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REPRINT

Green splits with priority to selected movements

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NOTE:

This paper is related to the intersection analysis methodology used in the SIDRA INTERSECTION software. Since the publication of this paper, many related aspects of the traffic model have been further developed in later versions of SIDRA INTERSECTION. Though some aspects of this paper may be outdated, this reprint is provided as a record of important aspects of the SIDRA INTERSECTION software, and in order to promote software assessment and further research.

Green splits with priority to selected movements

by **Rahmi Akçelik**, *Chief Scientist, Australian Road Research Board*

Introduction. This article describes a green split computation method that allows for priority specification for selected movements. The method is an extension of the traditional Webster[1], Miller[2,3] and Akçelik[4] line of methods, although its detailed formulation differs from previous methods in using the concepts of *required green times* and *excess green time*.

The general green split computation method described in this paper allows for:

(a) *unequal* practical (target) degrees of saturation;

(b) minimum and maximum green times; and

(c) *green split priority* for selected movements, which is particularly relevant to arterial signal co-ordination (e.g. see Moskaluk and Parsonson[5]), arterial call or semi-actuated signal control methods.

The method is simple in principle, and is suitable for manual calculations. However, its implementation allowing for various combinations of minimum and maximum times and priority specifications may appear to be somewhat complex. The method was developed for, and implemented in, the SIDRA 3 computer program[6-14].

Background

The green split computation method described in ARR Research Report ARR No. 123[4] was developed from the original Webster method[1]. The Webster method uses *flow ratios* (y values) as a basis for green split calculations for critical (or representative) movements at the intersection. This method distributes the total available green time (c–L, where c is the cycle time and L is the sum of critical movement lost times) to critical movements in proportion to their y values, and this results in equal degrees of saturation for critical movements. This method was also used in the traditional Australian method[2,3].

Instead of flow ratios, the ARR 123 method distributes the total available green time to critical movements in proportion to their *required green time ratios* (u values) calculated as

$$u = y/x_p \qquad \ldots(1)$$

where u = required green time ratio (ratio of the required green time to the cycle time)

y = flow ratio (ratio of flow to saturation flow).

x_p = practical (target) degree of saturation

This method allows the use of *unequal* practical degrees of saturation for different movements at the intersection (e.g. x_p = 0.90 for major movements and x_p = 0.95 for minor movements), and implies equal x/x_p ratios for critical movements. Where equal x_p values are used for all movements, the results are identical to those from Webster's y-value method. Thus, Webster's method implies an equal degree of saturation solution as a special case of the ARR 123 method. As a green split computation strategy, this is equivalent to minimising the intersection degree of saturation.

The general critical movement identification method introduced in ARR 123 (and implemented in SIDRA) as an extension of earlier methods enables the handling of complicated overlap movement cases in cycle time and green split calculations.

The ARR 123 green split computation method also introduced allowance for minimum green time effects. The method is simply to allocate the minimum green time to each movement whose required green time based on Equation (1) is less than its minimum green time. Such movements are excluded from green split calculations, and their minimum green times added to the total lost time. This *adjusted* total lost time (L') is used to calculate a new total available green time (c–L') which is distributed to remaining critical movements to achieve equal x/x_p ratios.

In SIDRA 2, this method was extended to allow for maximum green time constraints in a similar fashion.

The green split computation method using the *excess green time* concept (SIDRA 3) was developed to achieve more balanced degrees of saturation with minimum and maximum green constraints and, at the same time, to allow for green split priority allocation to selected movements.

The general method allowing for green split priorities is presented following a simple formulation of the method without green split priority. A simple example is given to explain various aspects of the method.

The required green times and excess green time

Instead of using the required green time *ratio* given by (Equation (1)), the new method is formulated in terms of *required green times* calculated from:

$$\overset{o}{g} = \frac{yc}{x_p} = \frac{qc}{sx_p} \qquad \ldots(2)$$

$$\bar{g} = \overset{o}{g} \quad \text{if } g_{max} > \overset{o}{g} > g_{min} \qquad \ldots(3)$$

$$= g_{min} \text{ if } \overset{o}{g} < g_{min}$$

$$= g_{max} \text{ if } \overset{o}{g} > g_{max}$$

where $\overset{o}{g}$ = *original* required green time (this is the flow-based required green time which corresponds to Equation (1) through $u = \overset{o}{g}/c = y/x_p$)

$\bar{g}$ = required green time *adjusted* for minimum (or maximum) green time

g_{min} = minimum green time

g_{max} = maximum green time

y = flow ratio (ratio of flow to saturation flow, q/s)

c = cycle time

x_p = practical (target) degree of saturation

A useful explanatory feature of Equation (2) is that the required green times are seen to depend on cycle time (this is not immediately obvious with the y-value method). Firstly, assuming constant saturation flows (and y values), the dependence of required green times on cycle time reflects what happens in real life; longer green times are needed to achieve the same degree of saturation if cycle time is longer. This is because longer cycle times mean longer red times, and hence, longer queues to clear. Expressing this in terms of Equation (2), a longer cycle time means that more vehicles arrive during one cycle (qc vehicles) and a longer green time is required to meet this demand.

Furthermore, unlike the assumption in Webster's method as used in most traditional methods (e.g. the well-known TRANSYT program), saturation flows are highly *dependent on signal timings* (cycle time and green times) due to short lanes, opposed turns and lane blockage in shared lanes, as clearly demonstrated through the capacity modelling developed for SIDRA[6, 7, 9, 10]. As a result, the flow ratios will also depend on signal timings. In this sense, longer cycle times may lead to reduced saturation flows and increased y values, and, in turn, result in longer required green times.

The dependence of required green times on cycle time, in fact, explains the tendency of vehicle-actuated traffic signals towards longer cycle times (through long maximum green times). This dependence also enforces the need for iterative calculations in capacity and timing analysis for traffic signals as adopted in SIDRA.

The first step in the green split computation method is to calculate the *excess green time* in the cycle as the difference between the total available green time *(c-L)* and the sum of *adjusted* required green times for critical movements:

$$\Delta g = (c-L) - \Sigma \bar{g} \qquad \ldots (4)$$

where $\Sigma \bar{g}$ = sum of adjusted required green times for critical movements
c = cycle time
L = sum of critical movement lost times

Depending on the value of the excess green time, the following degrees of saturation would result from green splits:

$$x \le x_p \text{ if } \Delta g = 0 \qquad \ldots (5)$$
$$x < x_p \text{ if } \Delta g > 0$$
$$x > x_p \text{ if } \Delta g < 0$$

The algorithm used in SIDRA 3 is structured according to the values of the excess green time, Δg. Some movements may be assigned their minimum or maximum green times depending on the value of the excess green time. The excess green time is then distributed to other critical movements in proportion to their original required green times and added to the original required green times. The resulting green times are checked against the minimum and maximum green times, and set to those values if the minimum or maximum constraint is violated.

The formulation of the general green split computation method appears to be complicated due to the handling of green split priority for selected movements combined with minimum and maximum green time requirements. A simpler formulation of the method without green split prioriy considerations is given in the following section before the general method is presented.

Green splits without priority

The method is described below in terms of distributing the total available green time in proportion to the required green times directly, rather than distributing the excess green time as used in the general method. This helps to demonstrate the similarity of the method given here to the previous methods described in the literature.

For critical movements, calculate green times from:

$$g_i = A \overset{o}{g}_i \qquad \ldots (6)$$

where

$$A = \frac{(c-L)}{\Sigma \overset{o}{g}_i} \qquad \ldots (6a)$$

where summation is for all critical movements.

Check green times, g_i, for critical movements and recalculate if necessary:

If, for a movement, $g_i < g_{imin}$, set

$$g_i = g_{imin} \qquad \ldots (7a)$$

or if $g_i > g_{imax}$, set

$$g_i = g_{imax} \qquad \ldots (7b)$$

Calculate an *adjusted total lost time* by adding to the lost time the green times of all movements whose required times have been set equal to minimum or maximum values:

$$L' = L + \Sigma g_{imin} + \Sigma g_{imax} \qquad \ldots (8)$$

Then recalculate green times for other movements from

$$g_i = A' \overset{o}{g}_i \qquad \ldots (9)$$

where

$$A' = \frac{(c-L')}{\Sigma \overset{o}{g}_i} \qquad \ldots (9a)$$

where summation is for all critical movements except those with $g_i = g_{imin}$ or $g_i = g_{imax}$ and L' includes g_{imin} and g_{imax} values of all movements with $g_i = g_{imin}$ or $g_i = g_{imax}$ as seen from Equation (8).

The resulting degrees of saturation

If the excess green time from Equation (4) equals zero, $\Delta g = 0$, then all critical movements will have $x = x_p$ except those which have $\bar{g} = g_{min}$ or $\bar{g} = g_{max}$. If $\Delta g > 0$, then $x < x_p$, and if $\Delta g < 0$, then $x > x_p$ will result for all movements except those which have $\bar{g} = g_{min}$ or $\bar{g} = g_{max}$. The movements which are allocated $g_i = \bar{g}_i = g_{imin}$ will always have $x \le x_p$ and the movements which are allocated $g_i = \bar{g}_i = g_{imax}$ will always have $x \ge x_p$.

An important implication of this method is that the movements with $\bar{g} = g_{min}$ are not always allocated $g = g_{min}$ as in ARR 123, but may be allocated longer green times, $g > g_{min}$ in order to achieve more balanced degrees of saturation. The example given below demonstrates this case.

Example. A simplified critical movement diagram and data for a three-phase case is shown in Fig 1. The green split results from the SIDRA method and the ARR 123 method for a given cycle time of c = 120 seconds are given in the following sections. In this example, equal practical degrees of saturation of x_p = 0.90, lost times of 5 sec. and minimum green times of 12 sec. are used for all movements.

The SIDRA results. In this case, the total lost time and total available green time are $L = 3 \times 5 = 15$ sec. and c-L = 120 - 15 = 105 sec. The sum of required green times is $\Sigma \bar{g}$ = 68.0 sec., and from Equation (4) the excess green time is Δg = 105–68.0 = 37.0> 0. Therefore, $x < x_p$ should result for all movements.

The sum of original required green times is $\Sigma \overset{o}{g}_i$ = 65.6, and from Equation (6a) the ratio of available green time to the sum of original required green times is A = 105/65.6 = 1.60061. From Equation (6), the green times are calculated as g_1 = 1.60061 × 9.6 = 15.37 sec., g_2 = 1.60061 × 20.0 = 32.01 sec. and g_3 = 1.60061 × 36.0 = 57.62 sec. All movements satisfy minimum green constraints and hence these green times are acceptable. Note that the adjusted required green time of Movement 1 is $\bar{g}_1 = g_{1min}$ = 12 sec., and a longer green time has been assigned to this movement. This results in equal degrees of saturation of x = 0.562 for all movements.

The *integer* green time results given in Fig 1 are from SIDRA 3 which adjusts critical movement green times in 1-second increments so as to minimise the largest x/x_p ratio for the intersection. With equal x_p values, this process is equivalent to balancing (equalising) movement degrees of saturation. The result of balancing for this example has been to round the green time for Movement 1 up (i.e. 16 sec.). The rounding of green times results in slightly unequal degrees of saturation, as seen in Fig 1.

The ARR 123 method. In this method, Movement 1 is assigned its adjusted required green time (minimum) value, $g_1 = \bar{g}_1 = g_{1min}$ = 12 sec., and an adjusted total lost time is calculated as $L' = L + g_1$ = 15 + 12 = 27 sec. If implemented in a way similar to the SIDRA method by excluding Movement 1, the ARR 123 method would give $\Sigma \overset{o}{g}_i = \overset{o}{g}_2 + \overset{o}{g}_3$ = 56.0 sec., c - L' = 120 - 27 = 93 sec., A' = 93/56.0 = 1.6607, and therefore g_2 = 1.6607 × 20.0 = 33.21 ≈ 33 sec. and g_3 = 1.6607 × 36.0 = 59.79 ≈ 60 sec. The resulting degrees of saturation are x_1 = 0.720, x_2 = 0.545 and x_3 = 0.540.

It is seen that this method results in a higher degree of saturation to Movement 1 because it is assigned a green time equal to its minimum and the excess green time available in the cycle is split between Movements 2 and 3. The resulting delays for Movements 1 to 3 are 57.7, 37.1 and 20.5 sec., respectively, and the average delay to all vehicles is 30.2 sec. Thus the results are close to the equal degree of saturation results shown in Fig 1, although this is not always the case.

Green splits with priority to selected movements

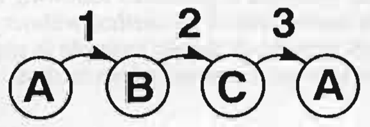
A general method for green split computation allowing for high green split priority for selected movements, in addition to allowing for minimum and maximum green times and unequal practical degrees of saturation, is to calculate green times for critical movements from:

$$g_i = \overset{o}{g}_i + \Delta g_i \qquad \ldots (10)$$

where

$$\Delta g_i = \frac{(c-L-\Sigma \overset{o}{g}_i - \Sigma \bar{g}_k)}{\Sigma \overset{o}{g}_i} \overset{o}{g}_i \qquad \ldots (10a)$$

Fig 1. Example for green split calculations (c = 120 sec., all movements with lost time = 5sec., g_{min} = 12sec., x_p = 0.90). Movements: 1, 2, 3. Phases: A, B, C, A.



Mov.	q	s	y	$\overset{o}{g}$	$\bar{g}$	g_i →	x_i	≈g_i →	x_i	d
1	108	1500	0.072	9.6<g_{min}	12.0=g_{min}	15.37	0.562	16	0.540	48.6
2	255	1700	0.150	20.0	20.0	32.01	0.562	32	0.563	38.0
3	486	1800	0.270	36.0	36.0	57.62	0.562	57	0.568	22.7
Total	849		0.492	65.6	68.0	105.00		105		30.5

where

Δg_i = extra green time allocated to ith movement (can be negative);

$\overset{o}{g}_i$ = *original* required green time (as calculated from Equation (2)) for ith movement which is to be allocated extra green time; and

$\bar{g}_k$ = adjusted required green time (as calculated from Equation (3) for kth movement which has been *eliminated* from the process of allocating extra green time due to a minimum or maximum green time, or a low or high priority specification. The elimination method is explained below.

Equation (10) can also be written in the form of Equations (6) and (9):

$$g_i = A\,\overset{o}{g}_i \qquad \ldots (11)$$

$$A = \frac{(c - L - \Sigma\,\bar{g}_k)}{\Sigma\,\overset{o}{g}_i} \qquad \ldots (11a)$$

where the sum $\Sigma\,\overset{o}{g}_i$ is for all critical movements except those which have been eliminated (due to a minimum or maximum green time, or a low or high priority specification), and the sum $\Sigma\,\bar{g}_k$ is for all eliminated critical movements.

The Elimination Method. *Case a — Without high green split priority specification:* In this case, all critical movements are treated equally according to the value of excess green time per cycle, Δg, calculated from Equation (4). There are two sub-cases according to whether the excess green time is positive or negative.

Case a. 1 — The excess green time is positive ($\Delta g > 0$): In this case, the movements with $\bar{g} = g_{max}$ are eliminated from the process ($g_k = \bar{g}_k = g_{kmax}$ is set) as a first step.

The green times, g_i, are then calculated from Equation (10) or (11), and checked against minimum green times. If $g_i < g_{imin}$ is found for any movement, it is eliminated from the process ($g_k = \bar{g}_k = g_{kmin}$ is set), and calculations are repeated by reapplying Equation (10) or (11) to remaining movements.

This case means that there is excess time in the cycle, and this time is distributed to all critical movements except those which have $\bar{g} = g_{max}$. Thus, all critical movements will have $x < x_p$ unless $\bar{g} = g_{max}$.

Case a. 2 — The excess green time is negative ($\Delta g < 0$): In this case, the movements with $\bar{g} = g_{min}$ are eliminated from the process ($g_k = \bar{g}_k = g_{kmin}$ is set) at the start.

The green times, g_i, are calculated from Equation (10) or (11), and they are checked against maximum green times. If $g_i > g_{imax}$ is found for any movement, it is eliminated from the process ($g_k = \bar{g}_k = g_{kmax}$ is set), and Equations (10) or (11) is reapplied to remaining movements.

This case means that there is insufficient time in the cycle to achieve $x \le x_p$, and time is taken out of all critical movements except those which have $\bar{g} = g_{min}$. Thus, all critical movements will have $x > x_p$ unless $\bar{g} = g_{min}$.

Case b — With high green split priority specification: In the case of high green split priority specification for some movements (as in the case of no priority), there are two sub-cases according to whether the excess green time per cycle, Δg, calculated from Equation (4) is positive or negative.

Case b. 1 — The excess green time is positive ($\Delta g > 0$): This case means that there is excess time in the cycle, and this time is distributed to high-priority movements except those which have $\bar{g} = g_{max}$ (maximum green time specification overrides the high green split priority specification).

The movements with low-priority for green splits are eliminated from the process. Thus, those movements that have $g_k = \bar{g}_k = g_{kmin}$ (low-priority movements) or $g_k = \bar{g}_k = g_{kmax}$ (low- or high-priority movements) are eliminated. If all movements are at maximum, any positive excess green is split equally according to movement demands (i.e. maximum green constraints are not applicable).

This process will result in $x = x_p$ for the eliminated movements unless $g_k = g_{kmin}$ ($x < x_p$ will result) or $g_k = g_{kmax}$ ($x > x_p$ will result). The movements with high green split priority will have $x < x_p$ (unless $\bar{g} = g_{max}$ for which $x > x_p$ will result).

Case b. 2 — The excess green time is negative ($\Delta g < 0$): This case means that there is insufficient time in the cycle to achieve $x \le x_p$ and time is taken out of low-priority movements except those which have $\bar{g} = g_{min}$. The movements with high-priority for green splits are eliminated from the process. Thus, those movements that have $g_k = \bar{g}_k = g_{kmin}$ (low- or high-priority movements) or $g_k = \bar{g}_k = g_{kmax}$ (high-priority movements) are eliminated. If all high-priority movements have $\bar{g} = g_{max}$, then they will not be eliminated and time will be taken out of their required times according to Equations (10) or (11).

This process will result in $x = x_p$ for high-priority movements unless $\bar{g} = g_{min}$ ($x < x_p$ will result) or $\bar{g} = g_{max}$ ($x > x_p$ will result). The movements with low priority for green splits will have $x > x_p$ (unless $\bar{g} = g_{min}$ for which $x < x_p$ will result).

Example

(a) Assume that high green split priority is specified for Movement 3 in the example given in Fig 1. Since the excess green time is $\Delta g = 37.0 > 0$, this is Case b.1. In this case, the low-priority Movements 1 and 2 will be eliminated and their green times will be set as $g_1 = \bar{g}_1 = g_{1min} = 12.0$ sec. and $g_2 = \bar{g}_2 = \overset{o}{g}_2 = 20.0$ sec. Thus, $\Sigma\,\bar{g}_k = 32.0$ sec., $\Sigma\,\overset{o}{g}_i = \overset{o}{g}_3 = 36.0$ sec. and $A = (120-15-32.0)/36.0 = 2.02778$. Since Movement 3 is the only high-priority critical movement, Equation (11) will give $g_3 = 2.02778 \times 36.0 = 73.0$ sec. The resulting degrees of saturation are $x_1 = 0.720 < x_p$ (due to minimum green time), $x_2 = 0.900 = x_p$ (because the green time equals the required value) and $x_3 = 0.444 << x_p$ (due to high green split priority.) The resulting delays for Movements 1 to 3 are 57.7, 83.3 and 12.6 sec., and the overall average delay is 39.6 sec. (compare with 48.6, 38.0, 22.7 and 30.5 sec., respectively, which are the delays from the equal degree of saturation solution without green split priority as shown in Fig 1). It is seen that, although the delay to Movement 3 is reduced as a result of priority, the overall average delay is increased significantly.

(b) Now assume that high green split priority is specified for both Movement 1 and Movement 3 in the example given in Fig 1. In this case, the low-priority Movement 2 will be eliminated and its green time will be set as $g_2 = \bar{g}_2 = \overset{o}{g}_2 = 20$ sec. Thus, $\Sigma\,\bar{g}_k = 20.0$ sec., $\Sigma\,\overset{o}{g}_i = \overset{o}{g}_1 + \overset{o}{g}_3 = 45.6$ sec., and $A = (120-15-20.0)/45.6 = 1.86404$. From Equation (11), $g_1 = 1.860404 \times 9.6 = 17.89 \cong 18$ sec. $> g_{1min}$ and $g_3 = 1.86404 \times 36.0 = 67.10 \cong 67$ sec. The resulting degrees of saturation are $x_1 = 0.480 << x_p$ (due to high green split priority), $x_2 = 0.900 = x_p$ (because the green time equals the required value) and $x_3 = 0.484 << x_p$ (due to high green split priority). The resulting delays for Movements 1 to 3 are 46.7, 83.3 and 16.0 sec., and the overall average delay is 40.1 sec. (compare with 48.6, 38.0, 22.7 and 30.5 sec., respectively, which are the delays from the equal degree of saturation solution without green split priority as shown in Fig 1).

Discussion

In summary, the SIDRA method for green split computation is a generalised method which can deal with:

(a) green split priority for selected movements;

(b) minimum and maximum green times; and

(c) unequal practical (target) degrees of saturation.

The presentation in this paper has been limited to a *single green period* for each movement as used in most traditional methods. Solutions to problems of calculating required green times and green splits in the more complicated case of *two green periods per cycle* have been implemented in SIDRA, and are yet to be published (note that, in SIDRA, green split priorities for movements with two green periods can be specified for either green period or for both periods).

In this paper, the green split computation method has been expressed in terms of critical movements in the signal cycle. In the case of overlap movements, the method is also applicable to sub-cycles (see ARR 123, Section 7[4]).

The green split computation method presented in this paper does not necessarily give a *minimum-delay* (or a minimum performance index) solution although the results are often close. For the simple example presented in this paper, the green splits which give minimum average delay for all movements (given cycle time of $c = 120$ sec. are $g_1 = 13$ sec., $g_2 = 26$ sec., $g_3 = 66$ sec. resulting in individual movement delays of $d_1 = 51.4$ sec., $d_2 = 43.4$ sec., $d_3 = 16.6$ sec. and an average overall delay of $d = 29.1$ sec. The average overall delay value is close to the SIDRA solution given in Fig 1 ($d = 30.5$ sec.), although the green times are significantly different.

On the other hand, a comparison of individual movement delays show that the SIDRA solution (d_1 = 48.6 sec., d_2 = 38.0 sec. and d_3 = 22.7 sec.) gives more equitable delays, or a lower value of the largest average delay to any movement, compared with the minimum delay solution. This leads to the consideration of a green split strategy which gives *equal delays* to all critical movements (equivalent to minimising the largest average delay to any movement). The difference between this strategy and the minimum overall delay strategy is similar to user-optimising and system-optimising strategies in traffic assignment.

The equal delay solution for the example in Fig 1 is g_1 = 30 sec., g_2 = 33 sec.and g_3 = 42 sec. resulting in d_1 = 36.4 sec., d_2 = 37.1 sec., d_3 = 37.2 sec. (approximately equal within the constraint of integer green times), and an average overall delay of d = 37.1 sec. For this example, the equal degree of saturation strategy used in SIDRA is seen to give a solution closer to the minimum overall delay strategy.

An interesting discussion of several green split calculation strategies in the context of combined traffic assignment and signal timing optimisation was presented by Van Uren, Smith and VanVliet[15]. In addition to the equal degree of saturation strategy (referred to as the *Webster Policy*) and the minimum overall delay strategy, Van Uren *et al* considered a strategy which aims to equalise the product of average delay and saturation flow (equal $s_i d_i$ policy) so as to allocate longer green times to major roads. For the example in Fig 1, the equal $s_i d_i$ solution is g_i = 25 sec. and g_2 = 36 sec. and g_3 = 44 sec. resulting in d_1 = 40.5 sec., d_2 = 34.6 sec. and d_3 = 33.9 sec. with an average overall delay of d = 34.9 sec. In contrast with the equal degree of saturation strategy, this solution is closer to the equal delay solution than the minimum overall delay solution.

Generally, the equal $s_i d_i$ strategy will give results which are close to the equal delay strategy when critical movement saturation flows (s_i) are close. In such cases, both the equal degree of saturation and the minimum overall delay strategies are better in terms of achieving the objective of allocating longer green times to major movements. Green splits with priority to major movements, or with unequal practical degrees of saturation (higher x_p values for minor movements), or both, could be used to achieve this objective in a more effective and efficient way.

In the literature, the minimum-delay and other signal timing computation strategies are often discussed without considering the type of intersection control (vehicle-actuated, fixed-time, co-ordinated or unco-ordinated) used in real-life situations. Many aspects of the *practical signal timing* method adopted in the SIDRA program (including the equal degree of saturation strategy for green time computation presented in this paper) relate to vehicle-actuated control better (see Akçelik[4,7] for techniques to determine critical movements and calculate a practical cycle time). Unlike the simple example given in this paper, non-critical movements exist in real-life intersection cases, and this contributes to the difficulty of expressing general relationships between alternative computation strategies. However, it appears that the equal degree of saturation strategy gives a solution between the minimum overall delay and the equal delay strategies, which may be an acceptable compromise between the user-optimising and system-optimising strategies.

More rigorous discussions on the relevance of various signal timing computation strategies and *optimisation* criteria (delay, queue length, a performance index, fuel consumption, cost, etc.) to real-life signal control systems and traffic conditions are needed.

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ARRB updates SIDRA

The Australian Road Research Board has released an updated version of SIDRA, its intersection modelling software package. Version 3.2 contains many new features which make it easier to use and increase the range of options and outputs: for example, users now have full control over specification of output tables and can use new features such as uninterrupted movements and variable flow scales. The package also includes new documentation in the form of four User Manuals, and SIDRA 3.2 also has an option to implement the U.S. *Highway Capacity Manual* method.

According to ARRB's Executive Director Dr Ian Johnston, SIDRA has been bought by over 140 organisations in 23 countries and has been used under a wide variety of operating conditions, enabling continuous development to take place in response to feedback from many practising engineers and planners. Work is proceeding on roundabout modelling and, with the support of VicRoads, on the development of RIDES (Road Intersection Data Editing System), a special graphics-based input data preparation program. Both features will be included in SIDRA version 4 .

SIDRA 3.2 can be used on any IBM PC or compatible, and is released under the terms of a software agreement. In Australia and New Zealand it costs A$1 400 for commercial organisations and A$450 for researchers — contact Dr Rahmi Akçelik at the Board, P.O. Box 156, Nunawading, Victoria 3131. The University of Florida's McTrans Center for Microcomputers in Transportation distributes the package in all other territories worldwide under a non-exclusive marketing arrangement.

In addition to References 13 and 14 given in the article above, recent ARRB documents by Dr Akçelik, SIDRA author, and Mark Besley, its programmer, include DN 1708, *Installation and running instructions* for the PC version; and DN 1709, *User notes for the Highway Capacity Manual option.*

Road traffic:
5 per cent growth, 1-3.90

Motor traffic was 5 per cent higher in the first quarter of 1990 than in the same quarter last year, according to provisional estimates issued by the U.K. Department of Transport in June.

Although the overall rate of growth in traffic seems to have been slowing during the last few quarters, motorway traffic was an estimated 12 per cent higher than in the first three months of 1989.

There were some signs of a slowdown in the rapid rise in light van traffic. Growth by this group was lower than that of heavy goods vehicles for the first time in two years. However, the use of 5-axled articulated lorries continued to rise at the expense of other HGV groups. The mileage of 4-axled rigid vehicles (used mainly for bulk haulage) was estimated to have fallen compared with the same time last year.

On a seasonally-adjusted basis traffic showed a 6 per cent quarter-on-quarter growth. However, the higher traffic levels because of the mild winter may well mean that this provisional estimate overstates the underlying trend.

Traffic in Great Britain — 1st Quarter 1990 (Statistics Bulletin (90) 6), is obtainable from the DTp's Publications Sales Unit in Building 1, Victoria Road, South Ruislip, Middlesex HA4 0NZ (*Tel:* 081-844 3425).