# Conflict-Free Intersection Design and PTV VISSIM Calibration for Mixed Traffic under MTHL Dispersal Influx: A Case Study of Airoli Junction – A Review

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**Abstract -** *This review paper synthesizes current literature regarding the limitations of traditional analytical methods, the theoretical foundations of microscopic traffic simulation using PTV VISSIM, psychophysical car-following parameter calibration (Wiedemann-74 and Wiedemann-99 models), and the efficacy of geometric versus temporal optimization techniques under heterogeneous urban traffic conditions. Rapid urbanization and major regional infrastructure developments, such as the Mumbai Trans Harbour Link (MTHL), have intensified traffic congestion at critical urban dispersal nodes. Unlike Western traffic streams characterized by strict lane discipline, Indian urban corridors feature highly heterogeneous, non-lane-based traffic comprising motorized two-wheelers, auto-rickshaws, cars, and heavy commercial vehicles. Conventional deterministic capacity models, including standard Passenger Car Unit (PCU) conversions and static Indian Roads Congress (IRC) or Indo-HCM guidelines, fail to capture the stochastic, two-dimensional interactions and aggressive lateral "seepage" inherent in these networks. The findings underscore the imperative for synergistic intersection designs that integrate spatial channelization, dynamic signal coordination, and grade separation to mitigate high-risk conflict points and transform congested nodes from Level of Service (LOS) F to sustainable operating standards.*

**Key Words: Heterogeneous Traffic, PTV VISSIM, Microsimulation Calibration, Wiedemann Models, Intersection Optimization, MTHL Dispersal.**

## 1. INTRODUCTION

Urban transportation networks in developing nations experience profound operational challenges driven by unprecedented vehicular growth and spatial expansion. In metropolitan regions such as the Mumbai Metropolitan Region (MMR), the commissioning of high-capacity regional links like the Mumbai Trans Harbour Link (MTHL) successfully bridges inter-city distances but abruptly discharges massive volumes of high-speed passenger and commercial freight traffic into existing, heavily burdened arterial networks. These mainland dispersal corridors exemplified by nodal junctions in Airoli and Thane are already saturated with intense local mixed traffic, public transit vehicles, and heavy industrial freight associated with nearby ports and manufacturing hubs. At the center of these dispersal bottlenecks are at-grade urban intersections. Unlike homogeneous traffic systems where vehicle interactions are strictly governed by lane markings, urban Indian corridors exhibit two-dimensional movement dynamics. Vehicles continuously exploit lateral gaps, engage in creeping behavior, and filter through stationary platoons. Traditional capacity analysis methods, including deterministic techniques outlined in the Highway Capacity Manual (HCM) and standard Indo-HCM frameworks, rely heavily on static Passenger Car Unit (PCU) conversions. While useful for macro-level planning, these deterministic models are fundamentally inadequate for capturing the stochastic friction, queue discharge rates, and complex conflict matrices observed at saturated urban junctions. Consequently, advanced microscopic traffic simulation software, specifically PTV VISSIM, has emerged as the principal engineering instrument for evaluating individual vehicle behaviors and testing alternative design geometries prior to physical capital investment.

## 2. LITERATURE REVIEW

Urban Indian traffic flow differs fundamentally from Western paradigms due to its high heterogeneity and complete absence of strict lane discipline. The traffic stream comprises a diverse mix of vehicle classes with vastly disparate static dimensions, power-to-weight ratios, and acceleration/deceleration characteristics, ranging from motorized two-wheelers (MTWs) and auto-rickshaws to multi-axle heavy commercial vehicles. According to Anand et al. (2021), vehicular interactions in mixed traffic streams occur simultaneously in both lateral and longitudinal planes. The dominance of smaller-sized vehicles (MTWs and auto-rickshaws) coupled with non-lane-based operation results in distributed traffic friction. Rather than being confined to strict lane boundaries, conflict points crossing, merging, and diverging events spread across the entire physical geometry of an intersection. This lateral filtering, commonly termed "seepage," enables smaller vehicles to bypass stalled queues and position themselves ahead of larger vehicles at signal stop-lines. Consequently, saturation flow rates and delay structures deviate significantly from standard lane-based models.

## 3. LIMITATIONS OF CONVENTIONAL ANALYTICAL CAPACITY

Conventional deterministic capacity evaluations, such as those prescribed by the Indian Highway Capacity Manual (Indo-HCM, 2017) and standard IRC guidelines, utilize empirical PCU conversion factors to aggregate heterogeneous traffic into a common denominator. However, these conversion factors are often static and fail to account for dynamic operating conditions, varying queue discharge characteristics, and signal phase geometry. Under heavy congestion, the assumption of uniform vehicle behavior breaks down. Stochastic gap-acceptance behavior, aggressive driver psychology, and side friction from roadside activities (e.g., bus stops, illegal parking, pedestrian encroachment) induce severe capacity degradation that static formulas cannot predict. Traditional analytical methods consistently underestimate queue lengths and overestimate intersection throughput under saturated conditions, necessitating the adoption of non-linear microscopic simulation frameworks.

## 4. TRAFFIC MICRO-SIMULATION AND PTV VISSIM CALIBRATION

Microscopic simulation tools like PTV VISSIM model individual driver-vehicle units second-by-second based on psychophysical car-following and lane-changing logic. However, VISSIM's default algorithms specifically the Wiedemann-74 and Wiedemann-99 (W-99) car-following models were originally formulated for homogeneous, lane-disciplined European traffic. Applying default parameters in an Indian urban context introduces severe calibration errors, typically leading to artificially inflated queue lengths and underestimated intersection capacity. Rigorous calibration of psychophysical parameters is therefore mandatory. Mathew and Radhakrishnan (2010) demonstrated that the Standstill Distance ($CC_0$), which defaults to a conservative 1.50 m in Western templates, must be reduced to a calibrated range of 0.50 m to 1.00 m to accurately replicate tight bumper-to-bumper queuing in Indian mixed traffic. Similarly, the Headway Time ($CC_1$) must be adjusted downward to reflect aggressive gap acceptance, while lateral clearance parameters must be minimized (often down to 0.10 m to 0.20 m at standstill) to permit two-wheeler seepage and lateral filtering. Furthermore, enabling "overtake on the same lane" is critical for capturing parallel vehicle operations within wide links.

## 5. SYNTHESIS OF OPTIMIZATION STRATEGIES

Mitigating congestion at high-volume regional dispersal nodes requires a structured hierarchy of intervention strategies, balancing capital cost against operational efficiency: Temporal Optimization: Adjusting signal cycle lengths, phase splits, and inter-green intervals using actuated control algorithms (e.g., VAP logic) to minimize overall intersection delay without altering physical geometry. Geometric Channelization: Implementing physical islands, dedicated turning pockets, optimized turning radii, and free-left slip-lanes to streamline vehicle paths and segregate conflicting turning streams. Hybrid and Grade Separation: Utilizing structural interventions such as flyovers or underpasses for major through movements (e.g., connecting high-speed regional corridors) while managing remaining turning movements at-grade, or implementing full cloverleaf interchanges to eliminate crossing conflicts entirely.

## 6. CONCLUSIONS

This review demonstrates that while conventional analytical models provide a baseline understanding of traffic demand, they are fundamentally inadequate for designing urban dispersal junctions under heterogeneous, non-lane-based traffic conditions. Microscopic simulation via PTV VISSIM, when rigorously calibrated with site-specific psychophysical parameters, provides an indispensable decision-support tool. Ultimately, sustainable traffic dispersal requires a synergistic design approach combining geometric channelization, tactical signal optimization, and strategic grade separation to eliminate high-risk conflict points, reduce node delays, and upgrade urban intersection performance from failure standards to acceptable operating levels

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