A New Metric for the Estimation of Dynamic PCU's in Intersections under Heterogeneous Traffic Conditions

Salawavidana Arachchige Suneth Thushara Salawavidana, H.R Pasindu, J.M.S.J Bandara, Rohan Munasinghe

Abstract

Most of the traffic signal design manuals currently in use across the globe have been developed based on traffic conditions typically found in developed countries. These conditions are generally characterized by car-dominant, lane-compliant, and nearly homogeneous traffic flows. As such, the foundational parameters used in these manuals—Passenger Car Units (PCU) and Saturation Flow (SF)—reflect these structured and disciplined conditions. However, applying these parameters to traffic systems in developing countries, which often exhibit vastly different characteristics, raises critical concerns regarding their validity and accuracy. In developing countries such as Sri Lanka, traffic conditions are far more heterogeneous and lack the consistent lane discipline that is a hallmark of developed-world traffic. This heterogeneity is marked by the coexistence of a wide range of vehicle types, including motorcycles, three-wheelers (tuk-tuks), cars, vans, buses, trucks, and even non-motorized vehicles. There is typically no single dominant vehicle class, and smaller vehicles tend to cluster at the mouth of intersections in an attempt to squeeze through gaps in traffic, often disregarding marked lanes. The resulting traffic flow is highly unstructured, and behaviors such as overtaking within a lane, frequent lane changing, and non-uniform vehicle movement are commonplace. Given these unique characteristics, the direct application of PCU and SF values derived from structured, homogeneous conditions is highly questionable. Several attempts have been made in the past to adapt or recalibrate PCU values for heterogeneous traffic conditions. However, these approaches often suffer from multiple drawbacks, including the inability to accurately measure average speeds under congested conditions, the neglect of safety spacing between vehicles, the omission of critical geometric parameters at intersections, and a dependence on costly or technically complex data collection equipment. In response to these challenges, the present study proposes a new and simplified methodology to determine the equivalent traffic impact of different vehicle types under heterogeneous conditions. This approach introduces the concept of Temporal Area Occupancy (TAO), which captures the time a vehicle takes to traverse the critical area of an intersection, from the point where its tail enters the intersection zone to the point where its entire body clears the mouth of the intersection. This method enables a more realistic estimation of each vehicle's impact on intersection capacity. To implement this approach, video footage from a congested urban intersection in Sri Lanka was analyzed. Each vehicle was modeled using three parameters: effective width, effective length, and time of traversal. These parameters collectively allowed for a comprehensive representation of a vehicle's dynamic spatial and temporal footprint. Based on this data, a new unit of measurement called the Standard Vehicle Unit (SVU) was introduced as a substitute for the conventional PCU. The SVU better represents the actual influence of each vehicle type in a heterogeneous, non-lane based traffic stream. Additionally, a Heterogeneity Index was developed to quantitatively assess the degree of traffic heterogeneity at the

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intersection. This index accounts for the distribution and behavioral dynamics of various vehicle classes and provides a means to classify traffic streams based on their deviation from homogeneous conditions. To align the derived SVUs with international standards, particularly those specified in the Highway Capacity Manual (HCM), a correction was applied to match the ideal saturation flow of 1900 PCU/hr/lane. The most probable SVUs for each vehicle type - such as motorcycles, three-wheelers, and heavy vehicles - were then calculated. These corrected values offer a more realistic and standardized basis for intersection capacity analysis under mixed traffic conditions. This study ultimately establishes the dynamic and context-sensitive nature of SVUs in heterogeneous traffic environments. The proposed method offers a more robust and cost-effective alternative for traffic engineers and planners working in the developing world. It provides a practical pathway to designing signalized intersections that are more reflective of local traffic realities, leading to improved safety, efficiency, and operational effectiveness in urban transport systems.

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Author details;

1. Additional Director (Highway Design), Road Development Authority.
   suneth.thushara@gmail.com

2. Professor, University of Moratuwa, Sri Lanka.
   h.r.pasindu@gmail.com

3. Professor, University of Moratuwa, Sri Lanka.

4. Professor, University of Moratuwa, Sri Lanka.
   rohan@uom.lk