Strategic Tram Priority Theory - Edinburgh

The typically lower frequency of trams relative to buses, combined with greater passenger loading, makes the provision of high tram priority very desirable.

The Edinburgh Tram is due to go live in summer 2014 and will provide an efficient method of transport across the City Centre and out to the Airport. A key component of this is to ensure that the tram incurs minimum delay at traffic signals. This will be done through a mixture of STM and 'LRT' priority. STM will be implemented across the city centre network at 21 signal controlled junctions and crossings mainly controlled via UTC fixed time plans, whilst junctions further out towards the airport will be controlled with more traditional controller defined 'local LRT' priority.

Overall Network strategy

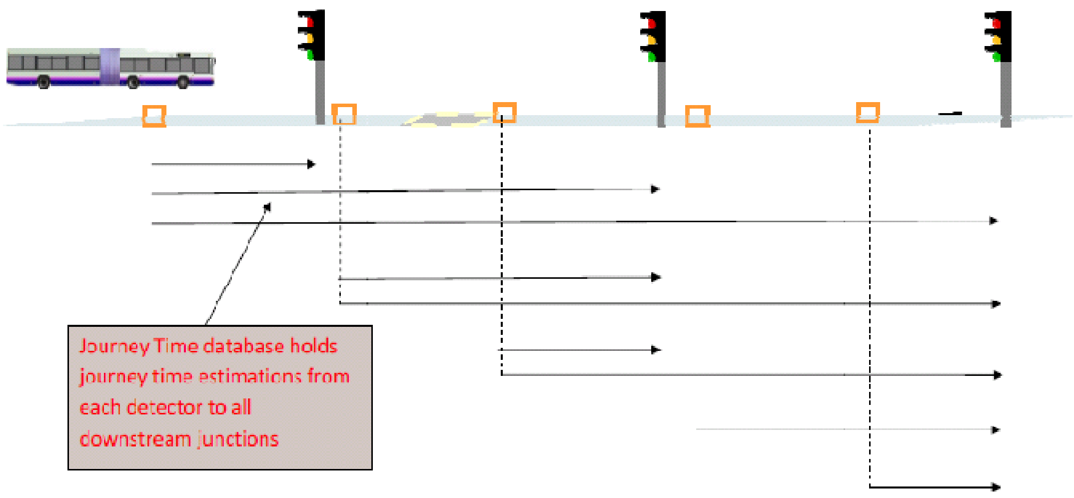
The key to achieving the aspiration of providing a high level of tram priority, balanced with minimal disruption to general traffic, is the ability to predict the arrival time of a tram at each junction. When coded with offline derived 'time of arrival' information (in terms of 'time in the signal cycle'), STM can then make strategic decisions on altering the downstream signal timings in advance of the tram's arrival at a particular junction. The object of this is to match the appearance of the green to the tram arrival, and in order to make it easier to achieve this at adjacent junctions it is envisaged that the network will be broken down into small coordinated 'sub networks', typically separated by tramstops.. In addition to this, STM will also monitor the greens, and calculate what compensation may be needed to minimize the disruption to other traffic.

Journey Time prediction

Since local LRT detection is being placed throughout the city centre (to allow 'LRT' priority to be used as a fallback mode to STM) STM will use this detection as its method of monitoring the trams.

The local LRT detector replies will be brought back via UTC reply bits, and can either be used in real time as logic inputs, or stored in the STM database for offline analysis of tram journey times. The STM priority strategies will use the detector replies to select the most relevant time-of-arrival values related to downstream junctions. The database will allow queries to be made between pairs of detectors by the Journey Time Tool.

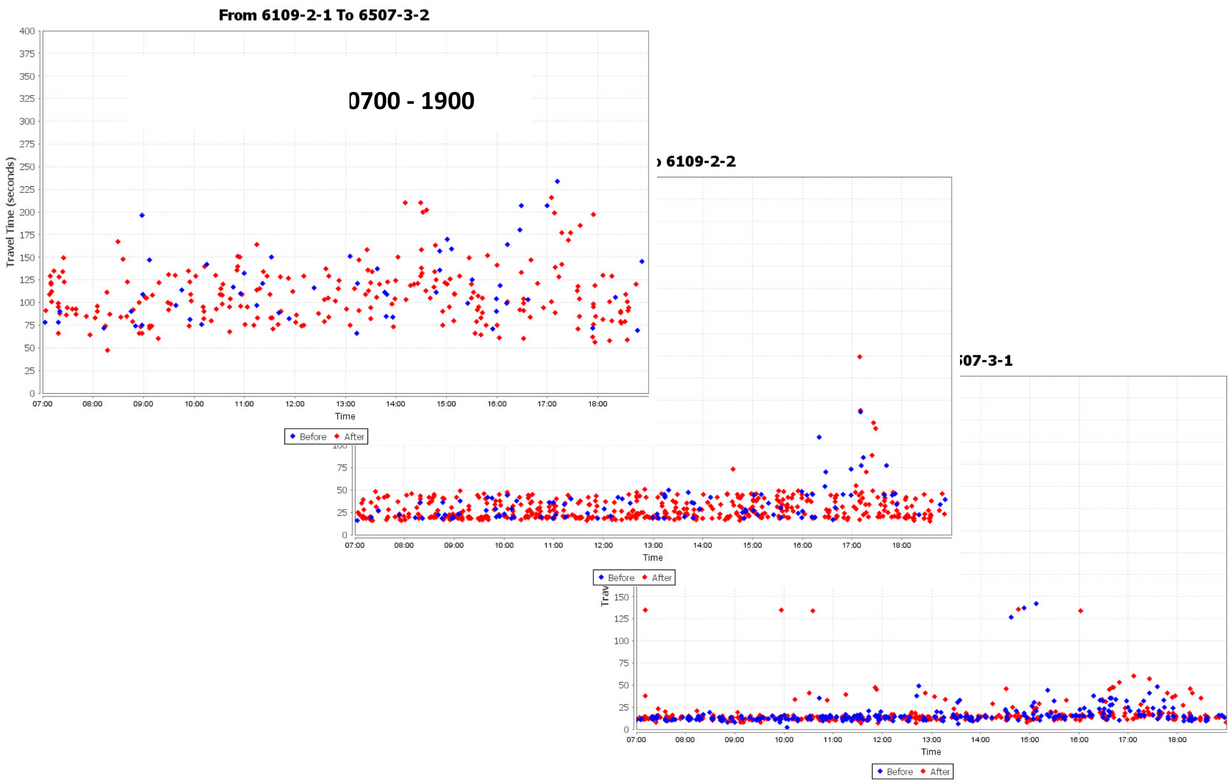
This diagram shows how detectors will have an associated journey time to downstream junctions



+brh LTD

The Journey Time Tool will be used to assess where the journey time from upstream detectors is within tolerable limits of variability, such that a realistic decision can be made as to whether to shift downstream timings ‘early’ or ‘late’. This tool allows time distance diagrams and scatter plots to be produced, **u**sing either ‘raw’ data (as shown in the scatter plots below), or ‘processed’ data where any non-priority signal delay has been removed.

The Journey Time scatter plots below show the (‘raw’) Journey Time variability decreasing as each new detector is passed, and hence the distance to the target junction decreases



Tram Strategy Overview – ‘Modes’

STM strategies use ‘Modes’ as a way of sub-dividing the various steps within a strategy. These modes have typically been used in bus priority to define basic extension/recall/compensation strategy steps. For Edinburgh Trams there will be 3 main priority ‘modes’ which will help define the strategy steps for an approaching tram (in practice these will be broken down into ‘sub modes’ to deal with such issues as ‘+ or -timing changes’, and ‘direction of travel’) .

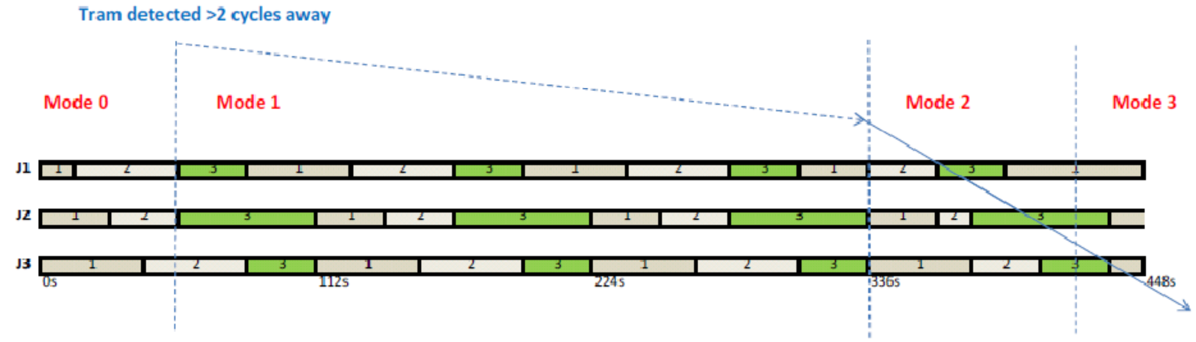
Mode 0: No STM priority.

Mode 1: When a tram is detected on the approach to a junction(s), STM will access a set of pre-defined arrival times derived from the historic journey time database. When this estimated arrival time falls within reasonable levels of variability, small timing changes can be made at downstream junctions, and as subsequent detectors are passed the variability will decrease, allowing the timings to be refined – and larger changes to be made if required.

Mode 2: Once the tram is within the ‘Prepare’ detector on the final approach to the junction a similar style of priority to local LRT priority will be implemented.

Mode 3: On clearing a junction, STM will then handle the transition back to non priority **mode 0** and normal fixed time plans - ensuring no crash changes and applying any necessary compensation.

The diagram below shows a tram being detected a number of cycles before its arrival at the first of a 3 junction sub-network. Mode 1 is initiated and timings over the next few cycles are altered in anticipation of the trams time of arrival within the cycle. Mode 2 will then handle the final approach with Mode 3 running a compensation cycle



Mode 1 – the key mode

Mode 1 is the critical part of the priority. Mode 2 is necessary, but If Mode 1 has been successful then Mode 2 will only need to handle the appearance and clearing of the tram priority stage – resulting in a far less aggressive change in timings than with local LRT.

To enable Mode 1 to deal with both directions of tram**,** optimal signal timing for each sub-network will be pre-defined for each tram direction.

Whilst the 'upstream' junction in a sub-network is being altered to match the time of arrival of the tram, the downstream junctions within the sub-network will be moved to the pre-defined optimized offsets, and thereafter moved together as a group until the tram passes. The key is to balance the need for quick timing changes with the likely disruption to general traffic.

A necessary part of Mode 1 will be directed towards the issue of whether timings within the sub network are required to be made 'early' or 'late'.

The diagram below shows pre-defined offsets within a sub-network for Eastbound and Westbound trams.