Session 8 Operations 1

Getting it Right - Some Common Issues for Traffic Operations

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Abstract:

This paper addresses a number of issues relevant to those preparing Traffic Operations Studies or Functional Designs for intersections and interchanges. The paper focuses on aspects of these issues that sometimes get overlooked in the design of development projects or highway upgrades.

Because we are looking at real world situations, we have to use these as examples. Our choice of examples in no way indicates that we consider these examples to be any worse or better than other examples that we could have chosen. It also does not indicate that these facilities are intrinsically unsafe, or that any liability is implied regarding these facilities or features. The intention is to show situations that could be improved in future projects.

The issues addressed in this paper are:

- Professional Responsibility and the Client.... (Who is the Client anyway?)
- Lane Drops, Merges and Auxiliary Lanes
- Safety Aspects of Access Location
- Traffic Projections - What is the Future Anyway?
- Analysis Time Periods (Intersections)
- Impact of Pedestrian Volumes on Signal Phasing
- Saturation Flow, Arrival Rate and Departure Rate

Introduction

Both of the authors of this paper have been involved in either (or both) the review of developer's submissions, or preparing traffic designs for development or highway upgrade projects. In this paper we are endeavouring to identify some issues that would help designers present projects in a way that is more likely to gain approval, and in a shorter timeframe. Over the span of many years we have seen numerous poorly prepared submissions, as well as many that were well conceived and presented.

We discuss isolated instances, out of the context of a specific upgrade project or development access design. Nevertheless, the principles discussed are relevant to many situations.

Professional Responsibility and the Client.... (Who is the Client anyway?)

To determine "who is the Client" we need to take a global view of a project. The ultimate user who needs to be satisfied with any transportation project is the public using the facility. This puts a rather different meaning to the "Client" who is usually taken to be the "owner", either a developer or Road Authority.

With this perspective, the focus of the planner/designer's work, in the context of a development access for example, may well change from short term and cost sensitive to longer term, operations orientated, to attract users to a well designed facility rather than for them to have to "fight to get there" so to speak.

To quote from APEGBC's Code of Ethics,

> *the Engineer has a duty to "Hold paramount the safety, health and welfare of the public, the protection of the environment and…."*

This clearly defines the engineer's responsibility as being to the public at large rather than to the "owner" of the project. With this in mind, the focus shifts to providing a balance between the public interest and the narrower interest of a "low cost" project. To address this the engineer has to provide a high standard of design that works well, and will continue to do so into the future.

Lane Drops, Merges and Auxiliary Lanes

The design of freeway and expressway lane drops, merges and auxiliary lanes is comparatively well understood. They require significant lengths and clear and effective advance signing to avoid safety and capacity issues. However, as shown in these examples, we sometimes compromise these criteria.

Figure 1 Merge from Highway Pullout, 80kph Expressway, no merge distance.

While this example is not development related, the principle is the same, the access point must be designed for ambient traffic (in this case the posted speed is 80kph, the location is upstream of a signal where queues form in peak periods).

The entrance to this facility also has no deceleration length. Both of these instances pose issues for drivers entering and leaving the pullout.

Auxiliary and merge lanes are used in a number of situations. One that seems to cause problems is an acceleration lane on at-grade expressway facilities. Freeway on-ramps with acceleration/auxiliary lanes are generally well designed if they have been constructed recently.

Although speeds may be lower on at grade facilities, traffic densities, especially immediately downstream of a signal, are often significantly higher than on freeways. This requires a proportionately longer time for drivers to accelerate and to find an acceptable gap. In this case the merge distance immediately downstream of a saturated signal is inadequate for merging without having a “forced merge” thus creating a congested area (note the brake lights).

Figure 2 Forced merge, Expressway, 80 kph, right lane is a free RT from the side road

The design criterion that we should be looking for is “adequate distance to accelerate to the ambient traffic speed, find an acceptable gap and to merge into the stream without causing a following vehicle to be placed in a situation compromising safety, while leaving adequate additional lane length to accommodate an aborted merge”. In this case, the “ambient traffic condition” is the saturated flow period of the signal, not the cross street green period (or average flow rate).

On streets however, there appear to be less consistently applied considerations. We too frequently find “trap lane” situations where an apparent through lane becomes a “must turn” or merge, lane with inadequate signing. A particularly bad situation happens when this occurs immediately downstream of a signalised intersection. In effect the dropped lane is inefficiently utilised through the signal and the few vehicles using it are forced into a merge with an already “full” traffic stream.

This example is immediately downstream of a signal, the right lane drops with no warning prior to the signal, and, there is a driveway, a bus stop and a second driveway in the taper area.

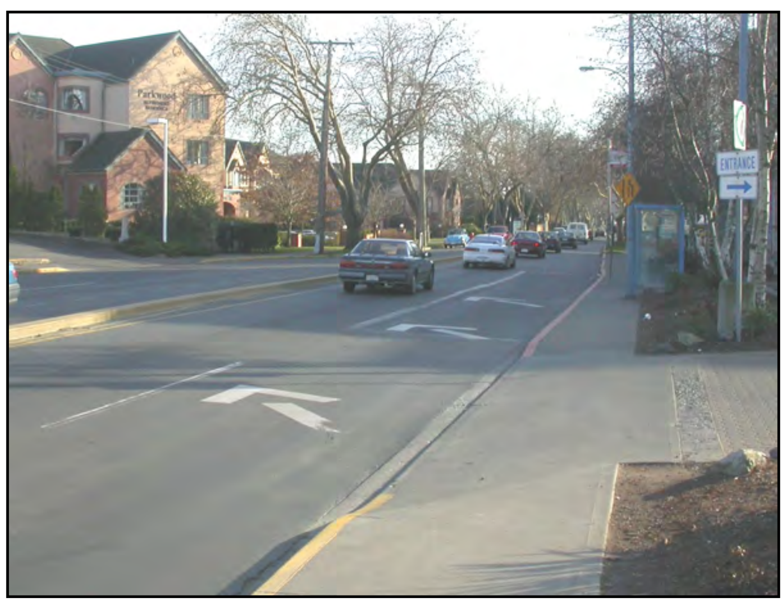


Figure 3a Inadequate Drop Lane design on urban arterial, 50kph

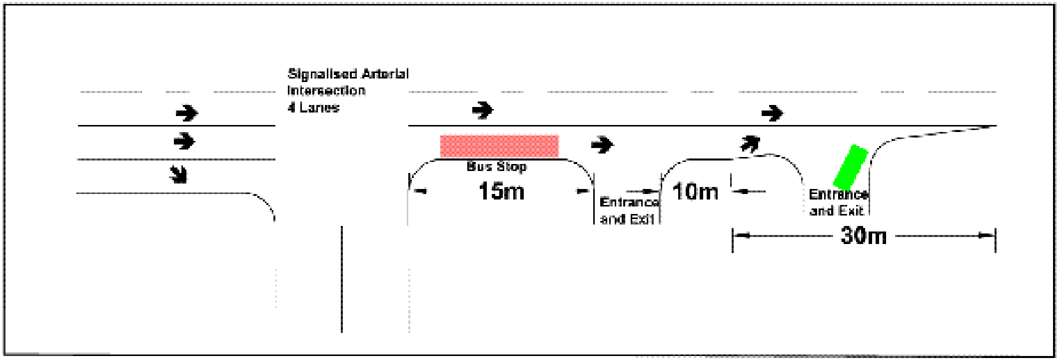


Fig 3b Inadequate Drop Lane - Diagrammatic

This situation can be shown graphically as in the diagram on the left (for a similar situation). The effect of this type of layout is to effectively reduce the signal capacity by one lane, which might be 800 vph.

Figure 4 Lane Drop, Collector, 50 kph

If trap lane situations cannot be avoided, they need to be clearly signed with adequate warning time for drivers to safely change lanes at the ambient speed and traffic conditions.

Ideally, we should avoid trap lanes at intersections or ramps by carrying a lane through the intersection and then dropping it downstream on the right. If a left turn situation is involved, the better solution is to either develop a protected left turn lane as an "added lane", then drop the right lane beyond the intersection, or to drop the right lane, then add the protected left turn lane if all traffic can be handled in one lane prior to the intersection.

Access Location – Safety and Capacity

Safety issues that might arise at access points include: sight distance, geometry, vehicle turn conflicts, and pedestrian/ cyclist conflicts with vehicles.

Capacity issues that might arise at access points include: turn storage lengths, and signal progression (spacing) issues.

Unfortunately some developments seem to be designed "from the inside out" with parking and access located on whatever "spare" space is available after buildings have been located on the site. This can lead to compromised access location where either, or both, safety and capacity constraints impact the effective use of the access.

In some instances these safety issues may be restricted sightlines, in others they may be that the location is too close to an adjacent intersection which imposes, for example, restricted weaving distance between the access and a subsequent left turn at an adjacent intersection.

Key to the solution to this situation is the full consideration of access location and design from the earliest stages of planning for the development. In this way key constraints can be identified and worked around to ensure that the best possible access (both from the point of view of the developer and the Road Authority) is obtained.

This approach requires that the developer consider access as a primary design criterion, on the same level as maximising the use of the site in the land use context. This may impose some "up-front" cost, however it can be readily demonstrated that this is likely to be more than recovered through improved access leading to more customers and a more easily "saleable" development.

Traffic Projections - What is the Future Anyway?

Projecting future traffic volumes is a key step in any roadway design, whether for a development or for a road improvement project. There are a number of tools available for this task, however most rely on some form of the assumption that "history will repeat itself" and that at least one component of future traffic growth is related to historic traffic volumes.

This assumes a good understanding of historic traffic volumes that requires consistent long-term data collection, and data in a publicly accessible database. Unfortunately in many cases this data is not available.

We are then left with collecting current data, often at not the most appropriate time of the year, and somehow "expanding" this to a 10, 15 or maybe a 20 year projection.

There are a number of accepted methods of doing this expansion, "growth factor", build-up based on land use projections or the use of a regional model for corridor volumes for example. Population and employment projections may be available from agencies such as Municipalities, Regional Districts and Regional Health Authorities. These projections can be used with current traffic volumes to estimate likely future volumes in the absence of a transportation model.

We also generally assume that the "site" traffic is constant over time, a convenient assumption but generally not substantiated because market area and "competition" change the level of business.

So the issue becomes, our "crystal ball" is somewhat cracked and we do not have a clear understanding of the likely range of future volumes. We used "range" deliberately. Since we cannot say with any certainty that the volume will be X in year Y, we should be looking at a likely range of volumes, or at least a sensitivity analysis to identify the consequences of the volume actually being different to our projection. Remember, that many of our projections are based on averages or "trend lines" with often not very good correlation coefficients. We know one thing with certainty about averages, we are quite unlikely to see a true "average" situation in real life, in other words, the answer is "wrong". The trick is to be able to refine our solution so that it is robust enough to survive under a range of likely conditions.

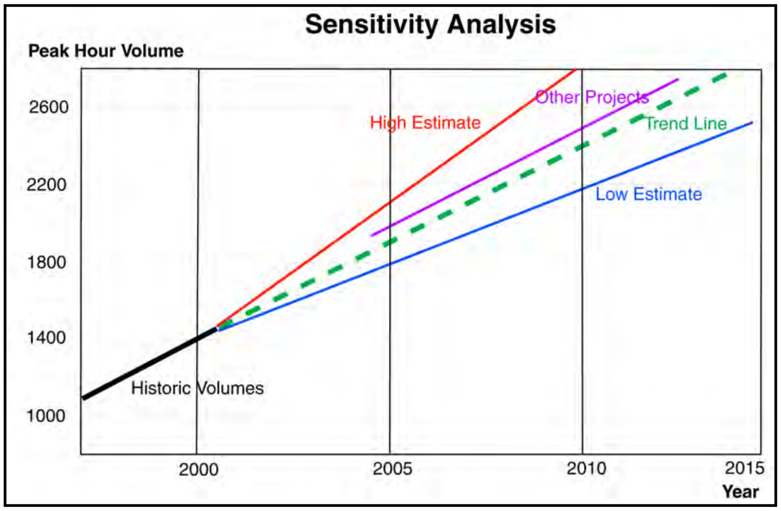


Figure 5 Sensitivity Analysis

This sensitivity analysis needs to assess changes in both street traffic and site generated traffic, as well as the likelihood of other adjacent developments not meeting, or exceeding, assumed traffic projections.

Clearly a range of volumes will give a range of levels of service, or a range of mitigation that may be required.

Analysis Time Periods (Intersections)

When is the “peak” for traffic? Generally urban traffic has 2 major daily peaks, the AM and PM “rush” hours. In smaller urban areas there may also be a lower midday peak. In general the PM peak shows higher volumes and more complex traffic patterns, primarily due to non-commuting traffic conflicting with the rush home.

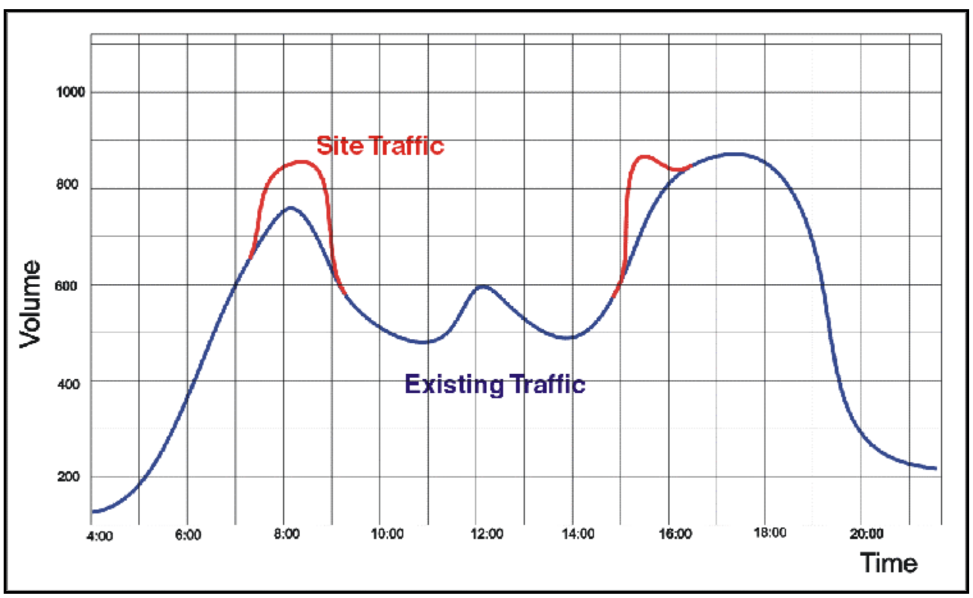
In larger urban areas, while total daily volumes may be growing, capacity issues limit the growth in peak period (15 minute or 1 hour) volumes. In this case the “peak period” becomes longer; queue lengths increase, but the peak volumes passing through a system of signals do not increase.

However there are many exceptions to these patterns. Rural tourist areas frequently show higher peaks on weekends, if the recreation is skiing, winter peaks can exceed summer peaks. One extreme example is traffic in major national parks. In one example peak volumes occurred on summer holiday weekends (most of the 30 highest hours of the year) with 7 hours occurring on one holiday weekend. The question may become “can, or should, we design for this?”

Other examples of unusual patterns are those resulting from shift changes at large employers. Perhaps most significant of these is the mid-afternoon shift change at a hospital (this also has a critical impact on parking requirements), although industrial facilities can also have significant impacts.

The objective should be to design to the "regularly recurring peak conditions" which can be expected over a reasonable future time period.

Despite our comment that the PM peak is often higher than the AM peak, care needs to be taken to ensure that the analysis recognises changes in conflicting movements. In one instance, due to a specific land use configuration and road network situation, the development was large enough to change the “worst conflict” situation from the PM to the AM peak. Unfortunately one analysis missed this and a design was prepared that failed in the AM peak. Any analysis should clearly identify the “worst cases” used for analysis. For actual design of the signals AM, PM and Off-peak time period analysis/design is required.



In this example the AM site traffic peaks concurrently with the AM street traffic, but the PM site traffic peaks before the PM peak on the adjacent street. This results in a significant change in the AM peak and little change in the PM peak. This situation can result in the AM peak traffic being the “control” for the system.

Figure 6 Peaking Characteristics

Care needs to be exercised to ensure that the worst conflict is identified, not just a routine analysis of “the peak” because “it’s usually the worst case”.

Impact of Pedestrian Volumes on Signal Phasing

Pedestrians have several important impacts on signal timing and thus capacity. . Perhaps the most obvious is the need to provide for the minimum walk and clearance times. This is true if a pretimed pedestrian phase is present, as is common in downtown situations, or, when the pedestrian phase is activated on a fully actuated signal.

In the case of fixed time (non-actuated) downtown signals the pedestrian phase is always present and has no other impact on cycle length or phase split. However, with fully actuated signals that include skip-any-phase capability, the analysis becomes more convoluted. If the signal is also in a coordinated system additional complications arise.

Apart from timing considerations, we also need to consider the capacity of conflicting vehicle movements when pedestrians are present. Clearly, pedestrians in a crosswalk will significantly reduce conflicting vehicle capacity, to the extent of only allowing minimal turning volumes at downtown intersections with high pedestrian flows.

In suburban situations conflicts with pedestrians can become problematic if, for example, there is a high volume transit route on the road and high pedestrian crossing volumes. Left turn capacity may be inadequate to service the demand during cycles when a bus arrives. This situation of pedestrian peaking needs to be specifically considered in the analysis.

Saturation Flow, Arrival Rate and Departure Rate

In many instances (maybe most…) we use traffic counts collected at the stop bar for intersection analysis. This is fine if the flow is not saturated and significant queues do not form. However, what happens when the flow is saturated and significant queues persist over many cycles?

In this case we are measuring the discharge rate, which for a given cycle length and split is a constant! What we are not measuring is the arrival rate at the back of the queue, which is the true demand for service at that location. Our analysis is thus not necessarily replicating real life unless we also investigate the queue length. This becomes critical when another intersection (or access) is close to the saturated location. A standing queue blocking an upstream intersection, or turn lane, is a significant operational issue.

A key parameter for intersection analysis is the “Saturation Flow Rate” – the highest volume (pcu’s per hour of green) that can be discharged through a single lane under the ambient road conditions.

This parameter is often assumed, but is in fact critical for good analysis, especially if there are unusual conditions or road user characteristics (such as an increasingly aging driver population with differing characteristics). It is important to note that there are differing definitions of how the data is measured that are specific to particular analysis procedures. The data must be collected using the correct methodology for the analysis procedure to be used.. Where saturated flow conditions exist, with long standing queues, it is recommended that site specific saturation flow rates be used rather than assuming default values.

It is important to measure and have the analyst (not the data collection person) observe traffic operations under all the key conditions (AM, midday and PM Peaks) to clearly understand how the system functions, what the queue lengths are (and their duration) as well as to identify any constraints on operation that may not be apparent from the data.

Summary

We have highlighted a number of issues which need careful attention if lasting safety and efficiency are to be obtained from development projects and highway upgrades. This is not an exhaustive list; we could have picked numerous other examples. They span the areas of highway planning, design, and traffic engineering as well as architecture and other specialties. There must be good iterative work and proactive communications among professionals and administrators to get them right. Tradeoffs may be inevitable but the consequences should be clearly outlined before decisions are made. Finally, we must always remember that the real client is the public who will be using the developments and roadway facilities.