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REVIEW ON PERCENT TIME SPENT FOLLOWING (PTSF) AS PERFORMANCE MEASURE FOR TWO-LANE HIGHWAYS LIGHT HILL THEORY

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Abstract

In case of two lane highways HCM uses Percentage time spent following as key service measure for assigning the level of service. However, the indicant is difficult to measure directly in the field. For this reason, its estimation up to date has been based on analytical procedures using equations derived from calculation and field observations at evocative location based on alternate measure; as the percent of vehicles traveling with headway less than 3 seconds (3 s). Award from empirical studies confirmed that the HCM conclusive procedures used in estimating PTSF yield results that are discrepant with the 3 s alternate measure and mostly overestimate the indicant. This paper presents a review on the estimation of PTSF on two-lane highways and commend probable approach to confirm the application of the current practice. Since PTSF is space related measure, In addition the composer of this paper altercate that the use of 3 s as alternate for estimating PTSF based on field observation at a specific point may not represent the actual time spent following over a long segment of two-lane highway. Hence, the authors suggest the use of light hill macroscopic approach over the highway segment to be evaluated to identify the variables that are required for the development of a representative PTSF measurement model. Closed-form expressions, it is familiar that this review and advancement offered will contribute in advancing performance analysis of two-lane highways.This research shows the synergy between slow and fast moving vehicles based on light hill theory of moving bottleneck.
Keyword: level of service, percent-time-spend-following, HCM, bottleneck.

I.INTRODUCTION

The majority of highways in India and worldwide are two-lane highway. Traffic movement in India is heterogeneous in nature with vehicles of different dimensions and operational characteristics. Because of vehicle inability to pass slow moving vehicles, vehicles may subject to delay. As follows vehicles develop interactions among themselves in the same lane as well as in the opposite lane. Thus the flow on such highway is different from the flow on freeways mainly because interaction grows with the increase in traffic flow in both directions. Due to this, a platoon formation takes place until a fast moving vehicle overtakes a slow moving vehicle safely.

The highway capacity manuals; HCM 2000 and HCM 2010 identified and use Percent-Time-Spent-Following (PTSF) as key service measure for two lane highway and to assign a particular LOS.

HCM use 3s surrogate measure for field measurement of PTSF. Finding from literature review, it declares that the HCM results mostly over estimated. HCM is not easy to be applied in practical condition. Driver impatience on two lane highways was analyzed and maybe this could be the reason why HCM has not taken into detail the driver's behaviour as his willingness to accept risk as delay increases and thus reduces their PTSF.

The queuing analogy, measure PTSF by measuring the headways inside and outside platoons on the two lane highways of Jammu and Kashmir. In this analysis, middle or average range will be that where number of headways inside and outside the platoon will be equal. This method is easy to be applied in practical conditions.

Weighted- approach method is effective when proportion of heavy vehicles is large. This method is also easy to be applied in practical condition but its results become inconsistent if the percentage of heavy vehicles is low. The weighted approach method is based on assumption that vehicle mix on two lane highways be expressed by mainly of two groups of vehicles: First group, Heavy vehicles (i.e. trucks, buses, and recreational vehicles) with relatively inferior performance and lower average speed. Second group, Passenger cars (i.e. automobiles, SUVs, minivans, and other smaller vehicles) with relatively higher performance and higher average speed.

Light hill macroscopic theory; It was make conclude that traffic in the opposing direction has a exogenously defined probability distribution. This assumption makes the problem obscured because it neglects the "recursive nature" of problem therefore traffic in each direction is affected by opposing flow in the same way. This is the simplest model that correctly anticipate traffic dynamics on a single lane. In this paper, author asserts a model which is positioned on moving bottleneck theory that assimilates the recursive nature of the problem specifically.

II. LITERATURE REVIEW

PTSF was first introduced as performance measure used highway capacity manual, HCM 2000 [L] also givenin its latest edition; HCM 2010[M] by for two-lane highways. Proceeding to this, other performance allowance had been used by the preceding editions of HCM; HCM 1950[C] and HCM 1965[D] of the Highway Research Board (HRB), and HCM 1985[E] of the Transportation Research Board (TRB) which depart through certain revisions as discussed in previous literature. Among the revised service measures, percent time delay (PTD); defined as the average percent of travel time that all vehicles are deferred while travelling platoons due to inability to pass [E], was the one closely related to PTSF. It was ascertained that PTD was difficult to measure directly in the field; hence, the proportion of vehicles travelling at headways less than 5 s was recommended as surrogate measure for its field measurement. Although PTD had been used for usable analysis of two-lane highways, other studies reported that the use of 5 s headway is not dependable with field data [B-I].

Guell and Virkler [B] criticized the 5 s criterion for field estimation of PTD and advised that revising the 5 s headway criterion to a range of 3.5 to 4 s would present more useful LOS classes, analytical and regular results. Similarly, a study conducted in Canada reported that PTD estimates in accordance with HCM 1985 procedures are higher than those observed in the field. It was also determined that fast vehicles were only disconcert by headways not exceeding 3 s. In another

reaction, Johnson [F]reported that field observations on different segments of rural two-lane roads in Sierra County, California shown that the average headway of vehicles travelling in platoons at or above posted speed limit was approximately 2 s. Thus, the author suggested 2.5 s criteria as cut-off headway for platooning vehicles (on the basis of assimilate a built-in safety bumper) as against the 5 s surrogate measure for PTD that made unacceptable results. Persula[I] determine that local platooning is a partisan estimator for PTD. He added that vehicles travelling with 5 s headway behind another are not followers, especially; slower vehicles should not be confidential as platooning.

PTD values reported in these comparison are quite lower than the 5s headway which patently accepted the conflict between the recommended surrogate measure and field data. In spite of the fact that PTD had been used for some time as a assistance measure for two-lane highways, some limitations cause the improvement of the indicator. In estimating PTSF on two-lane roads, the HCM 2000[F] uses two types of analytical procedures; two-way and directional analyses. The latest version of the manual, HCM 2010[G] eliminated two-way analysis procedure and uses only directional analysis method after which results from both directions are accumulate to obtain two-way estimates.HCM2010[G]consider directional analysis procedure more desired compared to two-way and thus discarded the eventual approach. Directional analysis abstain estimation based on equate the characteristics of traffic flow such as density, and the procedure is more accordant with the analysis method for multilane highways and freeways. However, in an attempt to approve the HCM 2000[F] approaches, a study was organize in Idaho, USA using field data accurately to examine the differences in PTSF estimates produced by the two-way and directional analysis procedures. Award from the study ,it fixed that the two-way analysis was more accurate than the directional analysis as the eventual produced more dissonance in relation to the field estimates using 3 s surrogate measure. The two-way analysis more closely resembles the field estimates, even though both approaches produced overestimated results. Thus, there is still the need to evaluate the measure using both two-way and directional analysis procedures with the method suggested in this paper to discover the extent of the differences; as to date, the question as to which procedure is more accurate is still doubtful.

A part from the use of equations, recommendation was also made for an another method for field estimation of PTSF on the basis of surrogate measure; as the percentage of vehicles travelling with headways less than 3 s. However, empirical studies detected high alterity among the procedures. Especially, the HCM analytical procedures were found to be broadly overestimating the PTSF as in comparison to field observed values.

III. ESTIMATION OF PTSF

In HCM 2000, there are two types of analytical procedures were used for estimating PTSF; two-way and directional analyses and HCM 2010 uses only directional analysis approach. In HCM 2000, equations 1 and 2 for two-way and directional analyses applies respectively; while HCM 2010 uses equation 3 (same form of expression used in HCM 2000 directional analysis) for the directional analysis, being the only approach accept for this version of the manual. In two-way analysis, flow rate, percent no-passing zones and directional split are the factors affecting PTSF in which an increase in any these variables results in an increase in PTSF. But in the case of

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directional analysis, increase in flow rate and percent nopassing zones results in corresponding increase in PTSF.

$$PTSF = 100\{1 - e^{-0.000879 v_p}\} + f_{d/np} \quad (1)$$

v_p = Two-way passenger-car}} equivalent flow rate for peak 15-minutes period (pc/h).

fd/np = Adjustment for the combined effect of the directional distribution of traffic and of the percentage of no-passing zones on PTSF.

$$PTSF_d = 100\left\{1 - e^{a v_d^b}\right\} + f_{np} \quad (2)$$

$PTSF_d$ = Percent time-spent following in the direction analyzed.

v_d = Passenger-car equivalent flow rate for the peak 15-min period in the analysis direction (pc/h).

fnp = Adjustment for percentage of no-passing zones in the analysis direction.

a, b = Coefficients used in estimating percent-time-spent-following for directional segments.

$$PTSF_d = 100\left\{1 - e^{a v_d^b}\right\} + f_{np} \quad (3)$$

All variables have the same meaning as defined for equation 2.
An alternative approach to analytical procedures for field estimation of PTSF was also recommended on basis of surrogate measure as the proportion of vehicles travelling with headways less than 3s.

The various researchers had conducted a number of studies to evaluate the HCM procedures for estimating PTSF on two lane highways are as given below;
Polus and Cohen estimated PTSF in Israel based on the number of headways inside and outside platoons. In the study, vehicles were only considered inside platoon when their headway is less than 3 s, else they are outside platoon. A PTSF function was developed and compared with that of HCM 2000. PTSF estimates obtained in this study were found to be significantly lower than those according to HCM 2000 values computed using two-way analytical procedure. Similar study was

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also conducted in the same country by the same authors in which PTSF was estimated based on average number of headways between and outside platoon on the basis of 3 s cut -off headway derived from vehicles arrival times.

The weighted approach method is based on assumption that vehicle mix on two lane highways consists mainly of two groups of vehicles: First group, Heavy vehicles (i.e. trucks, buses, and recreational vehicles) with relatively inferior performance and lower average speed. Second group, Passenger cars (i.e. automobiles, SUVs, minivans, and other smaller vehicles) with relatively higher performance and higher average speed. The proportion of passenger car travelling in platoons is the percent-time-spent-following for the two lane, two-way highways. This approach is effective when proportion of heavy vehicles is large. If however proportion of heavy vehicles is less, it starts giving inappropriate results.

In these studies, field estimates of PTSF using spot observation were compared with those according to analytical procedures. Conclusions were drawn regarding the agreement of the estimates or otherwise

Light hill macroscopic theory: We Considered a long two-lane, two-way highway where no-passing zones are imperceptible. Each lane obeys a triangular fundamental diagram represent by its wave speed−w and capacity Q, free-flow speed u. The input demand resembles to state A for one direction of travel, where a small (time-mean) proportion of Successive vehicles, r, and travels at a free-flow speed v < u. The variables which are in opposite direction are signify by a prime (e.g., qA0, r0, etc.).

We are attentive in enact occluded direction where platoons system owed to the exultancy of SVs; i.e. when SVs dominance back a queue strenuous while free-flow circumstances are analyze ensuing (until the next platoon). Let D be the long-duration mediocre free-flow state contemplated ensuing of a SV when it restrain a queue. Let U be the case of this queue. Remark that this elucidation evidence that the overtaking practice will be represent in its mean value over time, along with term where desultory is unthinkable and stage where desultory attain at some maximal rate. Consideration too that qD will be endogenously defined in the model.

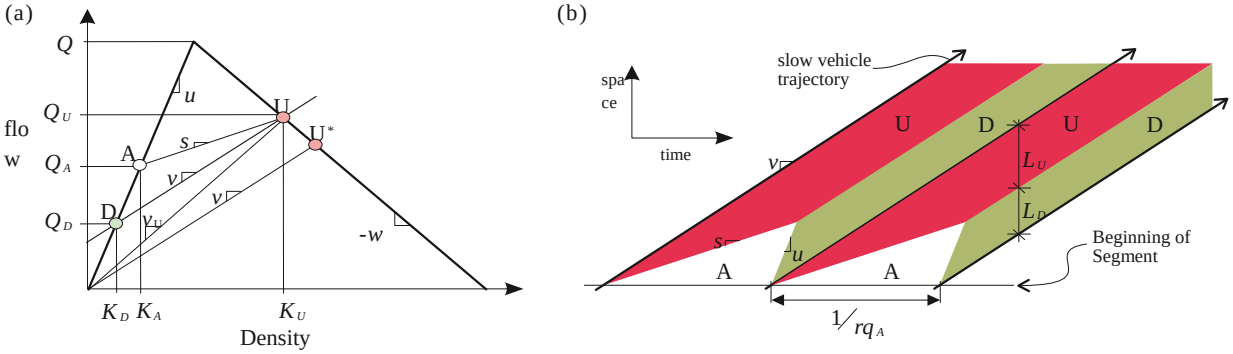

Figure 1.complication establishment in the (a) central diagram (b) time space diagram.[N]

To examine the bigotry imported by this expediency estimate, Along a vehicle trajectory, assume PTSFφ be the PTSF measured;

$$P\,T\,SF\varphi=\frac{(w-qD.v.c/\acute{c})(qA-qD)}{w.qA-(v+w)\acute{c}.qD}$$

For clarity in notation, the only exception to this notation rule is qU∗ (see Fig. 1), which will be denoted c, i.e.

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$$c=\frac{(u+w)v}{(v+w)u}$$

Where we have defined the function "over bar" that gives the complement of a dimensionless variable; e.g.,

$\bar{c} = 1 - c$.

IV. DATA COLLECTION

Data for the study were collected during dry pavement and good weather conditions on rural two lane highways in Jammu & Kashmir, India that were straight, free from other capacity restrictions and heterogeneous in character.

Number of headways inside and outside the platoons

Road	One-way hourly volume(Vph)	Average speed of vehicles(Kmph)	No. of headways inside platoons	No. of headways outside platoons	Average no of vehicles inside platoons	Average no of vehicles outside platoons
Akhnoor (north)	194	60.23	60	132	1.39	2.81
Akhnoor (south)	170	60.79	45	124	1.28	3.9
Jammu(north)	532	55.05	245	285	2.27	2.66
Jammu(south)	625	54.409	329	294	2.35	2.11
Jammu-katra(south)	376	52.6	196	178	2.57	2.34
Jammu-katra(north)	345	53	169	172	2.2	2.23

V. RESULT AND DISCUSSION

Established on the extent literature and/or various studies reviewed in this paper, it is evidently confirmed that the HCM analytical and field observation procedures for estimation of PTSF do not produce homogenous results. In fact, the analytical procedures produced overestimated values; or the field observed values based on 3 s surrogate measure were almost lower than those according to the analytical estimates. The dependable low values of field observed PTSF using the 3 s headway relative to the analytical method estimates could be as a result of the fundamental assumption that spot attended values act as long segment estimates. This could apparently be true for short straight sections on level terrain with acceptable sight distance and passing connection. Field conditions altered from these; such as road sections with deficient sight distance and absorb considerable proportion of hilliness and bendiness could result in higher PTSF values. Especially the field spot observation may not accurately tend of the effects of these characteristics as they could cause considerable condensing effects on passing opportunities on two-lane highways; which would therefore results in longer time spent following. Hence measuring PTSF along the segment may produce results that are closer to reality as allergic the current practice of spot measurement and to ascertain represent time spent following along a breadth of the road.

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The present not explained question on the estimation of PTSF based on the current practice of 3 s rule is that whether the 3 s cut-off headway used for field observation at ideal spot really represents the actual time spent following over a long section of two-lane highway or not? Although analyzer confirmed that HCM equations overestimate PTSF values as in comparison with those obtained based on spot observation in the field using 3 s as surrogate measure, the level of overestimation varies from one study to the other.

The absence of boundary on errors among the procedures left users with the elite of an access they feel more appropriate with and not be opposed the accuracy of the picked method and this could be ambiguous. The composer of this paper are therefore on the conclusion that provision of alternative method for field estimation of PTSF along two-lane highway's segment could be more realistic and also actualize the application of the existing practice.

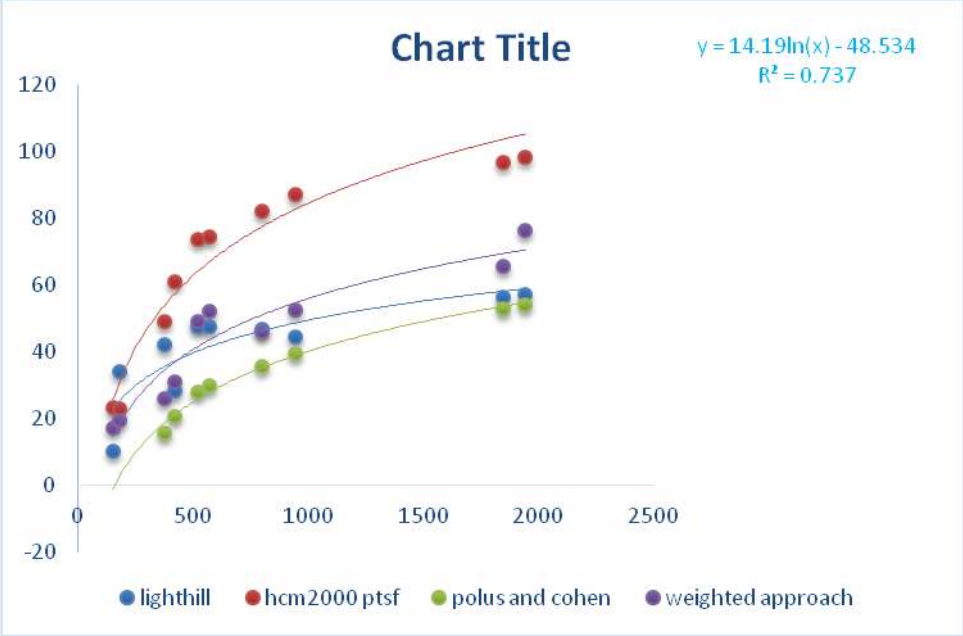

Figure 2. PTSF vs Flow plot comparisions for HCM, Weighted Approach , Polus and Cohen and Lighthill theory

VI. CONCLUSION

HCM use PTSF as service measure for two-lane highways faces exposition from diverse researchers not because of its dearth as per attainment indicant; quietly because, it is difficult to measure directly in the field. Also, the two approaches for estimating PTSF; analytical procedures and use of 3 s surrogate measure for field observations were accepted to produce conflicting results. HCM has overestimated the values of range of PTSF for various Level Of Service. HCM and other works considered homogeneous and lane based traffic for analysis, which do not really endure in India. The flow on two-lane highways is different as the vehicles in the one direction have to face the vehicles in oncoming direction.

IRC: 64-1990 gives some procedure for capacity of two-lane highways but allows very little

information related to LOS of these roads. In India we have to depend upon the techniques of highway capacity manual (HCM) which is especially for developed countries and may not uniform well to the Indian mixed traffic conditions. Speed decreases with the increase in the flow and with the increase in flow,PTSF also increases. Queuing method, to find PTSF has been developed quite easy to be apply to find PTSF though HCM approach is very tough to be applied to find PTSF over two-lane, two way highways. Weighed approach method is effective when proportion of heavy vehicles is large.If however proportion of heavy vehicles is less, it starts giving inappropriate results. In such cases, Lighthill theory may give commendable results.

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