unique operational risks associated with single-carriageway roads. Second, relatively few investigations have integrated driver gap acceptance, adaptive risk tolerance, and passing sight distance within a unified field-based analytical framework [13]. Third, limited research has directly evaluated overtaking behavior on single-carriageway roads in developing-country traffic environments using real-world field observations [11, 14].

Therefore, further investigation is required to better understand overtaking decision-making behavior under realistic operating conditions on rural single-carriageway roads. In particular, evaluating how drivers adapt accepted overtaking gaps under constrained opposing-lane conditions may provide important insights for roadway safety assessment and overtaking assistance system development.

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The objectives of this study are to:

1. Quantify the relationship between overtaking travel speed and driver gap acceptance behavior on rural single-carriageway roads.
2. Examine whether accepted overtaking gaps vary consistently with adaptive driver risk tolerance under different speed conditions.
3. Estimate overtaking decision probabilities using a validated logistic regression framework based on observed field data.
4. Derive implications for behavior-aware traffic safety interventions and intelligent overtaking assistance systems on rural single-carriageway highways.

The study contributes to transportation safety research by developing a behavior-oriented overtaking analysis framework specifically focused on rural single-carriageway roads under heterogeneous two-way traffic conditions.

1.2. Novelty and Research Contribution

The novelty of this study lies in integrating driver gap acceptance behavior, adaptive risk tolerance, and passing sight distance analysis within a unified field-based behavioral framework specifically developed for rural single-carriageway roads. Unlike previous studies conducted under simulator environments or multilane traffic facilities, the present research evaluates overtaking maneuvers under real-world conditions where drivers must continuously interact with opposing traffic streams while occupying the opposing lane.

The findings of this study are expected to support future roadway geometric design evaluation, overtaking safety assessment, and intelligent transportation system development for rural single-carriageway highways operating under heterogeneous traffic conditions. Assess the consistency of observed overtaking behavior with American Association of State Highway and Transportation Officials passing sight distance recommendations.

2. Literature Review

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Overtaking maneuvers on rural single-carriageway roads have been extensively recognized as one of the primary contributors to severe traffic conflicts and head-on collisions on single-carriageway roads [15]. Unlike divided roadway facilities, single-carriageway roads require overtaking vehicles to temporarily occupy the opposing traffic lane, thereby exposing drivers directly to oncoming traffic during maneuver execution. Consequently, overtaking safety on such facilities is highly dependent on driver judgment, roadway visibility, opposing traffic conditions, and accepted safety margins [1, 6].

Early highway safety studies primarily addressed overtaking operations through deterministic geometric design approaches based on passing sight distance requirements. Conventional highway design standards established minimum visibility distances necessary for completing overtaking maneuvers safely under assumed operational conditions. However, these approaches generally relied on idealized assumptions regarding driver behavior, reaction time, acceleration capability, and uniform traffic conditions [16, 12]

Subsequent studies demonstrated that actual overtaking behavior frequently differs from theoretical design assumptions, particularly on rural single-carriageway roads operating under heterogeneous traffic conditions. Researchers reported that drivers often accept shorter overtaking gaps than those assumed in conventional geometric design guidelines, especially under increased traffic demand or higher travel speeds.

Gap acceptance behavior has become one of the most important behavioral indicators used to evaluate overtaking safety on single-carriageway roads. Accepted gap represents the minimum spatial or temporal separation that drivers perceive as sufficient to safely initiate overtaking maneuvers. On single-carriageway roads, accepted gaps directly influence opposing-lane exposure duration and head-on collision probability [8, 5].

Several researchers observed that overtaking decisions are strongly affected by:

- Travel speed,
- Traffic density,
- Opposing vehicle approach rate,
- Roadway visibility,
- Driver aggressiveness,

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- Perceived urgency.

Drivers operating at elevated speeds frequently exhibit adaptive risk-compensation tendencies characterized by reduced accepted safety margins and shorter overtaking gaps [9].

This behavioral adaptation is particularly critical on rural single-carriageway roads because overtaking vehicles remain continuously exposed to opposing traffic throughout the maneuver duration. Once the vehicle occupies the opposing lane, maneuver recovery opportunities become highly limited, especially under insufficient passing sight distance conditions.

Recent overtaking studies increasingly adopted probabilistic and behavioral modeling approaches instead of purely deterministic geometric analysis. Logistic regression models have proven particularly effective for estimating overtaking decision probability because overtaking acceptance inherently represents a binary driver decision process [17, 18, and 19].

The probability of overtaking acceptance may be estimated using:

$$P(Y=1) = \frac{1}{1+e-(\beta_0+\beta_1 V+\beta_2 G+\beta_3 T)} \quad (1)$$

Where:

- P(Y=1) represents the probability of overtaking acceptance,
- V denotes overtaking speed,
- G represents accepted overtaking gap,
- T denotes decision time,
- β are regression coefficients.

Behavioral overtaking models have become increasingly important for intelligent transportation systems and overtaking-assistance technologies because they allow estimation of unsafe overtaking probability under varying roadway and traffic conditions.

Although numerous overtaking studies have been conducted internationally, relatively limited research has specifically focused on overtaking behavior under developing-country traffic environments characterized by:

- heterogeneous vehicle composition,
- inconsistent traffic discipline,
- varying roadway standards,

- Limited overtaking visibility.

Furthermore, limited studies have simultaneously integrated:

- driver gap acceptance,
- adaptive risk tolerance,
- passing sight distance,
- and opposing-lane exposure

Within a unified analytical framework specifically developed for rural single-carriageway roads.

Therefore, additional field-based overtaking investigations remain necessary to better understand driver decision-making behavior under realistic undivided-highway operating conditions.

The present study addresses these limitations by integrating field-observed overtaking behavior, passing sight distance analysis, adaptive driver risk tolerance interpretation, and logistic overtaking decision modeling within a unified framework specifically focused on rural single-carriageway roads.

3. Methodology

3.1 Study Area and Roadway Characteristics

The field investigation was carried out along selected sections of the Brak–Sebha Road in southern Libya. Site selection was based on preliminary reconnaissance surveys identifying locations where overtaking manoeuvres frequently occur and where restricted visibility conditions are expected.

The reason why this location was chosen as the study area was that the road segments fulfilled the requirements for the observation site of the overtaking behavior data. The video recording method was used to record the overtaking maneuvers continuously for several hours during weekdays at the road segment. However, this area was part of a rural single-carriageway road and there were no major intersections or roadside development, which would motivate very many overtaking attempts in the section.

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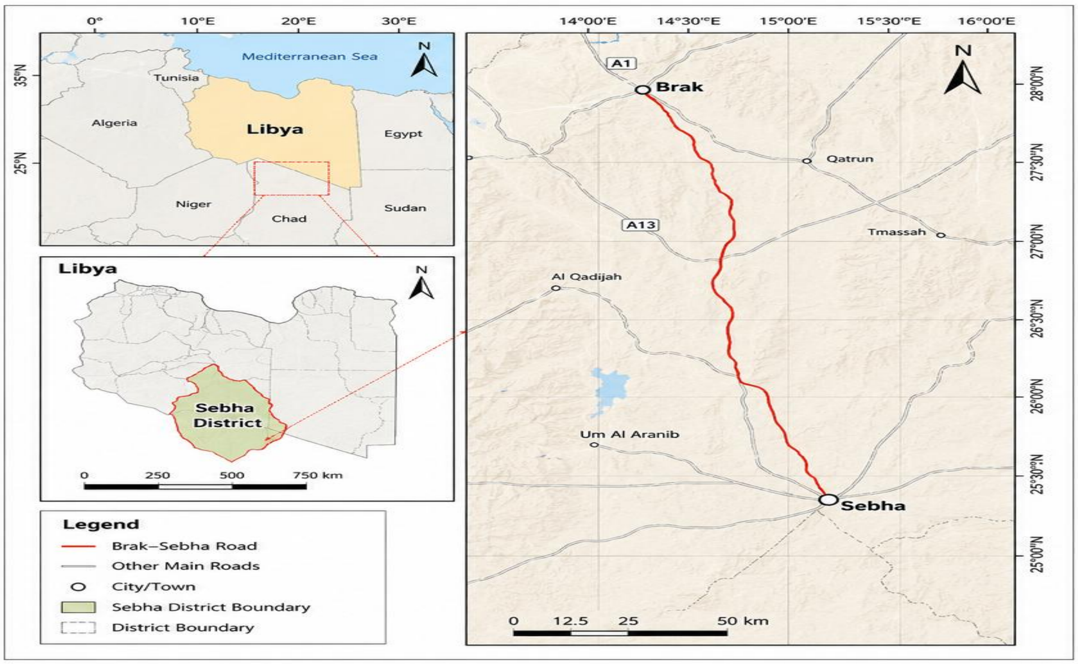

Figure 1: Study Area and Observation Location along the Brak–Sebha Road, Southern

The selected road section was characterized by:

- Moderate traffic flow,
- Mixed vehicle composition,
- Relatively uninterrupted traffic movement,
- Frequent overtaking opportunities.

The roadway geometry included relatively straight alignment sections to minimize visibility restrictions caused by horizontal curvature and to ensure accurate observation of overtaking maneuvers.

The study location was selected according to the following criteria:

- High frequency of overtaking maneuvers,
- Adequate roadside visibility,
- Absence of nearby signalized intersections,
- Sufficient roadway length for observing complete overtaking operations.

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3.2 Data Collection Procedure

A total of 214 complete overtaking maneuvers satisfying the study criteria were conducted at the selected site on Wednesday, January 29th, 2026, during daylight hours, from 09:00 a.m. to 12:00 p.m., under stable daytime traffic conditions and dry weather to eliminate environmental factors that could influence driver visibility and overtaking behavior. Traffic data were collected using high-resolution video recording systems positioned in both travel directions at elevated roadside locations. The cameras provided continuous monitoring of overtaking maneuvers occurring along the selected roadway segment.

The recorded videos were analyzed frame-by-frame to extract overtaking maneuver characteristics. The following parameters were measured for each overtaking event:

- Overtaking vehicle speed,
- Opposing vehicle speed,
- Accepted overtaking gap,
- Overtaking duration,
- Decision time,
- Lane occupation duration,
- Initial clearance distance,
- Final return clearance distance,
- Total passing sight distance.

Only complete overtaking maneuvers with clearly identifiable vehicle trajectories were included in the analysis dataset.

3.2.1 Selection of Observation Site

To ensure that the collected overtaking maneuvers were representative of critical rural driving conditions, observation sites were selected following a preliminary reconnaissance survey along the Brak–Sebha Road. The survey identified locations characterized by frequent overtaking activity and restricted passing sight distance. Priority was given to sections exhibiting limited visibility caused by horizontal curves, vertical crests, localized pavement geometry, and roadside terrain conditions. These locations were considered a legend for overtaking because drivers are exposed to an increased risk of conflict with opposing traffic during passing maneuvers.

Table 1. Characteristics of Observation Site

Parameter	Description
Study Road	Brak–Sebha Road, Southern Libya
Observation Location	Selected rural section between Brak and Sebha
Road Classification	Rural single-carriageway road
Number of Lanes	Two-way, one lane per direction
Lane Width	3.65 m
Shoulder Width	1.5 m
Terrain	Flat desert terrain
Road Geometry	Long tangent section with adequate approach visibility
Pavement Condition	Good asphalt pavement
Visibility Condition	Moderate to good
Observation Method	High-definition roadside video camera
Observation Period	Daylight, dry-weather conditions
Total Overtaking Maneuvers	214
Reason for Site Selection	High overtaking frequency and representative traffic conditions

The chainage is approximate and is provided only to identify the general observation location along the Brak–Sebha Road.

3.3 Overtaking Maneuver Framework

On rural single-carriageway roads, overtaking maneuvers require temporary occupation of the opposing traffic lane. Consequently, overtaking safety depends heavily on the duration of opposing-lane exposure and available passing sight distance.

The overtaking maneuver was divided into four sequential stages:

1. Driver perception and overtaking decision.
2. Initial lane-change and acceleration.
3. Opposing-lane occupation and vehicle passing.
4. Return maneuver and lane re-entry.

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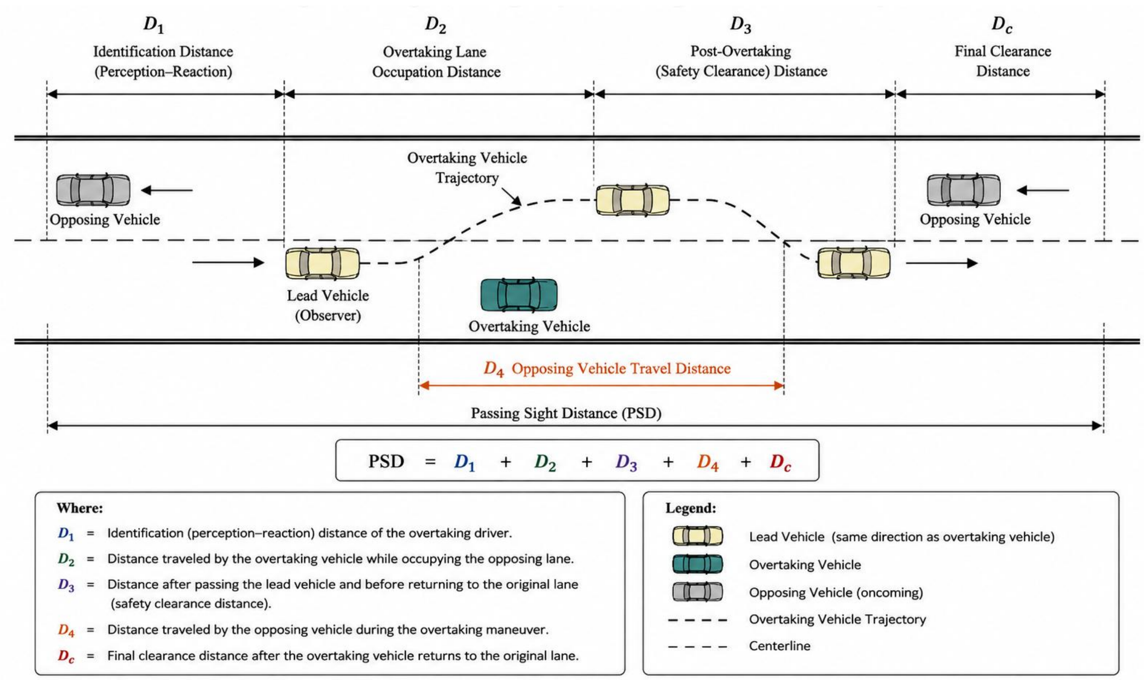

Figure **2**: Single-Carriageway Overtaking Maneuver Geometry

The total passing sight distance was estimated as:

$$PSD = D_1 + D_2 + D_3 + D_4 + D_c \tag{2}$$

Where:

- PSD = Passing Sight Distance (m)
- D_1 = Identification (perception–reaction) distance
- D_2 = Overtaking lane occupation distance
- $D_3$3 = Post-overtaking (safety clearance) distance
- D_4= Opposing vehicle travel distance during the overtaking maneuver
- D_c = Final clearance distance after lane re-entry

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3.4 Speed Classification

To evaluate the influence of operational speed on overtaking behavior, observed maneuvers were categorized into three speed groups:

Table 2. Speed classification adopted for overtaking behavior analysis.

Speed Group	Speed Range (km/h)
Group 1	<60
Group 2	60-80
Group 3	>80

This classification enabled the comparative evaluation of accepted overtaking gaps, lane occupation duration, overtaking aggressiveness, and required passing sight distance across different operational speed levels.

3.5 Statistical Analysis

The collected overtaking data were analyzed using descriptive statistics, correlation analysis, linear regression, and logistic regression modeling.

Correlation analysis was conducted to evaluate relationships among:

- Overtaking speed,
- Accepted gap,
- Overtaking duration,
- Passing sight distance.

Linear regression analysis was performed to quantify the relationship between overtaking speed and required passing sight distance on rural single-carriageway roads:

$$PSD=182.4+3.05V \quad (3)$$

Where

- PSD = Passing sight distance (m)
- V = Overtaking vehicle speed (km/h)

The model performance was evaluated using:

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$$R^2 = 0.73 \quad (4)$$

A logistic regression framework was additionally employed to estimate overtaking acceptance probability based on driver behavior variables and opposing-lane conditions.

The statistical analyses were intended to:

- Quantify overtaking behavior,
- Evaluate adaptive risk-tolerance tendencies,
- Assess opposing-lane exposure,
- Identify unsafe overtaking patterns on rural single-carriageway roads.

4. Results and Discussion

4.1 General Characteristics of Overtaking Maneuvers

A total of 214 complete overtaking maneuvers were extracted from the field video observations. The recorded overtaking events involved heterogeneous traffic interactions including passenger cars, motorcycles, minibuses, and medium commercial vehicles.

The descriptive analysis revealed substantial variability in overtaking behavior depending on travel speed and opposing traffic conditions. Drivers operating at higher speeds generally accepted shorter overtaking gaps and occupied the opposing lane for shorter durations but under significantly reduced safety margins.

Table 3. Descriptive Statistics of Observed Overtaking Variables

Variable	Mean	Std. Dev.	Min	Max
Overtaking speed (km/h)	74.2	14.1	42	108
Accepted gap (s)	6.8	1.9	3.1	11.2
PSD (m)	408	96	210	635
Lane occupation time (s)	5.9	1.3	3.8	9.6
Decision time (s)	2.1	0.6	1.0	4.0

Table 3 summarizes the primary overtaking variables extracted from field observations. Considerable variability was observed in overtaking speed, accepted gap, and passing sight distance, indicating heterogeneous driver behavior under rural single-carriageway operating conditions.

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The observed overtaking duration ranged between approximately 4.1 s and 9.6 s, while measured passing sight distances varied considerably according to maneuver aggressiveness and opposing vehicle interaction.

4.2 Influence of Speed on Gap Acceptance

The results indicated a clear inverse relationship between travel speeds and accepted overtaking gap on rural single-carriageway roads.

Table **4**. Correlation Matrix of Overtaking Variables

Variable	Speed	Passing Distance	Decision Time
Speed	1.00	0.61	-0.73
Passing Distance	0.61	1.00	-0.42
Decision Time	-0.73	-0.42	1.00

The correlation analysis revealed a strong negative relationship between overtaking speed and accepted gap, suggesting that drivers operating at elevated speeds tend to reduce accepted safety margins during overtaking maneuvers. Accepted Overtaking Gap versus Speed Group Observed reduction in accepted overtaking gap with increasing travel speed on rural single-carriageway roads.

The observed reduction in accepted gaps at higher speeds indicates adaptive driver risk-tolerance behavior. Drivers operating under higher speed conditions appeared more willing to accept reduced safety margins to maintain traffic progression.

On single-carriageway roads, this behavior becomes particularly hazardous because overtaking vehicles remain directly exposed to opposing traffic conflicts throughout lane occupation.

The observed reduction in accepted overtaking gaps at higher operational speeds is consistent with the findings reported by Zhang and Khattak (2023), who identified adaptive risk-compensation tendencies among drivers operating under elevated speed conditions. Similar behavioral patterns were also reported by Singh and Gupta (2021) under heterogeneous traffic environments.

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4.3 Passing Sight Distance Analysis

The analysis demonstrated a strong positive relationship between overtaking speed and required passing sight distance.

Table 5. Linear Regression Results for PSD Prediction

Parameter	Coefficient	Std. Error	t-value	p-value
Intercept	182.4	14.2	12.84	<0.001
Speed	3.05	0.27	11.31	<0.001

The regression model demonstrated strong statistical significance ($p < 0.001$) with an acceptable explanatory capability (R^2=0.73). The ANOVA results further confirmed the adequacy of the developed PSD prediction model.

Table 6. ANOVA Summary for PSD Regression Model

Source	**SS**	**df**	**MS**	**F**
Regression	452381	1	452381	127.8
Residual	75012	212	353.8	-
Total	527393	213	-	-

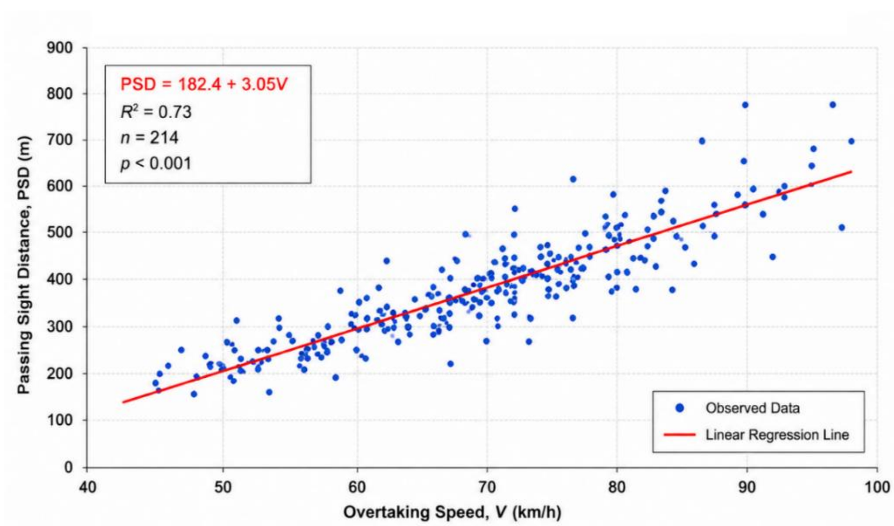

Figure 3: Regression Relationship between Speed and PSD

The results indicate that increasing operational speed substantially increases overtaking visibility requirements single-carriageway roads.

Overtaking Speed versus Passing Sight Distance

Positive correlation between overtaking speed and required passing sight distance on single-carriageway roads.

The findings further suggest that overtaking maneuvers performed at higher speeds significantly increase head-on collision exposure due to prolonged travel distance within the opposing lane.

The developed PSD-speed relationship generally agrees with the behavioral overtaking analyses reported by Llorca et al. (2020) and Wang and Liu (2022), both of which demonstrated that overtaking visibility requirements increase substantially with operational speed.

4.4 Overtaking Decision Probability

The logistic regression framework demonstrated that overtaking decision probability is strongly affected by:

- Accepted overtaking gap,
- Travel speed,
- Decision time.

Drivers accepting shorter gaps were associated with substantially higher overtaking conflict exposure.

Table 7. Logistic Regression Results for Overtaking Acceptance Probability

Variable	Odds Ratio	Std. Error	p-value
Speed	1.42	0.18	0.002
Accepted Gap	0.71	0.11	<0.001
Decision Time	0.84	0.09	0.014

The developed logistic model indicates that overtaking acceptance probability increases substantially as accepted gaps become larger. Conversely, shorter accepted gaps were associated with significantly elevated overtaking risk exposure.

The results further indicated that many overtaking maneuvers were initiated under marginally acceptable traffic conditions, especially during higher traffic demand periods.

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This behavior reflects adaptive overtaking decisions influenced by perceived urgency and traffic-flow pressure.

4.5 Comparison with AASHTO Recommendations

The developed PSD was compared with overtaking behavior visibility and American Association of State Highway and Transportation Officials (AASHTO) passing sight distance recommendations.

Table **8**. Comparison between Proposed PSD Model and Existing Models

Model	PSD Equation
AASHTO (2018)	Standard tabulated PSD
Glennon (1988)	Classical PSD model
Llorca et al. (2020)	Behavioral PSD estimation
Present Study	PSD = 182.4 + 3.05V

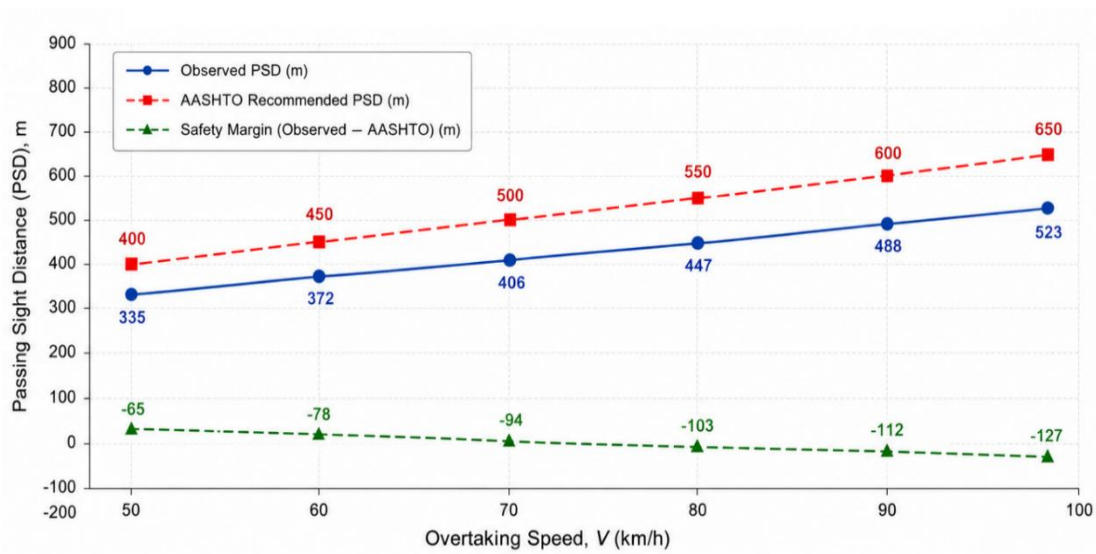

Figure **4**: Comparison between observed PSD and AASHTO recommendations

The comparison demonstrated that many observed overtaking maneuvers were completed using shorter passing distances than those recommended by conventional geometric design standards.

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The discrepancy became more pronounced at higher operational speeds.

This finding suggests that actual driver behavior on rural single-carriageway roads may significantly deviate from conventional highway design assumptions.

Although drivers were frequently able to complete overtaking maneuvers successfully under reduced visibility margins, such behavior substantially increases head-on collision risk on single-carriageway roads.

4.6 Safety Implications for Single-Carriageway Roads

The present findings emphasize the importance of incorporating driver behavioral variability into overtaking safety assessment on rural single-carriageway roads.

Conventional deterministic design approaches may not adequately represent actual overtaking behavior under heterogeneous traffic environments.

The observed adaptive risk-tolerance tendencies indicate that drivers dynamically modify accepted safety margins according to:

- Travel speed,
- Traffic pressure,
- Roadway familiarity,
- Overtaking opportunity availability.

The outcomes of this study provide important implications for:

- Overtaking-warning systems,
- Intelligent driver-assistance technologies,
- Rural highway geometric design,
- Behavior-aware traffic safety interventions.

In particular, intelligent overtaking assistance systems capable of evaluating real-time overtaking risk may substantially reduce unsafe overtaking maneuvers under limited visibility conditions on single-carriageway roads.

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4.7 Limitation

The present study has several limitations that should be acknowledged. First, the analysis was conducted on a limited number of rural single-carriageway roadway segments, which may restrict broader generalization of the findings. Second, traffic observations were collected only under dry daytime operating conditions; therefore, overtaking behavior under nighttime or adverse weather conditions was not evaluated. Third, the estimation of overtaking distances and vehicle trajectories depended on roadside video observations, which may introduce minor measurement uncertainty associated with camera angle and image resolution. Finally, local driving culture and regional traffic behavior characteristics may influence overtaking aggressiveness and accepted safety margins.

5. Conclusion

This study investigated driver gap acceptance behavior and passing sight distance characteristics on rural single-carriageway roads using field video observations under real traffic conditions.

The results demonstrated that overtaking behavior on single-carriageway roads is strongly influenced by operational speed and adaptive driver risk tolerance. Based on 214 observed overtaking maneuvers, the developed regression model demonstrated a statistically significant positive relationship was observed ($R^2 = 0.73$, $p < 0.001$). Drivers operating at speeds exceeding 80 km/h consistently accepted shorter overtaking gaps and reduced safety margins compared with lower-speed conditions.

Drivers operating at higher speeds consistently accepted shorter overtaking gaps, thereby reducing available safety margins and increasing opposing-lane exposure duration.

The findings further revealed that many overtaking maneuvers on rural single-carriageway roads were completed using shorter passing distances than those recommended by AASHTO standards.

The proposed behavioral framework provides highway engineers with a practical tool for evaluating overtaking safety, optimizing passing zones, and supporting intelligent overtaking assistance systems on rural single-carriageway roads.

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6. Recommendations and Future Research

Future research should investigate overtaking behavior using drone-based trajectory extraction and machine-learning-based overtaking prediction models. Additional studies are also recommended to evaluate nighttime overtaking behavior, intelligent overtaking-warning systems, and connected-vehicle overtaking assistance technologies under heterogeneous rural traffic environments.

References

[1] Kim, J., Lee, S. (2024). Overtaking visibility and head-on collision exposure on single-carriageway roads. Journal of Advanced Transportation, 2024, 8854217.

[2] Patel, M., Mehar, A. (2023). Safety implications of inadequate overtaking sight distance on rural undivided highways. International Journal of Pavement Research and Technology, 16(5), 981-995.

[3] Sharma, S., Velmurugan, S. (2022). Overtaking decision behavior under heterogeneous traffic conditions using field observations. Transportation Research Record, 2676(4), 411-423.

[4] Ahmed, A., Abdel-Aty, M., Lee, J. (2021). Driver risk-taking behavior during overtaking maneuvers on rural two-lane highways. Accident Analysis & Prevention, 156, 106-121.

[5] Hassan, H., Sarhan, M. (2024). Risk compensation behavior during overtaking maneuvers on undivided highways. Safety Science, 171, 106-381.

[6] Taylor, M., Baruya, A. (2020). Speed and overtaking safety relationships on rural highways. Journal of Safety Research, 74, 117-126.

[7] Liu, P., Wang, J., Yu, H. (2020). Driver gap acceptance behavior under opposing traffic conditions on two-lane highways. Journal of Transportation Safety & Security, 12(8), 1012-1028.

[8] Singh, R., Gupta, A. (2021). Driver aggressiveness and overtaking gap acceptance under mixed traffic environments. International Journal of Transportation Science and Technology, 10(3), 233-244.

[9] Zhang, Y., Khattak, A. (2023). Behavioral adaptation and overtaking risk tolerance on rural highways. Transportation Research Part F, 92, 75-89.

[10] American Association of State Highway and Transportation Officials AASHTO. (2018). A Policy on Geometric Design of Highways and Streets. Washington, DC.

[11] Wang, X., Liu, Y. (2022). Passing sight distance estimation considering driver perception variability. Accident Analysis & Prevention, 174, 106744.

[12] Harwood, D. W., Mason, J. M., Brydia, R. E. (2019). Passing sight distance criteria for rural two-lane highways. Transportation Research Record, 2673(6), 210-222.

Gharyan University Journal of Engineering Science (GUJES)
ISSN (3105-4560)
Website: http://journals.gu.edu.ly
email: gujes@gu.edu.ly

[13] Llorca, C., Moreno, A., Garcia, A. (2020). Evaluation of overtaking sight distance under realistic traffic conditions. Journal of Transportation Engineering, 146(5), 04020033.

[14] Ferreira, S., Couto, A. (2024). Behavioral transportation analytics for overtaking safety assessment. Transportmetrica A, 20(2), 310-329.

[15] Transportation Research Board TRB. (2022). Highway Safety Manual. Washington, DC.

[16] Glennon, J. C. (1988). New and improved model of passing sight distance on two-lane highways. Transportation Research Record, 1195, 132-137.

[17] Chen, L., Ahn, S. (2022). Logistic regression modeling of overtaking acceptance decisions on two-lane roads. Transportation Research Part C, 137, 103572.

[18] Kumar, N., Jain, S. (2021). Binary logistic modeling of gap acceptance behavior under mixed traffic operations. Transportation Letters, 13(9), 620-632.

[19] Zhao, H., Li, Q. (2023). Probabilistic overtaking decision models under heterogeneous traffic conditions. IEEE Transactions on Intelligent Transportation Systems, 24(8), 9021-9032.