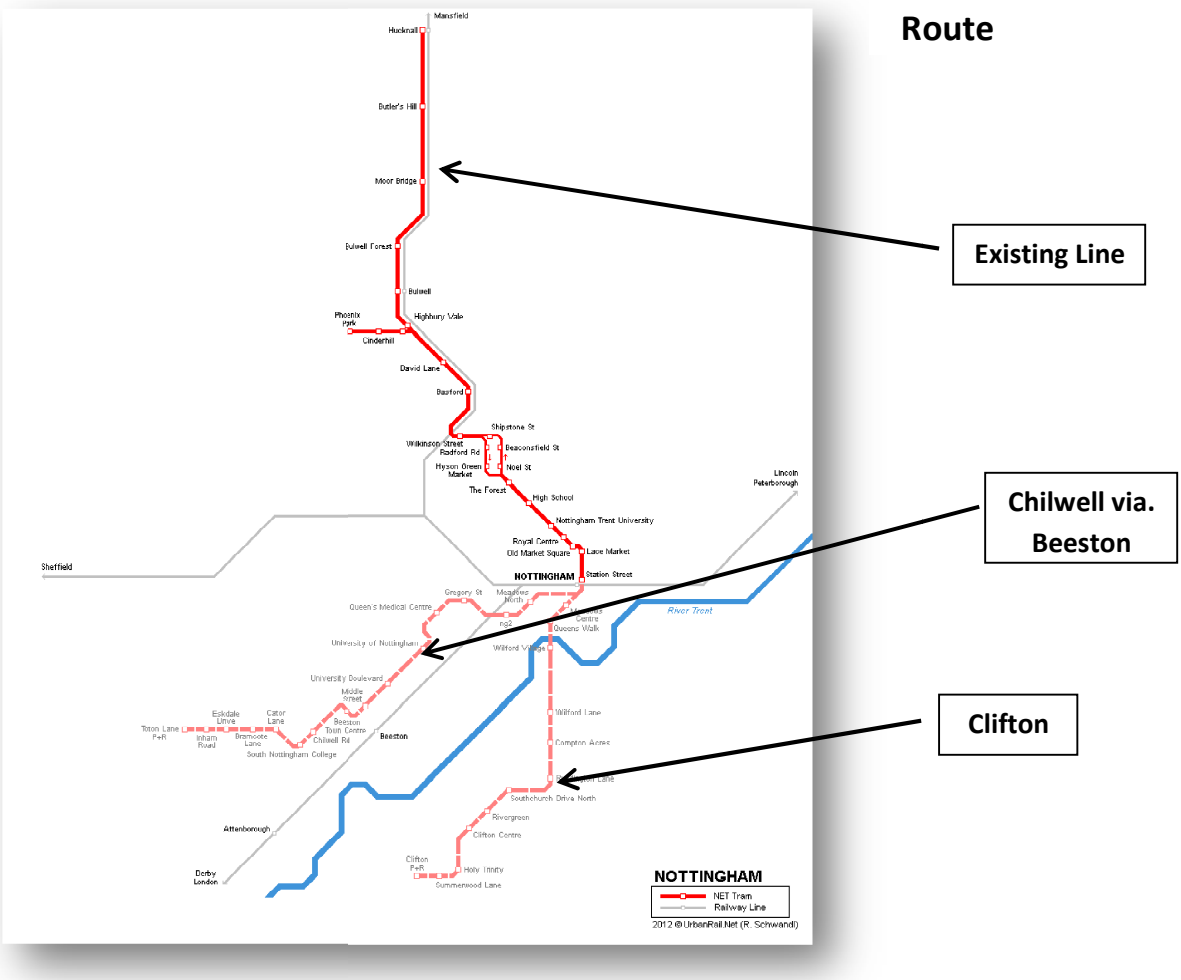
NET2 – Tram Story 2

David Parkin david.parkin@mottmac.com and
Tom Hargreaves tom.hargreaves@mottmac.com

Mott MacDonald

NET2 is the second phase of the Nottingham Tram system that already runs from the mainline railway station through the city centre and to the north of the city. The existing line was opened in 2004 and is approximately 14km long, with only about 4km running on street. As a result there are not many road junction traffic signals controlling the tram.



NET2 will continue south from the railway station and split into two routes, one to Clifton and one to Chilwell. The line to Clifton is 7.6km long and 63% of it is segregated. The line to Chilwell via. Beeston is 9.8km long and 59% of it is segregated. The two routes will pass through almost 40 sets of traffic signals. The overall process of planning and designing the tram route is a very lengthy process and

Mott MacDonald has been involved in the planning and design of NET2 since 2002. The routes pass through both Nottingham City Council and Nottinghamshire County Council's jurisdiction.

Existing Line 1 Tram Signal

To be able to provide a fast and efficient tram system with reliable running times, it is essential to be able to provide a high level of priority for the trams whilst ensuring that the impact on the road network is minimal. To this end a lot of time was spent at the advance stages of the design to model the operation of the traffic signal controlled junctions along the route of NET2, especially where the route passed through areas of densely populated signal junction or where an area wide adaptive traffic control system is currently operating. It was also very important to liaise closely with the relevant stakeholders to ensure that the level of priority given to the tram would not result in an unacceptable level of detriment to general road traffic.

Levels of Priority

In the preliminary stages of signals design for NET2 it was identified that there are generally 4 levels of priority that are possible:

- Level 1: The tram stage operates in sufficient time so that the tram incurs no delay (subject to forward visibility and track geometry).
- Level 2: The tram stage is inserted into the cycle as soon as the stage during which the tram is detected has satisfied its stage minimum value and the required intergreen has elapsed.
- Level 3: The stage during which the tram is detected operates for its normal duration; the tram stage is then inserted into the cycle.
- Level 4: The tram stage operates at one fixed slot during the cycle only.

The level of priority provided on LRT systems is not always a result of what can be achieved, but the level of priority the Local Authority may wish to achieve at the expense of other traffic. The level of

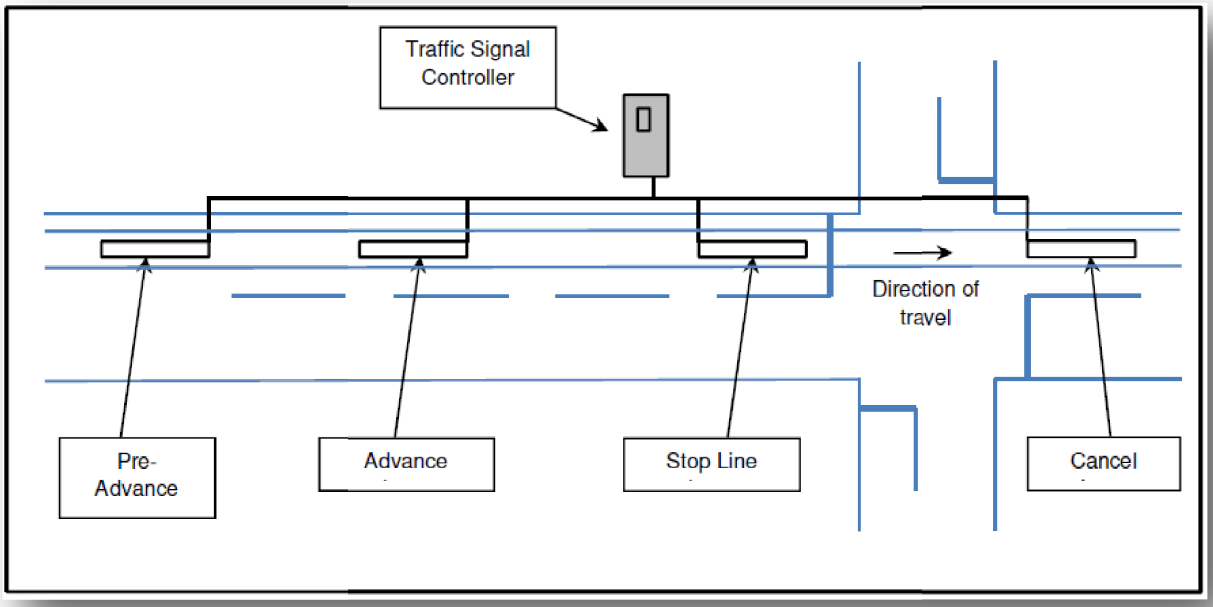
priority can also be dependent on whether the tram is running to schedule or not, or if the headway is being achieved. This will rely on an interface with the scheduling system for the tram so that this information can be shared. For NET2 it was agreed that the tram would operate with Level 1 priority at all junctions. To achieve this, a lot of time was spent deliberating how the signals needed to be prepared in advance of the demand being received for the priority stage and the time the traffic signals required to provide priority.

Tram Detection

Tram detection control is generally achieved by using four loops:

- Pre-Advance.
- Advance.
- Stop Line.
- Cancel on the exit of the junction.

Four Loop Detection



The **Pre-Advance loop** is used to prepare the junction for the arrival of the tram. This is the first loop and is often set a long distance before the junction. This loop may initiate an immediate move to a stage to clear the traffic in front of the arriving tram, or may service a particular stage or stages that are important not to miss out during a cycle. If the junction happens to already be on the desired stage the controller will be prevented from changing away from this stage. This is achieved by using either a Hurry Call, Priority Mode or LRT Mode in the traffic signal controller. The required distance of this loop from the junction is dependent on the complexity of the junction, the duration of the stages and interstage timings. The distance is calculated using this information along with the proposed tram approach speeds. It is extremely important to get this loop at the correct distance

from the junction, if it is not the controller may not have enough time to react in order to provide the required level of priority.

The **Advance loop** is used to demand the tram proceed signal and/or the tram stage depending on whether the junction has been prepared to the stage the tram runs in or not. Again the distance to this loop from the junction will depend on the time required to change to the right of way stage. The tram signal should normally be set to 'proceed' in advance of the tram's arrival at the stop line so that the tram doesn't need to slow down in preparation to stop.

The **Stopline loop** has two functions. The first function is to cancel the tram proceed signal and to instigate a tram clearance period (Stopline cleared). The second function is to provide a demand for the tram if the earlier loops have failed or the tram has been delayed (Stopline Presence).

The **Cancel loop** is used to cancel any extended tram clearance period and move the traffic signal controller back from tram priority mode to normal operation. This is important as it allows the junction to operate more efficiently rather than operating a larger fixed clearance period.

In certain locations a TRTS (Tram Ready to Start) input will be used. This is primarily used at locations where a tramstop is on the approach to the traffic signals. The TRTS button is activated by the tram driver and is treated by the signals in the same way as an Advance loop demand or even a Pre-Advance demand if the tramstop is located further away from the junction.

A considerable amount of time was spent during the detailed design stage developing special conditioning to ensure that Level 1 tram priority could be achieved whilst maintaining suitable operation for both normal traffic and pedestrians. Various methods of control were used depending on the complexity of the junction. In the main, Hurry Call and Priority modes were used to control the tram operation. At busier junctions SCOOT and MOVA was specified. At the start of the construction works it was decided to use the LRT mode of operation available in the Siemens ST950 controller. The controller configurations were then converted to utilise this facility.

There were various operational considerations that needed special attention. For instance, a situation could occur where two trams in opposing directions could approach the signals at the same time. If both trams receive priority in the same stage then this is not a problem. To ensure that the priority control for the second tram is not cancelled by the first tram passing through the signals and crossing the cancel loop a window timer is used to hold the priority stage.

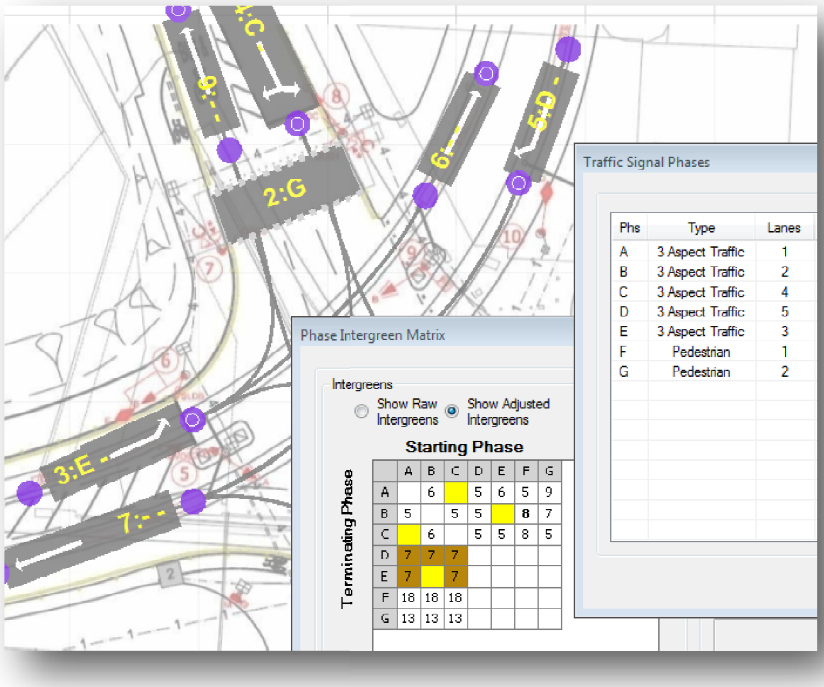
At some locations trams in opposite directions do not run in the same stage and usually there is one movement that needs to have priority over the other i.e. a tram that runs with traffic has more priority then a tram that is 'off-street'. In these locations a window timer is again used, started by the tram with least priority crossing the pre-advance loop. If an opposing tram with higher priority crosses its pre-advance loop during this window timer, then this tram will "take over" priority control. If a tram has already reached its advance detector and the priority stage has been called then the opposing tram demand will be served as soon as possible afterwards.

Tram Clearance

An important aspect of signal control is safety and ensuring that the clearance time of the tram is sufficient. For NET2 we developed a methodology for calculating the clearance period needed for the tram before the following traffic movements were allowed to achieve right of way. TAL 1/06 provides methodology for calculating intergreens based on relative travel distances of leaving and gaining traffic movements. This does not allow for tram intergreens, however the main difference with trams is the overall length. As a tram is approximately 20m longer than an articulated lorry we therefore added 20m to the distance measured for the tram movement that is losing right of way. To provide an additional "comfort factor" a further 2 seconds was then added.

Total Tram Clearance = (Tram Distance to Conflict Point + 20m) – Traffic Distance to Conflict Point = Intergreen calculated from TAL 1/06 + 2s Comfort Factor (Minimum 7s).

The additional 2 seconds comfort factor is controlled by an extended all red time that can be curtailed when the tram clears the junction and activates the Cancel loop.



JCT's QuickGreen (Intergreen Calculator)

QuickGreen was found to be an excellent tool to calculate and document intergreen timings (as well as the tram calculation sheets produced specifically for NET2), and provides an auditable trail for future reference.

Signals Recovery

Following the tram receiving its priority signal it is necessary to revert to normal control. If any traffic or pedestrian movements have been skipped or truncated in order to provide the tram with its priority operation it may be necessary to adjust the signal timings for the following cycle in order for the traffic conditions to recover from the disruption. This is generally achieved on NET2 by using the

Compensation Time event within Priority Control facility (LRT Compensation Time and 'exceptional stage' facilities are used for the ST950 controller).

If the junction is part of a co-ordinated network of adaptive traffic signals (SCOOT), it may be preferable to try and retain co-ordination as much as possible. Where NET2 passes through an area controlled by SCOOT, priority for the tram is achieved by dropping out of SCOOT control and using the local priority control in the controller. The SCOOT system will continue to monitor the operation of the signals during the priority period so that when SCOOT regains control it will be able to adjust the signal timings in order to compensate any stage that was disadvantaged during the priority period. If these events occur too frequently the system may struggle to regain co-ordination long enough for the junctions to recover before the event is repeated. If this is the case a decision needs to be made by the controlling authority if the same level of priority for the trams is sustainable.