Introduction

When signal calculation – Linsig, Transyt, Arcady, are examined, it is all too common to find that the saturation flows proposed are significantly at odds with how the junction will work in the real world. It is all too easy to show 10%+ reserve by making inappropriate assumptions, only to find that when the actual behaviour of people is taken into account, the junction is seriously overloaded. To regularise matters, Birmingham has produced a set of “standards” to be used for all calculations.

Background

Saturation flow is the rate at which traffic will pass over the stop-line assuming an infinite reservoir. To calculate the saturation flows of a junction, it is essential to look, really look, at how a junction will work. When this is done, taking into account the normal behaviour of people, it comes as a surprise to some, that the saturation flow of a junction can and will vary with changes in flows and destinations.

This means that consideration must be given to the fact that the saturation flow for each lane is a constant for a set of traffic flows, not for the junction. It will depend on which traffic uses which lane, what local widening is present, the location of bus lanes, refuges, storage space for turning traffic, even the effect of preceding junctions and their stage sequence (though fortunately not often).

Points to consider

In order to consider a junction, the ideal and easiest method is to go and look. However, for many, possibly most designs, they don’t yet exist, the drawing contains all the facts which are available. But do they? Often the proposed site exists, it is just that the signal layout hasn’t been built yet. By visiting the site, it is possible to gain a major insight into how people will behave when the signals are installed. Such information is valuable, it will improve the quality of the design analysis enormously. The time spent is almost never wasted.

What should be looked for? Every examination needs to be thorough, considering each aspect of the design. No two people will follow the same sequence, nor is there any need to, what matters is that the whole design is considered. How will each lane behave? Will there be interactions with other movements, how will people behave?

If you examine it, the worked example in the Birmingham Saturation Flow Standard, covers many, but not all the important points. (In point of fact, it is a real design.) However, it would be useful to go over the common features met in designs.

Right turning vehicles

This is a complex area where changes in flow and flow pattern have major effects on capacity, as can the choice of cycle time and the stages used. Of necessity each case requires an element of judgement. There are general guidelines, but these aren’t invariant, local features can cause deviation from the norm. However, starting from the norm is always prudent. Deviations can then be justified on logical grounds. It is better to be conservative, rather than optimistic, at least any error is in the “safe” direction.

Where a lane is unopposed, then no account needs to be taken of opposing flows. However the mix of traffic will have an effect. The normal allowance factor is applicable for low turning flows. Moreover regardless of the fact that there is no opposing flow, as the number of turning vehicles increases, there comes a point where a lane will become an exclusive right turning one, even though straight on traffic could use it. In general, the lower speed turning traffic is seen as an obstruction to be avoided, once there is more than about 25% to 30% of the mix turning right.

With an opposing flow, matters become complex. The physical layout of the junction plays a major part in the result. If the right turn flow is low enough so that on nearly every cycle, the turning vehicles can move into the junction and wait clear of straight on traffic, then people will be willing to share use. Once traffic usually blocks back, then the lane will switch to being an exclusive right turn, even though on paper, this affects capacity - people aren’t interested in theory. This means that lane use can vary sharply with the time of day, the AM and PM calculations can be quite different. As a rough rule of thumb, a flow of about 250 vehicles/hour can be accommodated without a separate phase, providing the geometry is “normal”. That is two to three vehicles a cycle will succeed in turning without special assistance.
With opposing right turn lanes whether the flows hook or pass near-side to near-side can make a big difference. Hooking flows will severely limit capacity if there is no separate turning facility, it can even cause the junction to lock up and cause clearance problems. The junction layout will dictate how people use it.

The choice of cycle time sometimes becomes critical. For example, in Birmingham, we have one site under SCOOT control, with a maximum cycle time of 60 secs. From any direction, the turning flows are only 80 - 90 vehicles/hour, but because it is a compact junction, there is no space for segregation of the right turn vehicles and only space within the junction for two vehicles at best. Allowing the cycle to go above 60 secs., means the turning vehicles block the ahead flow and the junction locks up.

Left turn lanes
The performance of a left turn depends on the relationship to other lanes, is it independent or does it interact? If a lane widens close to the junction, so that in practice only one or at best two vehicles could fit in before the stopline, what is the left turn saturation flow value? What is the proportion of left turn’s to other movements? Typically it will be of the order of 1:5, left to straight on flow. That means that there will rarely be anyone be waiting at the left turn stopline, so no consideration should be taken of that lane in any calculation. All to commonly it is given a full lane value, with a consequent error in calculating the capacity of the junction.

Bus Lanes and Bus Stops (and delivery points)
These can have a major effect on the capacity of a junction. There is significant pressure when designing a scheme with bus priority, to bring the end of a bus lane to only a few vehicles back from the stopline, in the belief that it won’t affect capacity. Not so, if the distance is less than the length of queue which can be discharged during the green, then that space becomes just a local widening and has to be treated as such in the calculations. This can mean that the cycle time and the end of the bus lane have to be “tuned” to achieve a desired capacity, which can be very unpopular with the proponents of public transport. However creating serious queues at a junction can be very counter productive to PT priority. A balance has to be achieved.

In a similar manner, the presence of a heavily used bus stop, or one where the stop time of the bus is long can have a major effect on capacity and by implication saturation flow. If headways are less than 2 minutes or the loading or discharge is more than ten people on average, then the time the bus stands still can have a significant influence, turning the performance of a lane into a part time local widening. The location of the stop, whether before the junction or on the exit is important. Unfortunately the location is often dictated by outside factors and not readily negotiable.

Local Widening
The geometry of a junction on the exit will have as great an effect as on the entry. Both have to be taken into account, either of them will determine how the junction behaves, use the lowest benefit which ever it is. Unfortunately, it is very common for peoples real behaviour when using local widening, to be ignored, resulting in an optimistic result.

Lane width
The TRL study does show that saturation flow is affected by the lane width. The important point is that this isn’t a spot measurement at the stop line, but the lane width throughout the whole travel time through the junction. In practice in the real world it has little or no effect - ignore it.

Roundabouts
Without doubt the most difficult type of signal junction to design. In order to start calculating the saturation flows for a roundabout, it is first necessary to determine which vehicles will use which lanes. Lane use is never even and should not be assumed to be so. Similarly, shared use of lanes will be very conservative. How people will change lanes is critical. Each design has to be carefully considered taking into account the vehicles origin and destination. It is painstaking work, with significant penalties for getting it wrong.

The choice of cycle time is critical to ensure that the short links don’t block back. (In Transyt calculations, the circulation links will need significant “loading”, of the order of 10-20.) Typically every site will have one and only one cycle time, which works. This will rarely be as high as 60 secs., and often needs to be much shorter. This in turn, means that changes in flow can be difficult to accommodate and there is little flexibility, because some offsets have to be “locked”.

The views expressed are those of the author and do not necessarily reflect the policy of Birmingham City Council.