# Fire Engine Green Wave Project – Leeds 2010

During 2010 the West Yorkshire Fire & Rescue Service (WYFRS) became aware of the West Yorkshire 'Traffic Light Priority' project, and approached Metro with an idea of adapting the AVL and SPRUCE system for use on their Fire Appliances.

Although by law Fire Appliances can proceed through red signals with caution, it can cause difficulties for both the firefighters and other motorists, and naturally slows appliances down as they attempt to safely negotiate other traffic. In addition to this 'in junction' delay, sometimes appliances cannot get to the signals quickly because of queuing traffic on the approaches to junctions.

### Appliance accidents, and response times

In 2009 the Fire Service undertook some research into accidents and '999' response times. The research showed that in 2009/10 there were 2922 accidents involving Fire Appliances – with around 40% of these being whilst they were 'on blue lights' (data compiled and produced by the Chartered Institute of Public Finance and Accountancy (CIPFA).

This research also highlighted an increase in response times in line with increasing growth in traffic levels:

**West Yorkshire Data, average dwelling fire response time(min) and average traffic levels million vehicle/KM**

| | 1996 | 2006 |
|---|---|---|
| Response time | 5.4 | 6.3 |
| Traffic levels | 13,868 | 15,818 |

Using response time fatality rate relationships WYFRS predicted that the increased response time may contribute to around:

- 13 additional fatalities in dwelling and other building fires each year
- Possibly 65 additional deaths in RTAs
- An £85 million increase in building fire damage.

## LEEDS GREEN WAVE PILOT (DEC 10-MAR 11)

WYFRS was driven by the desire to increase road safety for their appliances and other road users, and also to reduce appliance response times. In consultation with Leeds City Council, they established a set of criteria for the success of the pilot.

### Pilot success criteria

- Give a green light to each emergency journey in at least 90% of instances,
- Ensure and increase safety levels for the public whilst using the road during an emergency journey,
- Flush traffic from both the next and subsequent junctions ahead of the Fire Appliance's arrival.

Hunslet Fire Depot in South Leeds was chosen for the trial. This Depot has 3 main routes that Fire Appliances could use to access different parts of the city, all suffering from congestion in the peak periods and having a number of signal controlled junctions. Two Fire Appliances were fitted with the same AVL priority hardware as used by buses, the units becoming active once the Appliance is under 'blue lights'. As the technology was already in use, adapting it for Fire Appliances was relatively straightforward.

## STM SPRUCE STRATEGIES

Because Fire Appliances are low-frequency vehicles, it is possible to give them 'high priority' - because lives are at stake it doesn't matter if other traffic is inconvenienced by short-term queuing.

It was agreed that Appliances in Leeds could be granted the highest level of priority possible, with certain guidelines being set out to help define this:

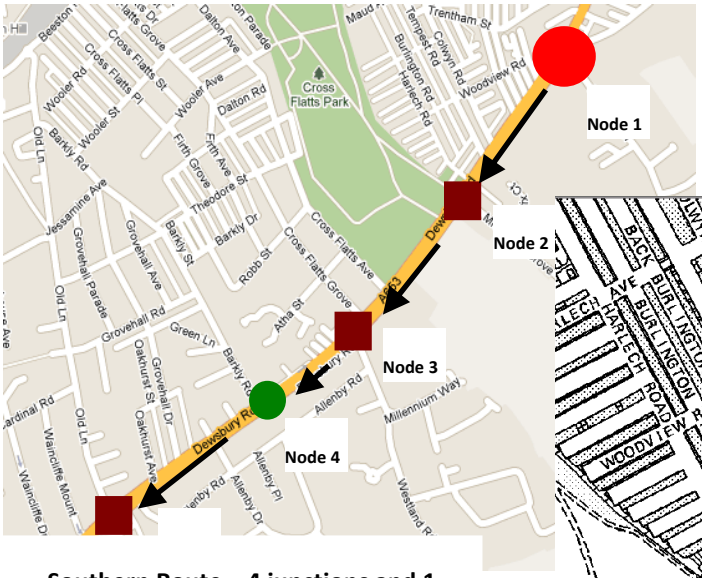
- Stage skipping could be considered if deemed safe to do so.
- If stage skipping occurred to the detriment of a pedestrian stage, the demand must be satisfied on the next stage move following priority.
- Compensation was not necessary due to the infrequent disruption, and the understanding by the public having just seen a fire appliance 'on blues' proceed through the junction.

As well as the low frequency of Fire Appliances compared to buses there are other key differences that needed to be considered, which the strategies had to cater for:

- ***Advantage*****:** Fire Appliances do not stop at bus/tram stops. Analysis of the travel times along the routes showed more consistency than buses, although there were still time-of-day trends in line with peak hour congestion.
- ***Disadvantage***: Fire Appliances do not follow known routes. On leaving the depot all routes had to be activated with priority until it could be determined which route the Fire Appliance was taking. Appliances can also turn off the route unexpectedly, or switch off their blue lights.

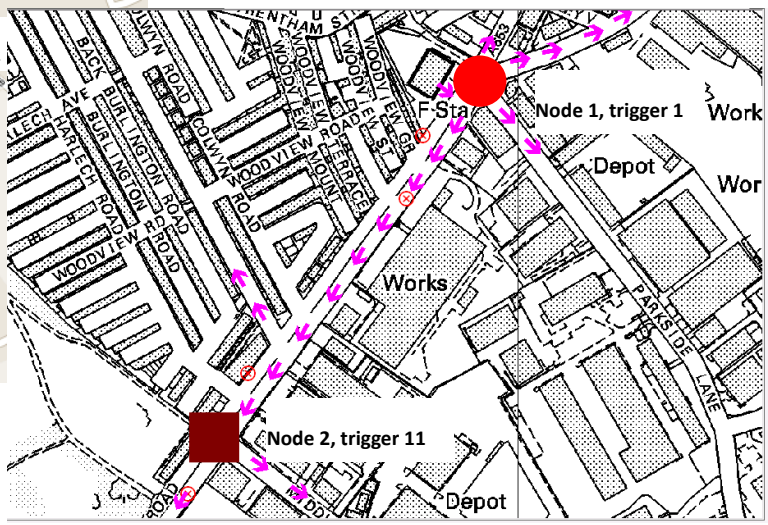
### Hunslet Southern Route

Below we see one of the three routes from the Hunslet Depot. The Fire Depot itself exits into a signalized junction (Node 1) which uses a traditional push button and hurry call stage at the signals. This push button is the first 'trigger' in initiating the priority, but at this point the route is still unknown and so the first junctions on ALL three routes are activated (including Node 2 in the route shown below). Only once the Appliance commits to a particular route can the two unused routes be cancelled and the full strategy on the selected route be committed to.




**Southern Route – 4 junctions and 1 pedestrian crossing**

**Numerous AVL Triggers are used to constantly monitor the Appliance's progress and to determine it's route**




## EXAMPLE OUTLINE LOGIC

As a Fire Appliance passes along the route its progress is tracked by AVL triggers placed around every 50m. Having numerous triggers gives some redundancy, especially at the exit from the Fire Depot where there were concerns over how quickly the Fire Appliance's onboard GPS would be able to start tracking its location. The triggers are often grouped together to initiate the same strategy, for example southbound triggers 1-5 all initiate the same strategy at the downstream junctions. Not until triggers 6-8 are reached does the next strategy get initiated, and so on along the route. Below is some example high level logic for 2 example triggers;

### Trigger 1 – at the Fire Station Exit

- Node 1 – Travel time =0s
  - Hurry Call stage calls all red at Fire Station junction
- Node 2 - Travel time ≈20s
  - If in Priority stage then hold stage
  - If not in priority stage then immediate move to priority stage (allows stage skipping)
- Node 3 – Travel time ≈45s
  - If in priority stage 1 then hold stage.
  - If in stage 2 then immediate move to stage 3
  - If in stage 3 at start of green run min and move to priority stage 1
  - If in stage 3 and already run stage min then do nothing
- Node 4 – Travel time ≈60s
  - Do nothing
- Node 5 – Travel time ≈120s
  - Initiate a plan to clear queuing traffic (more plan aggressive in PM peak)

### Trigger 11 – at the exit of Node 2

- Node 2 - Travel time 0s

    - Smoothly drop back to UTC fixed time plans ensuring pedestrian stage run next.
- Node 3 – Travel time ≈15s
    - If in priority stage 1 then hold stage.
    - If in stage 2 then immediate move priority stage 1
    - If in stage 3 then immediate move priority stage 1
- Node 4 – Travel time ≈30s
    - If in priority stage 1 then hold stage.
    - If in stage 2 then immediate move to priority stage 1
- Node 5 – Travel time ≈90s
    - Run plan to clear queuing traffic.

It can be seen that as the Fire Appliance moves along the route the urgency in how a junction moves to the priority stage is increased. By initiating those junctions with sufficient pre-emption early enough, it is possible to avoid harsh stage changes and stage skipping.

### Other supporting logic

- The clear-down of the priority stage must allow sufficient time for a following Appliance.
- Any trigger fired on a side road will cancel the green wave – this indicates the Appliance leaving the route
- A timeout of 30s from the last trigger received will also cancel the greenwave - this covers the Appliance turning off its blue lights.

## PILOT RESULTS

The overall reliability of the green wave pilot was between 85%-95%, with the higher values being achieved towards the end of the pilot.

Unlike buses and trams it is difficult to fully quantify the benefit to Fire Appliances in terms of pure delay reduction, since they routinely 'jump reds'. However, evidence from WYFRS firefighter testimony indicates that on the approach to an active junction there is significantly reduced or zero standing traffic, which is supported by the following quantified delay benefits:

**Three Routes Activated (Journey Time in seconds)**

| **Route** | **Average** | | | **Worst Case** | | |
|---|---|---|---|---|---|---|
| | Before | After | Saving | Before | After | Saving |
| Southern Route | 90 | 77 | 13 (14%) | 240 | 89 | 151 (63%) |
| Northern Route | 59 | 54 | 5 (8%) | 90 | 66 | 24 (26%) |
| Garnet Rd Route | 35 | 30 | 5 (14%) | 41 | 33 | 8 (19%) |

In addition to the delay benefits ranging from 19-63% in the pilot, there is also an anticipated reduction in accidents costs, which will require to be monitored over a longer time period.

WYFRS consider that the Green Wave system will mean safer and faster journeys for firefighters en route to emergencies. It should also assist other drivers at traffic signals, who are known to be unpredictable when faced with an emergency vehicle using blue lights, by allowing them to continue rather than queue. This view is reinforced by the fact that in 2011 the WYFRS Management Board approved an expansion of the pilot to include two more depots and 4 more Fire Appliances in Leeds, with a view to it being rolled out across West Yorkshire.