Streamlining phase intergreen measurement for traffic signal junctions

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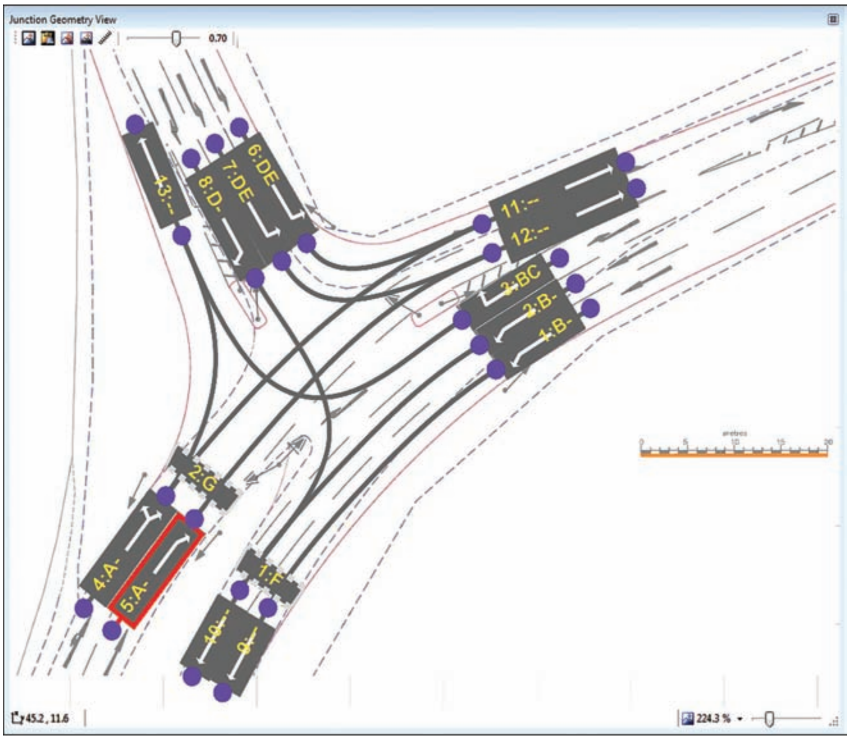
When designing a traffic signal junction perhaps the most fundamental and important design inputs are the phase intergreens. The accuracy of intergreens are important not just for providing safe clearances between phases when moving between signal stages but also in the overall efficiency of the junction. It should be self evident that inaccurate intergreens which are too short are unsafe, however, inaccurate intergreens which are too long lead to inefficient junctions and can also frustrate drivers leading to safety problems. This paper describes a new software tool – quickGreen – which helps signal engineers with the process of measuring, checking, archiving and auditing intergreens.

Background

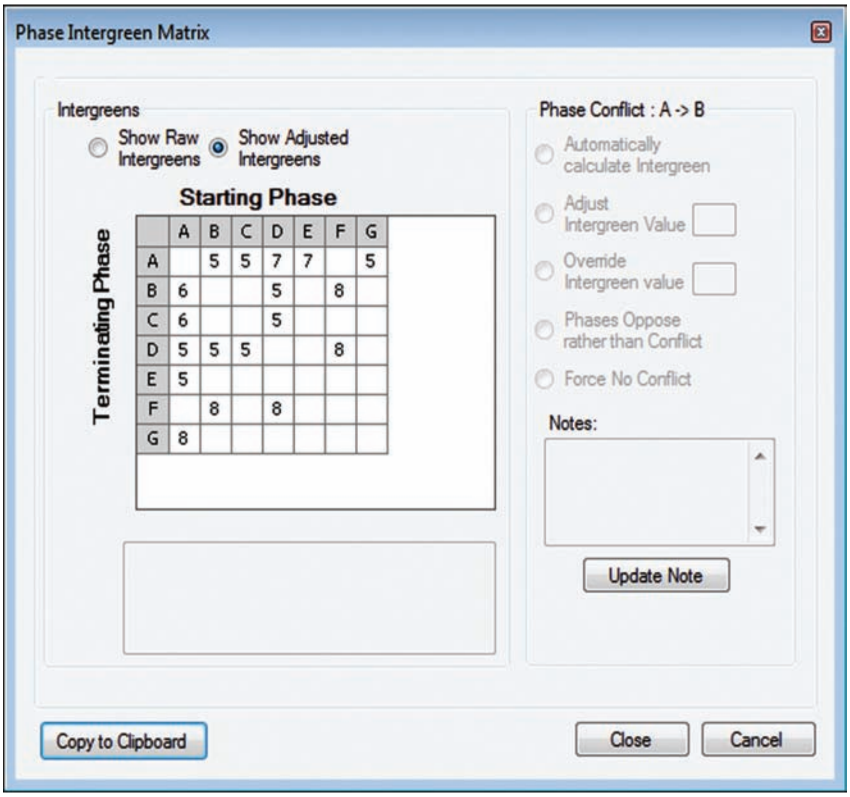
A phase intergreen is defined as the clearance time between the green period terminating on a traffic signal phase which is losing right of way and the start of the green period on a phase gaining right of way where vehicle movements conflict. The intergreen period ensures that clearance time exists for traffic losing right of way to sufficiently clear the junction before traffic gaining right of way on conflicting movements arrives. In the UK the calculation of the minimum intergreen required between two traffic movements is governed by the UK Department for Transport Traffic Advisory Leaflet 1/06 *General Principles of Traffic Control by Light Signals* (TAL 1/06). Intergreens between traffic and pedestrian phases are governed by TAL 5/05 *Pedestrian Facilities at Signal Controlled Junctions*. Significant detail is provided in these Traffic Advisory Leaflets on how intergreens are defined and used and anyone not already familiar with the concept should refer to these documents for additional detail to that provided below.

Calculation of Intergreens

The Traffic Advisory Leaflets describe a method for determining phase intergreens from a junction's geometry. This involves considering potential conflict points where traffic movements controlled by different phases would conflict and assessing the relative clearance to the conflict point between movements losing and gaining right of way. A constant cruise speed for all traffic is assumed in order to simplify the process. Measurements are taken from a scale drawing of the distance traffic losing right of way needs to travel after crossing the stop line to clear the conflict point and also the distance traffic gaining right of way must travel from the stop line to the conflict point. The difference between these clearance distances for gaining and losing right of way traffic is termed the 'X distance'. A positive X distance indicates that traffic losing right of way has further to travel to clear the conflict point than traffic gaining right of way and therefore may require a larger intergreen to provide adequate clearance between the two movements. The



The Junction Geometry View shows vehicle paths through the junction and conflict points



An intergreen matrix is produced which can be copied to any signal design software.

larger the X distance the larger the required intergreen. TAL 1/06: Part 4 provides a look up table which allows different X distances to be translated into different intergreen values. The minimum intergreen between two normal three aspect phases will normally be 5 seconds although lower values may sometimes be used with indicative green arrow phases.

For most junctions of non-trivial complexity many different conflict points will exist for different combinations of losing and gaining phases and for different combinations of lanes where a phase controls multiple lanes. Each conflict point will potentially give different conflict distances, a different X distance and a different intergreen value. It is vital to successfully identify the critical conflict point for each pair of phases which will give the highest calculated intergreen value. This could of course be achieved by simply measuring the intergreen for every conflict point however this would often lead to a large amount of work.

The most common technique, especially for experienced engineers, is to determine a smaller number of likely critical conflict points by inspection and measure the intergreens for each point. Although more efficient this is of course crucially dependent on the level of experience and the diligence of the person measuring the intergreens. The distance measurement can also be quite time consuming as it involves measuring distances along curves. Many techniques have been used in the past such as intergreen wheels or even pieces of string but all have tended to be time consuming, repetitive and tedious and therefore potentially error prone.

The intergreen calculated is actually a minimum intergreen as the actual intergreen may be extended if specific conditions arise such as red lamp failures or, on high speed roads, if a high speed vehicle is detected. These issues are outside the scope of quickGreen.

Intergreens between traffic phases losing right of way to pedestrian phases are determined in a similar way as traffic to traffic intergreens by defining conflict points where traffic movements cross the centre line of a pedestrian crossing. The only significant difference in method is that no reduction of intergreen is made to allow for the time pedestrians take to walk from the kerb to the conflict point on the crossing.

Intergreens between pedestrian phases losing right of way to traffic phases are mainly dependent on the time taken for pedestrians already on the crossing at the end of green to clear the crossing. For pedestrian crossings with far sided signals a rule of thumb used for calculating the intergreen has been to use an assumed pedestrian walking speed of 1.2 m/s and the width of the crossing to calculate the time for a pedestrian to cross and add an additional two seconds clearance time. This rule is by no means universal and several variants assuming different walking speeds or clearance times are in use by different organisations.

Puffin crossings within a junction are more complex as the possibility exists for variable intergreens based on the detection of pedestrians. Further information is provided in TAL 5/05.

The role of quickGreen

quickGreen is a software tool which assists with the calculation of intergreens by carrying out the repetitive conflict distance measuring work which is time consuming for a person to do but is easy for a computer. As well as speeding up the process of calculating intergreens it also reduces the likelihood of measurement or arithmetic errors, makes it very easy to check the intergreens and provides a convenient way of archiving the intergreens and the process by which they were calculated. Having calculated an intergreen matrix the intergreens can be easily transferred to other software such as LinSig to carry out traffic signal calculations.

The quickGreen process

quickGreen is used to measure intergreens by building up a geometric model of the junction on top of a background scale drawing. The steps involved are:

- A drawing of the junction is imported into quickGreen from any of the usual sources including AutoCAD, a PDF, satellite imagery or even a scanned drawing.
- After importing the drawing is calibrated to a known scale within quickGreen.
- Lanes, turn paths, and pedestrian crossings are added by overlaying them on the scaled drawing. Turn paths can be easily refined to fit any geometry using typically one or two control points on the path.
- As the model is built up, quickGreen will use sophisticated computational geometry to locate conflict points and measure distances between stop lines and conflict points, as required by the calculation method described above. This results in X distances for the critical conflict points.
- Signal Phases are added to group lanes controlled by the same phase.
- The critical X distances are used to calculate a phase intergreen matrix using the lookup table in TAL 1/06.
- The intergreen matrix can be exported to LinSig or other signal design software.

As the measurement calculations are carried out instantly any changes to intergreens due to changes to the junction's geometry can be quickly recalculated without the need to manually measure everything from scratch again.

Manual Adjustment of Integreens

For some junctions issues such as turn radii, gradients or speeds on an approach may mean that the engineer decides that the calculated intergreen is insufficient and that, as suggested by TAL 1/06, an adjustment to the intergreen is required. quickGreen accommodates this by allowing intergreens to be overridden at any time either by adding an incremental value or by replacing the calculated intergreen with a custom value. Where this occurs quickGreen requires a note to be entered describing why the intergreen has been changed.

Auditing and Archiving Intergreens using quickGreen

Two additional benefits of quickGreen are that the calculation process and results of the intergreen calculations are easy to audit and archive.

Previously with manual methods the only way of thoroughly checking intergreen calculations was to repeat either all or a sample of the intergreen conflict distance measurements. This is time consuming as it essentially involves repeating the whole process again. When using quickGreen because all of the repetitive measurement and calculation are carried out automatically the checking engineer can concentrate on checking issues such as whether lanes and turning paths are positioned correctly and whether any manual adjustments to calculated intergreens are valid, rather than on lots of re-measuring. Using quickGreen also provides evidence that intergreen calculations have actually been carried out properly and estimates of intergreens have not been used.

quickGreen also simplifies the process of archiving intergreen calculations. As intergreens are safety related it is possible the issue of their correctness and how they were calculated may arise in legal proceedings either for personal injury cases or driving offences a number of years after being carried out. Currently there is significant anecdotal evidence from speaking to signal engineers that the method and robustness of archiving of intergreens varies widely between organisations and in some cases intergreens are in use for which a record of their calculation no longer exists. quickGreen helps with the archiving process by allowing an electronic copy showing the basis of the calculation as well as the results to be retained, as well as storing an audit trail of when and who carried out the original calculations and any subsequent amendments.

Conclusion

This paper has briefly set out some of the issues arising when calculating and using phase intergreens. It has also introduced a new software tool – quickGreen – which aims to streamline the process of calculating intergreens by removing large amounts of repetitive calculation whilst avoiding removing important decisions from the engineer. The software will be available shortly but we would welcome feedback and comments on the concept as set out above.

References

1. TAL 5/05, Pedestrian Facilities at Signal-controlled Junctions. DfT
2. TAL 1/06, General Principles of Traffic Control by Light Signals. DfT.

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