Data Driven Decisions for Centralised Bus Priority in Dublin City

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Abstract
Dublin City Council has recently adopted an approach to measure, monitor and quantify the transportation performance for significant transportation changes in the city centre using dashboards and interactive reporting. Real-time data and historical data captured from different sources can be presented in an aesthetically pleasing, clear and meaningful view, using data visualisation tools. This enables policy makers, transportation planners and transport management centres to have a clear view of the dynamics of the city's transportation, which then providing the basis of informed decision making. It provides key insights for planning decisions and enables rapid performance feedback when transportation changes are being implemented. With the development of connected vehicles and digital infrastructure, opportunities have emerged to utilise this data rich environment. It is an approach that Dublin City Council has taken in the implementation of a *Centralised Bus Priority*[1] system by utilising bus position data from the Dublin Bus AVL[1] System.

Introduction
In Dublin City, day to day traffic management is provided via SCATS (Sydney Coordinated Adaptive Traffic System), which has an API/ITS Port allowing external ITS applications to interface with traffic signal operation. Using this API and the real-time SIRI-VM[2] data feed from Dublin Bus, Dublin City Council, working with Nicander[3], has developed an interface module for the purpose of implementing the Centralised Public Transport Priority system. Dublin Bus AVL system provides a SIRI-VM data feed which contains the position of each in-service bus in the fleet at a polling period of approximately 20 seconds. Also contained in this data feed is information on whether the bus is in congestion or not, and if the bus is loading passengers at a bus stop. This system offers the possibility of a centralised network response to bus problem locations, not just an individual junction response, but to corridors and city-wide routes via multiple junction adjustments, providing a platform for C-ITS vehicle to infrastructure connectivity. Figure 1 presents the component architecture of the

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1 AVL Automatic Vehicle Location

2 Service Interface for Real Time Information – Vehicle Monitoring

3 Nicander Intelligent Solutions, NICANDER INTELLIGENT SOLUTIONS www.nicander.co.uk,

Centralised Bus Priority System.

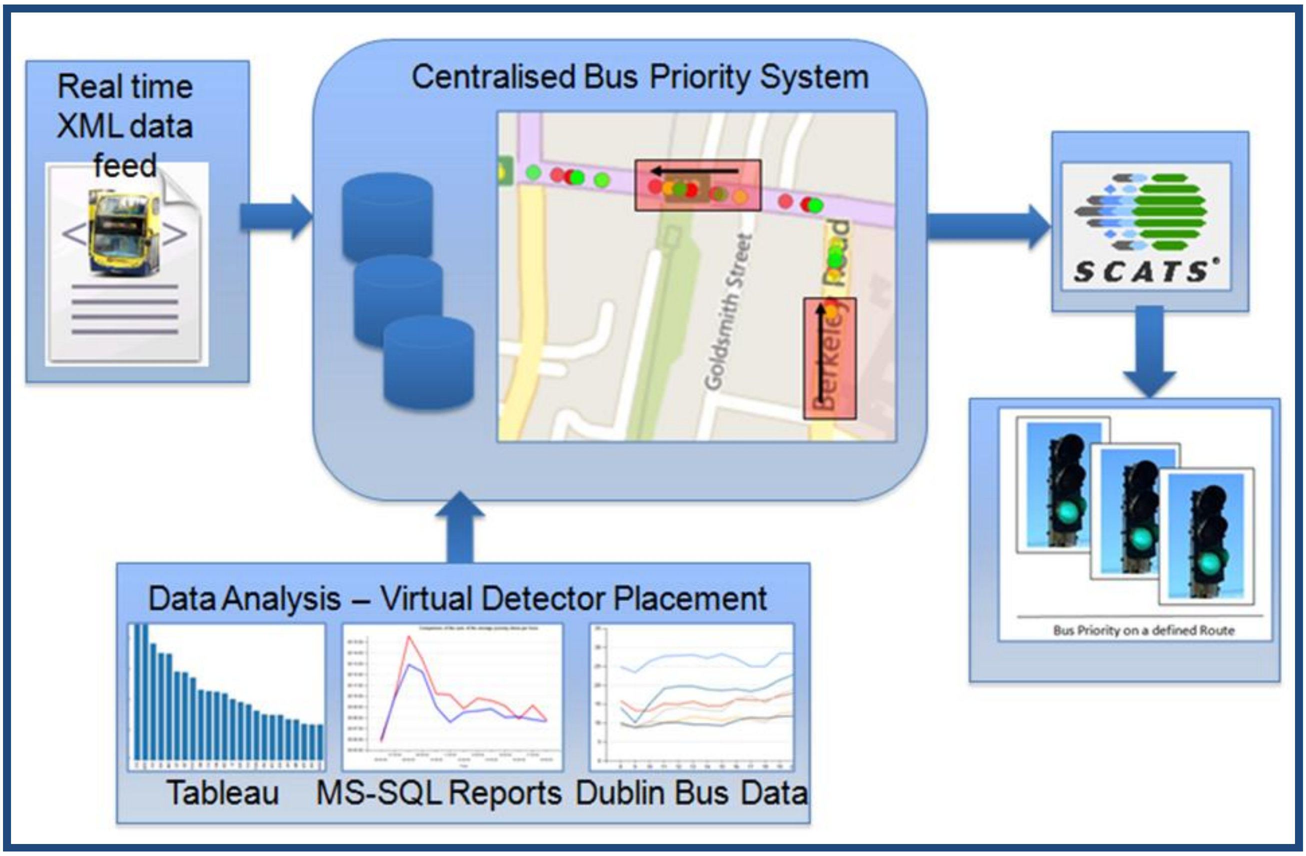


Figure 1 - Component Architecture of the Centralised Bus Priority System

The main driving force is the real-time SIRI-VM bus position data, continually being monitored for known congestion areas within the city. These areas are configured via virtual detectors that are drawn on the Centralised System's map based tool. Should the coordinates of a bus position be within the virtual detector's shape, then an automatic priority call is made into SCATS via the SCATS API/ITS Port, thus giving more green time via a number of different priority measures. The data is also archived for reporting, analysis and bus performance monitoring which feeds back into the bus performance measures. It can also be used to indicate the most effective location for the placement of the virtual detectors. The SIRI-VM data provides a connection to the bus every 30 seconds, in a "Vehicle to Infrastructure" platform, so we can plot the vehicle, highlight if it stopped at bus stop on route, its ID, its route, the next approaching bus stop, its schedule deviation and if it is in congestion.

Data Visualisation

Using this data and visualisation tools, a single vehicle can be plotted as presented in Figure 2, where the larger dots represent when the vehicle is at a bus stop on route.

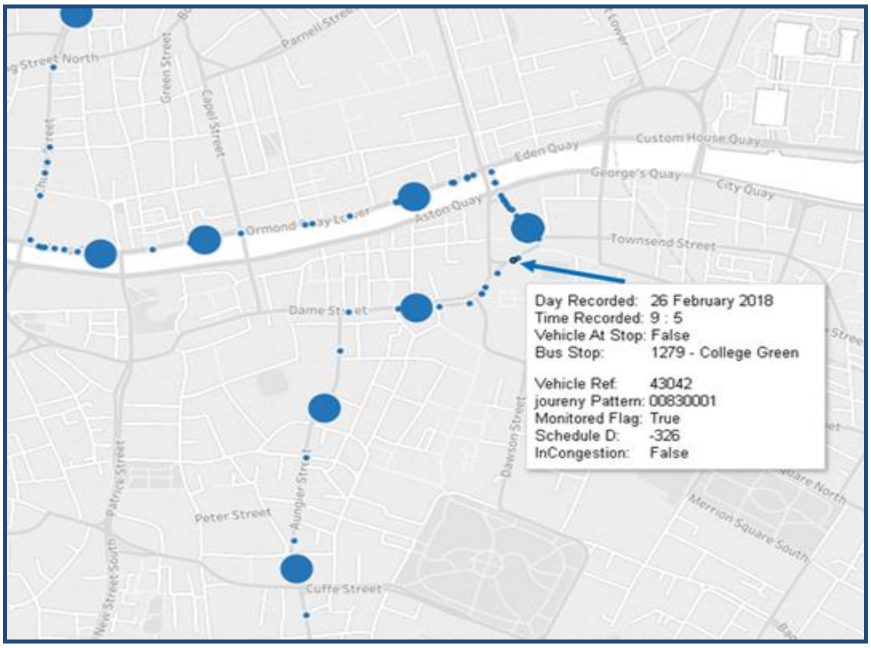


Figure 2 – The SIRI VM data attributes.

In using the data attributes for each SIRI VM data element, one approach to aggregate this data would be in using its reference to the next bus stop it is approaching. With the data, we can calculate and quantify an approximate stop to stop journey time due to the 20 second interval of the bus position data. Then mapping this gives indications of congested areas for buses approaching a stop. This is represented in Figure 3 on the bus stops basis via size and colour.

Figure 3 – Stop to Stop Journey time representation for all services servicing that bus stop.

The variance in bus journey times can also be viewed as presented in Figure 4, presenting on a per hour basis the variations in journey time to stop during the morning peak. It shows the areas of possible congestion using the bus position data.

Figure 4 – Variations of bus performance for hour to hour.

Using data visualisation tools, the bus position can be mapped, thus highlighting congestion for a specific time. As in the 'Before' sections in Figure 5, the closer the bus position data points, the lower the bus's progression. This area can be highlighted by the Centralised Bus Priority System and configured with virtual detectors. These detectors can be drawn via the map base tool, covering the area of known congestion, and assigned threshold values that, when breached, then the Centralised system would automatically call a predefined SCATS API/ITS Port call. When the SIRI-VM bus data coordinates of the real time bus data feed are within these configured shapes, the system dynamically interfaces with the traffic signals for bus priority in a specific preconfigured direction.

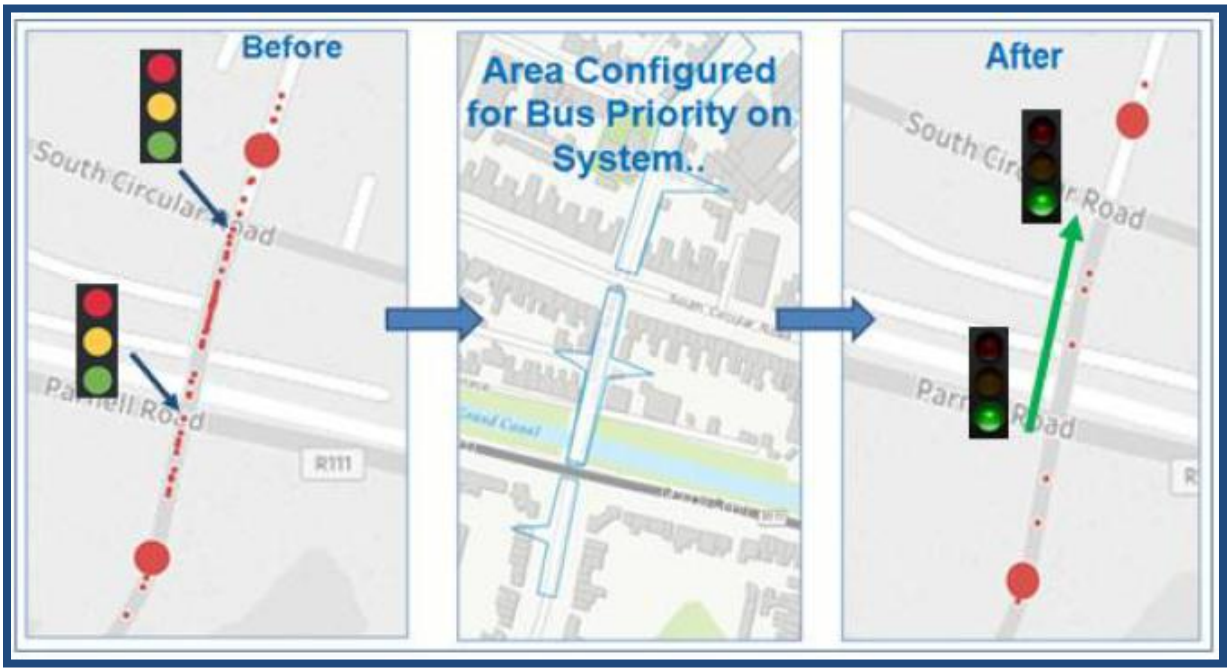


Figure 5 – Data driven placement of virtual detectors for bus priority.

This combination of business intelligence tools and data visualisations provides the opportunity to review the performance of a corridor and bring in effective automated adjustments to traffic signals at strategic locations in order to provide a consistent level of service. Using data visualisation tools and the AVL data from Dublin Bus delays, can be mapped, quantified and addressed.

Different flavours of Priority

The SCATS API/ITS Port offers a number of calls that can be programmability invoked by a third party application. For the Centralised Bus Priority System, the following approaches are used to dynamically change traffic signal operation for bus priority;

- **Immediate Green Signal.**

  Also known as a Hurry or Crash Call for a green signal, though in SCATS term it is referred to as a Dwell. This is a very powerful and effective method, though it has its drawbacks. The traffic signal site will drop out of coordination with other linked sites, it could skip phases (or stages) to bring in the dwell, and SCATS will take time to recover from this call. Ideal for use by infrequent vehicles at specific location, such as right turning movements across lanes, entry onto main roads or at locations where loss of coordination to adjacent junctions is not an issue.

- **Bias Traffic Signal Timing Plans**.

  Using the SCATS API, preconfigured traffic signal timing plans can be dynamically put into operation as required. In SCATS terms, referred to as Split plans, a high percentage of the cycle time would be given to the bus route or stage or signal, thus providing the vehicle quick access though the junction.

- **SCATS Flags to modify junction behaviour**.

  SCATS has a number of flag values which can greatly change the behaviour of a traffic signal junction depending on their state, either off or on. These flags have a number of useful functions. The flags utilised most often are NG (No Gap), PD (Permanent Demand), and FG (False Green). An NG may be chosen because a phase gaps out before the bus reaches an intersection. Hence, when the bus enters the detector and triggers this bus priority call that applies an NG, the phase will no longer gap out.

For a junction running under SCATS, an NG may also be applied if an intersection frequently changes to master isolated. That means that pivot phase of an intersection is free to gap (in Masterlink operation it does not). A PD may be chosen because there may be little to no traffic on approach to an intersection. Dublin has detector loops installed in its roads which allow SCATS to determine whether or not a phase should be skipped, as there may be no call for it. By having a PD flag on when a bus enters the virtual detector, SCATS will not skip past the phase even though the detector loop has not triggered. This can be useful on quieter roads when a bus is on approach to an intersection, to ensure that the phase that the bus needs is not skipped. An FG may be chosen to allocate more time to the desired phase. An FG applies time to a phase, which previous phases did not require, as they gapped-out early or where not called at all.

In Figure 5 – the example presented two virtual detectors for each direction. The first virtual detector was configured to call an immediate green signal (Dwell) at the most adjacent junction and the second one configured to call a timing plan for the next junction downstream. In Figure 6 – the example presented shows a bus approaching a junction and its coordinates have been detected within a virtual detector configured with thresholds to call for priority on occupancy of 1 or more.

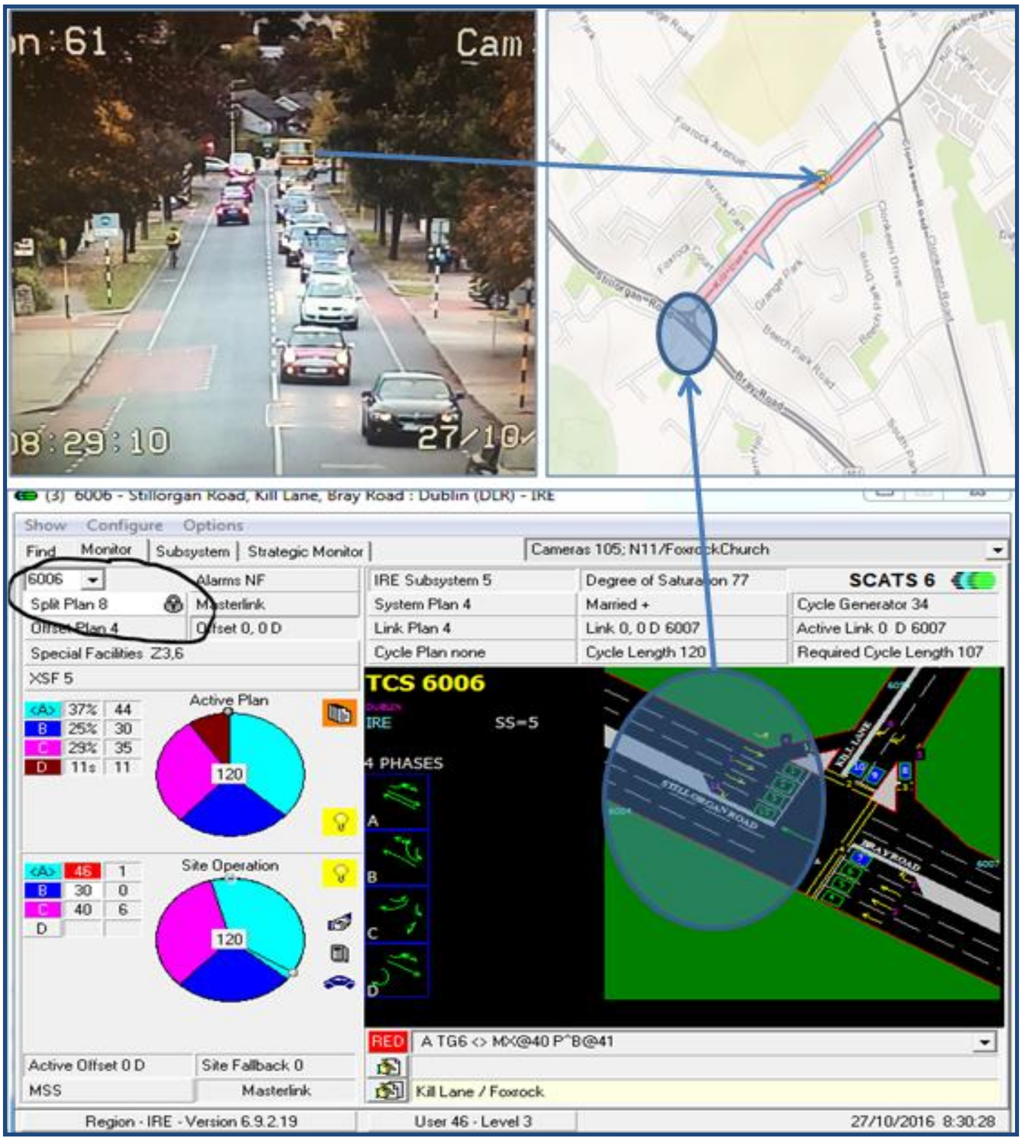


Figure 6 Example of Priority Call via virtual detector.

As in the example above, timing plan 8 is locked in via the priority call made by the

Centralised system. As presented in Figure 7, plan 8 provides more green time for the lane from which the bus is approaching, plus it uses SCATS flags FG, NG, and TG to utilise more green time with a no-gap facility. This keeps the junction in coordination with its adjacent junctions as it services as a main arterial route for all traffic.

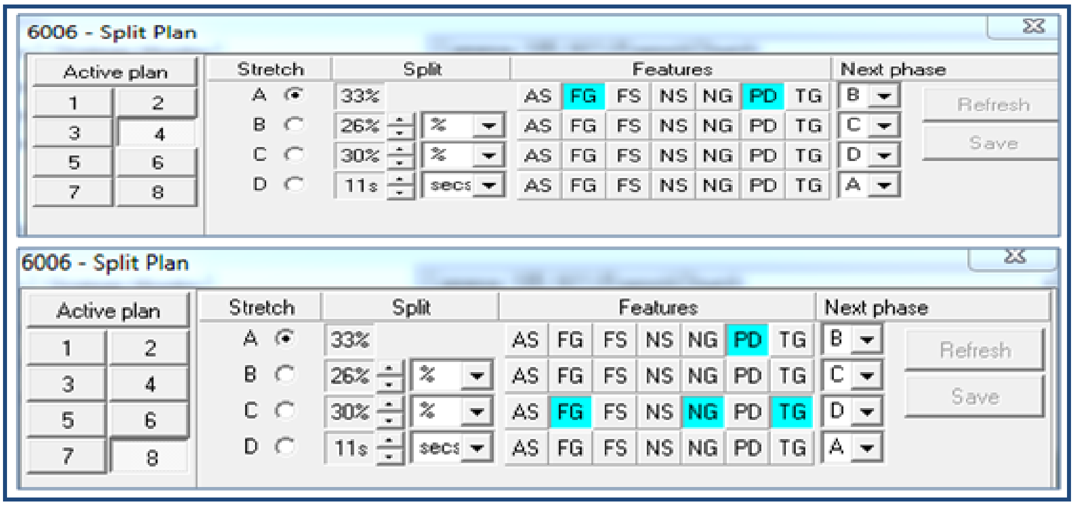
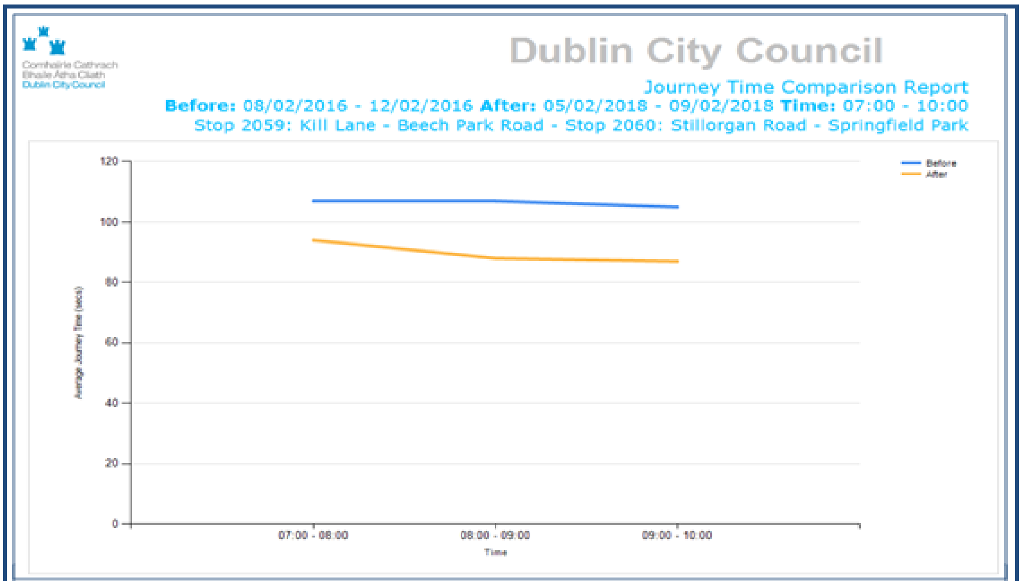


Figure 7, Normal operations is plan 4. Bus Priority is plan 8.

Results can be quantified from the archived data. For this location, it shows an overall 15% improvement for buses, with no adverse effects for traffic on the main arterial route.



	Before		After		Comparison
Time Interval	Total No of Buses	Avg Journey Time	Total No of Buses	Avg Journey Time	% Difference
07:00 - 08:00	38	107	35	94	-12.15
08:00 - 09:00	43	107	42	88	-17.76
09:00 - 10:00	33	105	42	87	-17.14

Figure 8 – Results from the Bus Priority Intervention.

The archived bus position data is not only used to quantify the improvements resulting from the bus priority measures, but is also used to support significant transportation changes in prime locations within the city.

Data Driven Decisions for Significant Transport Changes

In the summer of 2017, Dublin City Council undertook a significant transformation change in its traffic road usage within the core of the city centre. The River Liffey, which runs through the heart of the city, is bounded by the North and South Quays, both of which are key routes for public and private transportation. For public transportation, there are a number of bus stops on this route which service a high number of buses. Using the SIRI-VM bus position data, Figure 9 maps out these bus stops and presents the typical high number of buses daily servicing these stops. All traffic on the Quays travels in one direction; for the North Quays the direction in eastwards into the city centre, for the South Quays it is westwards away from the city centre. Each consists of more than one lane. Comparing the number of buses servicing the bus stops during the two peak times, in the AM peak, the North Quays have a high number of buses to accommodate the movement of people going into the city centre for work. And in the PM peak, the South Quays have a significant increase of bus services per bus stop to accommodate the movement of people out of the city centre to the suburbs.

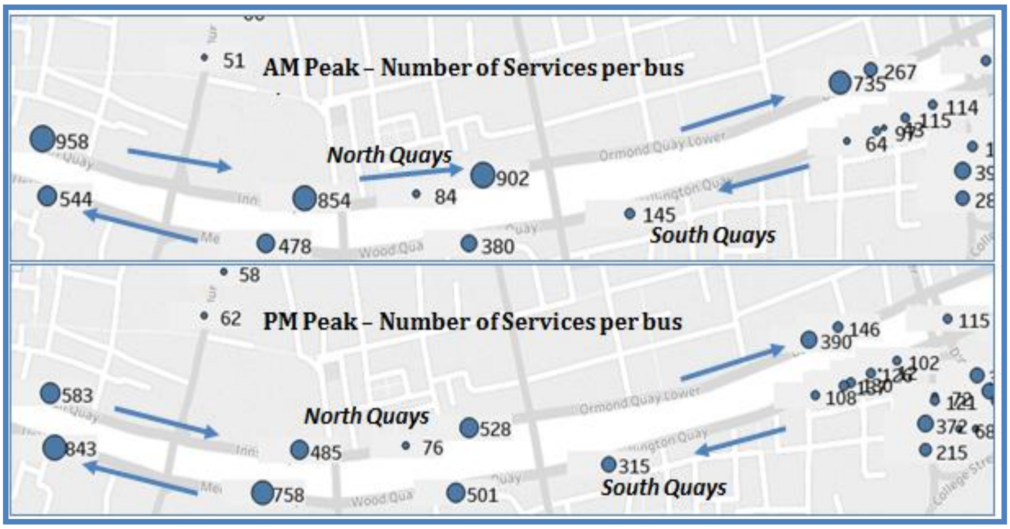


Figure 9 Dashboard Map of Bus Stops shows the daily number of buses servicing each stop (22/01/2017)

Apart from the high activity levels at the bus stops, the Quays also carry high volumes of general traffic. Figure 10 maps the high throughput of traffic volumes at each traffic signal junction showing the total traffic throughput for all approaches over a period of five days (3/4/2017 to 7/4/2017), thus presenting a very congested area of the city centre.

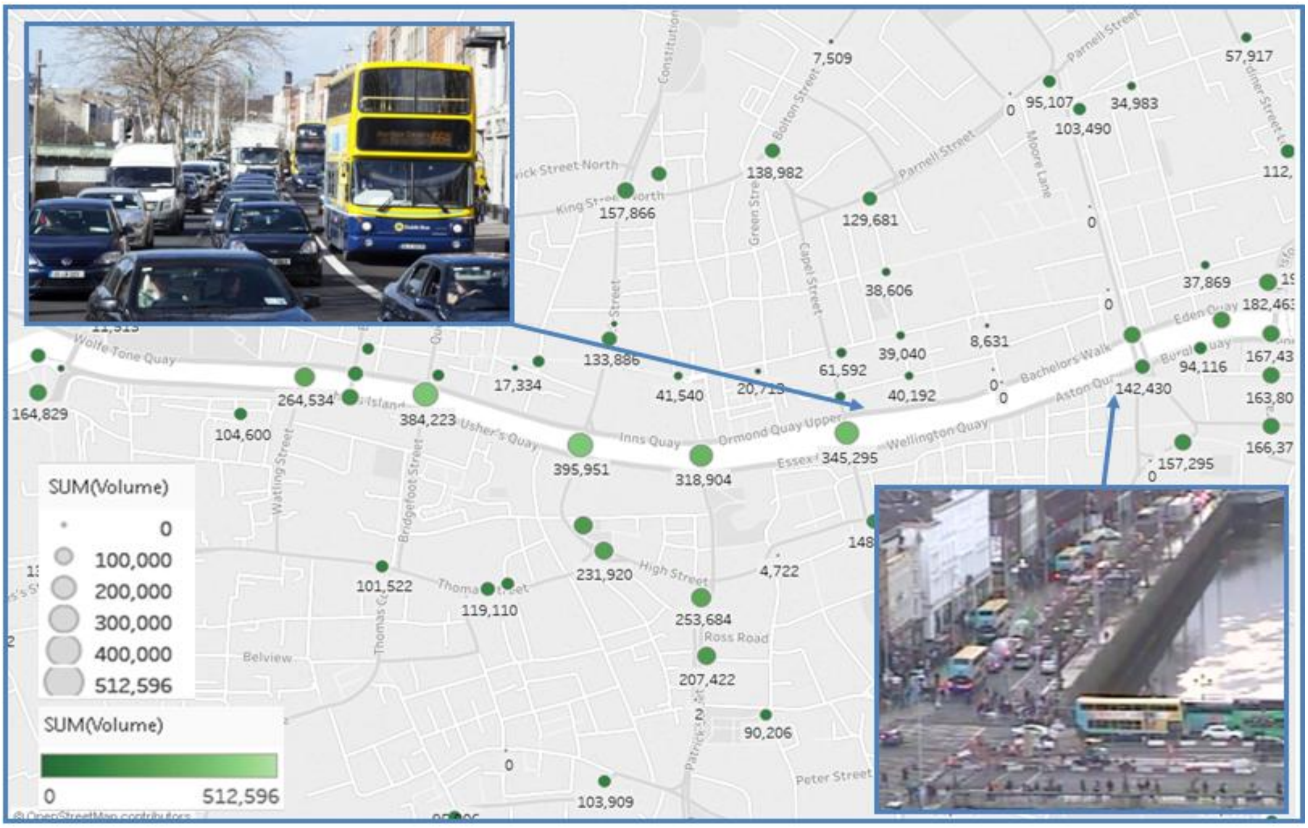


Figure10 Dashboard Map of Traffic Signals and their total traffic volume throughput for all approaches. [4]

Quantifying the Delays

As mentioned earlier, using data visualisation tools and the SIRI-VM data from Dublin Bus, we can map and quantify these delays. Another data set from Dublin Bus is the "Unscheduled Stop" details, which measures stationary time for buses on route. This information can be mapped on a per bus stop location as delays before and after a bus stop, as presented via a dashboard in Figure 11. This clearly presents the North Quays as the most congested, and that route experiences the most delays. Figure 11, shows that for a typical week, there were 517.8 minutes of accumulated delays for all buses servicing that stop.

[4] North Quay Photo reference – Extra.ie Social Media on announcing 'Cars being reduced to using one lane on the Quays. *https://extra.ie/news/irish-news/dublin-gears-up-for-new-luas-cross-city.*

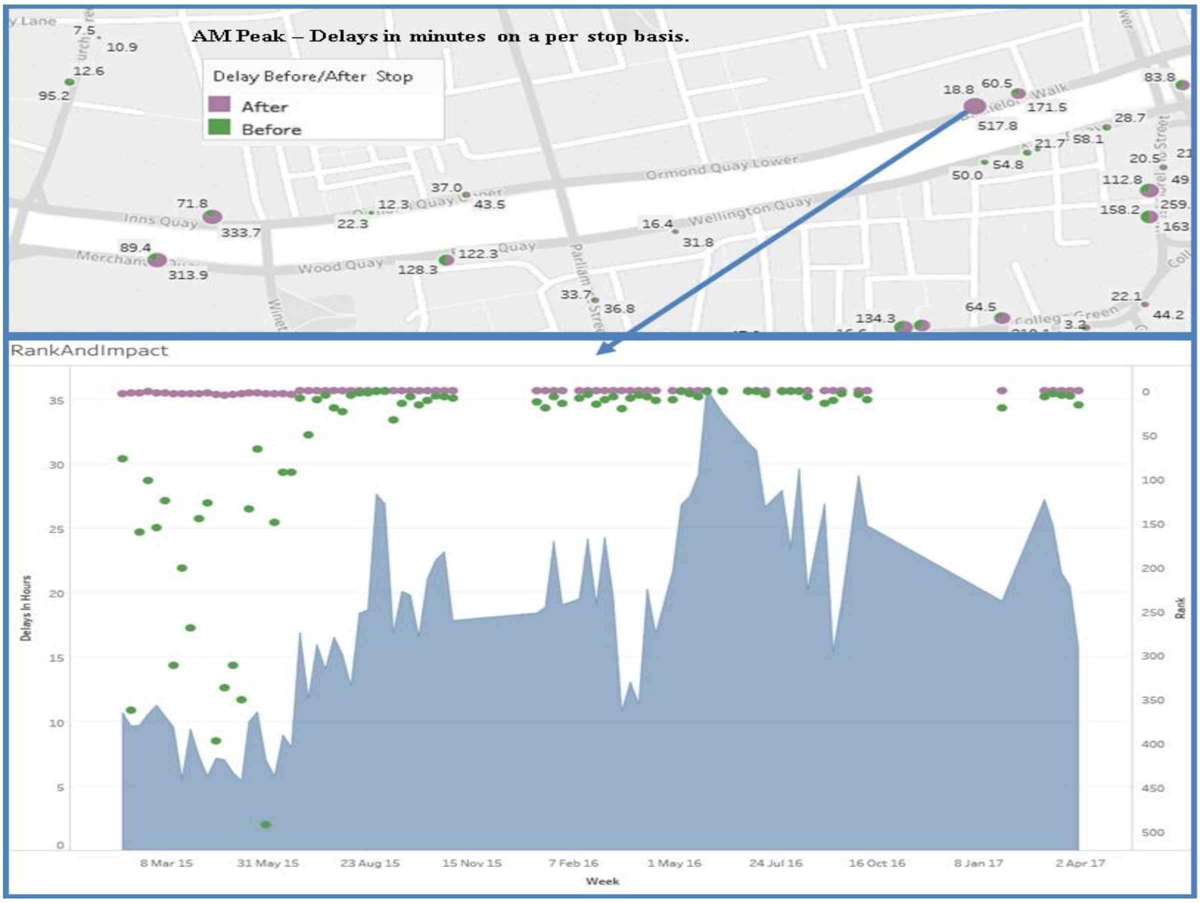


Figure 11 Dual Axis Graph presents the Impact (delays in Hours) and ranking of bus stop with most delays

The dual axis graph shows the trend of impact of delays in hours at a consistent pinch point and that the area in approaching and leaving that stop constantly ranked highly in congestion. The main cause for this congestion is the number of buses and volume of traffic that use the North Quays and similarly high quantities of services on the South Quays. We can view this in real-time using the Centralised Bus Priority system, as presented figure 12. This shows a high number of buses that traverse along the Quays for the north-west to south-east direction. From the information and the presentation/visualisation of this data, it was clear that the road layout was not sustainable, especially with the new development of the LUAS tram extension across the city. Both the LUAS tram extension and buses will be competing for priority right in the heart of the city.

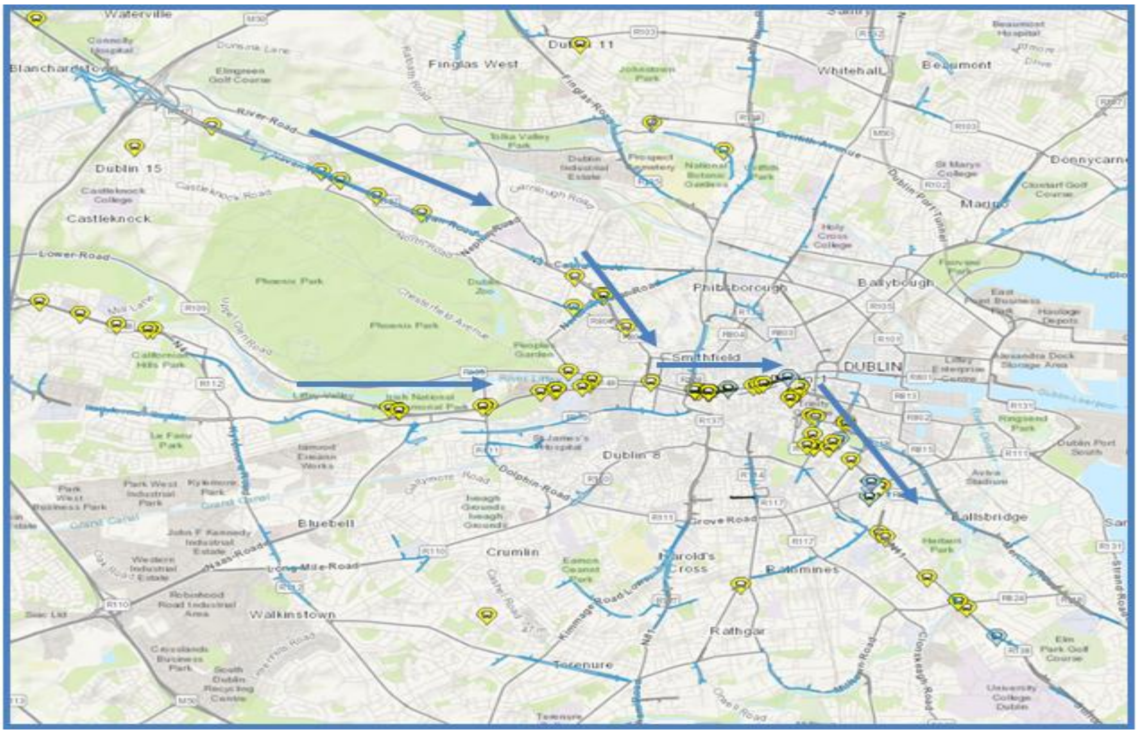


Figure 12 Centralised Bus Priority System displaying in real-time, the location of all buses servicing one Stop, for a single point in time on the North Quays. (Each icon represents a bus location)

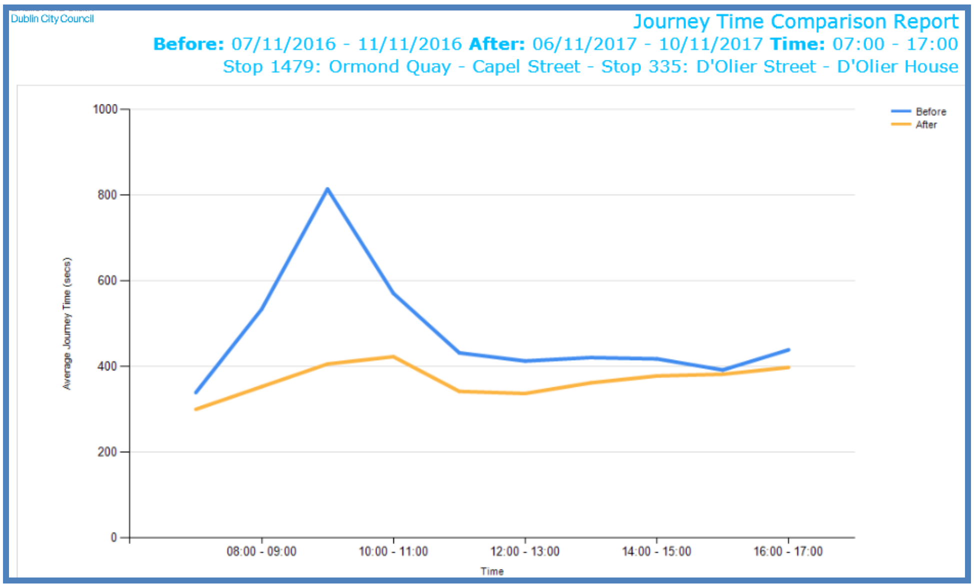
City Centre Traffic Management Changes

With the confidence of the consistent and quantifiable delay patterns, Dublin City Council brought in plans to provide extra facilities on the Quays for public transportation [2]. This consisted, as in Figure 13, of converting an existing traffic lane to a double bus lane, thus allowing easy bypassing of buses that are already servicing stops. General traffic was reduced to one lane along with other restrictions, but access to car parks within the city was maintained. These changes were brought in during August 2017, which allowed for an adjustment time before the usual increase of 'end of holidays' traffic. Using the same reporting and data visualisations to identify, quantify and highlight the delays, the effect of such significant changes was monitored and managed.

Figure 13 Bus Priority changes within the City Centre, traffic reduced to one lane.

Effects of the Traffic Management Changes

As more road capacity was given over to bus lanes, the buses benefited from reduced journey times as presented in Figure 14, in comparing a week in November 2016 against November 2017.



	Before		After		Comparison
Time Interval	Total No of Buses	Avg Journey Time	Total No of Buses	Avg Journey Time	% Difference
07:00 - 08:00	32	339	37	300	-11.50
08:00 - 09:00	52	534	57	353	-33.90
09:00 - 10:00	58	815	68	406	-50.18
10:00 - 11:00	52	571	34	423	-25.92
11:00 - 12:00	37	432	30	342	-20.83
12:00 - 13:00	37	413	35	337	-18.40
13:00 - 14:00	40	421	30	362	-14.01
14:00 - 15:00	31	418	36	378	-9.57
15:00 - 16:00	30	392	27	382	-2.55
16:00 - 17:00	37	439	28	398	-9.34

Figure 14 Before and After bus journey times on the North Quays.

From the Unscheduled Stops data, the delays were significantly reduced as presented in Figure 15 (extension in time of figure 11 of same bus stop).

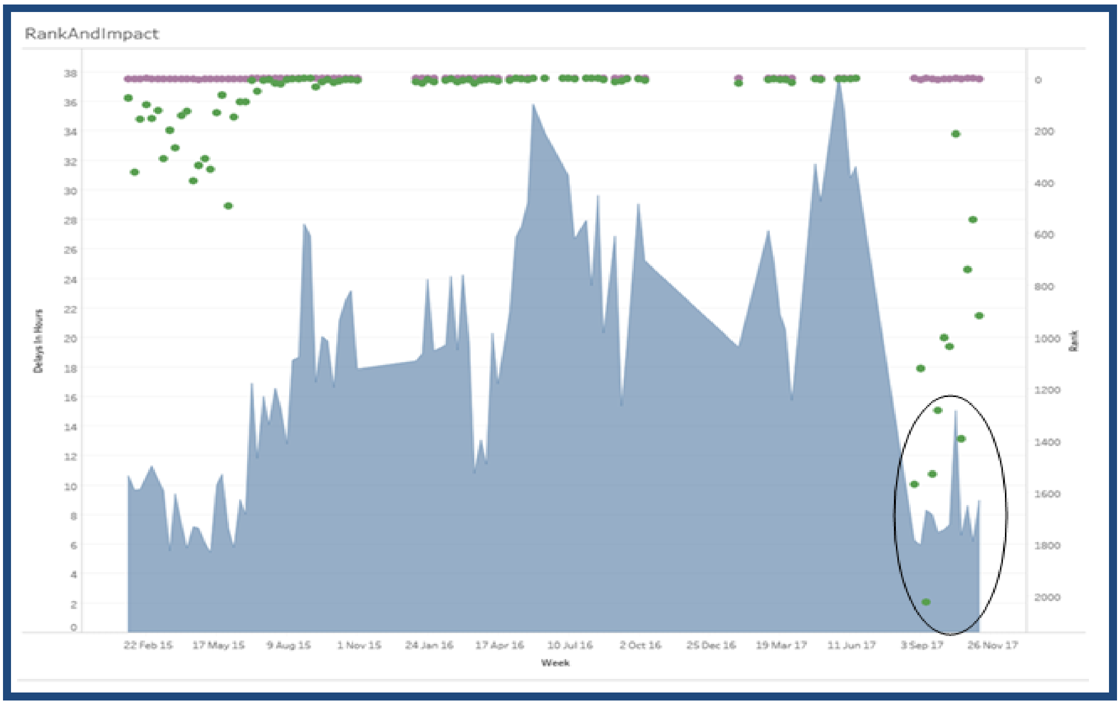


Figure 15 After August 2017, Dual Axis Graph presents the reduction in Impact (delays in Hours) (right axis) and ranking of bus stop.

Displacement of Traffic

By comparing the difference in the traffic volumes for the time periods before the change 3/4/2017 to 7/4/2017, to after the change 2/10/2017 to 6/10/2017, the variance of displacement within Dublin City can be mapped as presented in Figure 16.

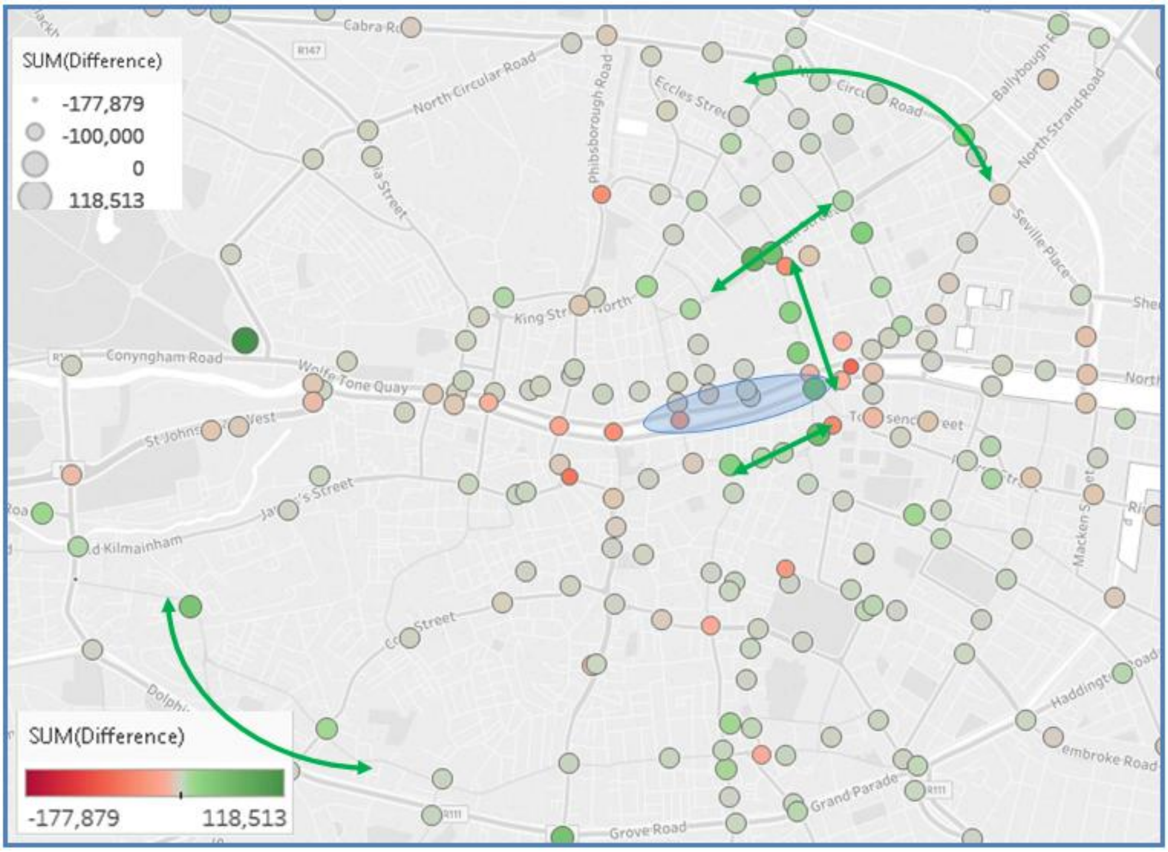


Figure 16 City view of the variance in traffic volumes per site – all approaches.

The area highlighted in blue in Figure 14 shows the location where the bus priority measures have been implemented. The sites on either side show a reduction in volumes on approaching this area, and a slight increase in adjacent sites due to the redirection of traffic. With less general traffic approaching the city centre, the mapping shows an increase in the main public transportation route, as indicated by the green straight arrows. The sites on the main orbital route, as indicated by the green curved arrows, are also presenting an increase in traffic volumes. Converting a traffic lane in a centre city area to a bus lane had the intended effect of displacing the traffic to the outer orbital. This displacement is highlighted in Figure 14, showing an increase in traffic volumes on sites in the outer orbital area (shown by the green icons via size and colour) with a reduction in traffic volumes centred on the Quays (shown by the red icons).

Conclusions

The data visualisations provided a feasible and immediate means of measuring and managing the impact of significant changes for sustaining public transport within Dublin City, on a daily, weekly and monthly basis. Such immediate information gives a level of transparency to transport performance and provides the benefit of making early adaptive changes to best manage traffic. With the information automatically accumulated, and with dashboards integrated with the data, this provides readily accessible interactive reports to the stakeholders involved, such as Dublin Bus and the NTA[5], to communicate the success of such changes. Prior to the transportation changes being implemented, the news and social media presented a predicted negative view when such changes were announced earlier in 2017. After the implementation of the changes, the data shows a lower percentage reduction of traffic than anticipated on the Quays. This reduction has been offset by the gain to public transportation in reduced journey times and a reduction in delays on the North Quays, which has previously been one of the most congested road sections. These changes have encouraged general traffic to use the outer orbital routes which are designed and configured to give traffic quick access to other parts of the city instead of traversing the city centre.

The use of data visualisation tools and readily accessible data provides a digital distributed platform for interactive reports, presenting a layer of transparency of transport performance. The dashboards presented in this paper were developed following the “best practiced” guides [3] and provides a means of managing and quantifying transportation in Dublin City Centre. No longer necessary are specialised IT personnel with skills in interactive and distributed reporting, as these data visualisation tools provide an ‘ease of use’ platform, allowing the traffic personnel, familiar with transportation metrics and data, to build and deploy their own Traffic Dashboards. Thus, traffic personnel can develop customisable KPIs relating to the ‘State of Play’ dashboards on transportation from their diverse data sets, providing information in an accessible and interactive manner.

References

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[5] NTA – National Transport Authority, Ireland.