

IMPROVING WOLVERHAMPTON'S AIR QUALITY USING INTEGRATED DATA

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1 What did we set out to do?

Wolverhampton wanted to take action and be a leader in regard to the public health issue that is air pollution. Working together with SWARCO and NOW Wireless, the City of Wolverhampton wanted to use data to enable them to make informed decisions around their traffic strategies and to see if they could resolve issues that the city faces.

According to the 2019 Air Quality Annual Status Report (ASR) carried out by City of Wolverhampton Council. 'The main air quality issues in Wolverhampton relate to emissions of nitrogen dioxide (NO₂) from road traffic. The areas most affected are close to busy roads, junctions and parts of the city centre, particularly where the traffic is congested, the roads are narrow, or there is a high proportion of heavy goods vehicles (HGV's). Trend data over the last 15 years shows that levels of NO₂ are going down. This has led to a significant drop in the number of locations where the annual mean air quality objective for NO₂ of 40µg/m³ is being exceeded, however, there are still hot spot areas remaining. In 2018 the monitoring data identified 3 exceedances of the objective at locations where members of the public are likely to be exposed. These are on Broad Street in the City centre, on the A454 at Horsley Fields and on Lichfield street Bilston. The Department for Environment, Food and Rural Affairs (Defra) National PCM Model has also identified 4 other road links in Wolverhampton with projected exceedances of the NO₂ objective up to 2021. Defra has required the council to carry out a feasibility study to deliver nitrogen dioxide concentration compliance in the shortest possible time on these road links.'¹

2 What was the problem?

General

Pollution, be it noise, light, or air, is a recognised challenge to health and wellbeing in the urban and rural landscape. The problems have been most acutely experienced in urban areas where the migration of large numbers of the population to cities created crowded living conditions. As more data has become available, it appears the problem also affects anyone living and working near significant transport infrastructure. Some of the highest levels of pollutants are now being recorded in areas considered to be unaffected in the past. Ambient air pollution, and precisely a combination of small and fine particulate matter with traffic as the leading cause, is stated as the greatest risk to health – causing more than three million premature deaths yearly worldwide².

Why is urban pollution a cause for concern?

- 4.2 Million deaths linked to outdoor air pollution globally.³
- The cost of air pollution to the economy in England could reach £5.3 billion by 2035, unless action is taken⁴.
- 49% of cities in high-income countries do not meet WHO air quality guidelines²

Vice versa, improvements in air quality have been directly linked to declines in the risk of stroke, heart disease, lung cancer, and chronic and acute respiratory diseases, including asthma.

The City of Wolverhampton Council, along with many others, are becoming more aware of the health issues for the public arising from over-exposure to high levels of pollutants including NO₂. The initial analysis done by the Council highlighted three or four areas of concern, where higher than normal levels of NO₂ could be identified. There was clearly a need for a more defined picture of what was happening on street with regards to NO₂ levels. Unfortunately, the traditional Chemiluminescent sensors can cost tens of thousands of pounds and a more cost-effective solution was needed. This solution needed to be accurate, and still provide data in real time (as opposed to diffusion tubes).

¹ City of Wolverhampton Council (February 2020), 2019 Air Quality Annual Status Report (ASR), Page 1

² World Health Organisation, (2018), WHO Global Ambient Air Quality Database (update 2018)

³ World Health Organisation (2018), Ambient (outdoor) air pollution, Key Facts, paragraph 1

⁴ Public Health England (2018), New tool calculates NHS and social care costs of air pollution, paragraph 1

3 Solution

The West Midlands (combined authority) already had the NOW Wireless secure carrier grade wireless network in use for their on-street applications and had been for over ten years, amounting to around 2,000 devices. This system provides a communication network that devices, such as Pollution Monitors, and Bluetooth Detectors, can utilise.

Having already carried out many successful trials of Bluetooth detectors and Pollution monitors across the UK with partners such as TfL and West Yorkshire, over a thousand have been installed and are a proven reliable solution.

The NOW Wireless in-house GUI, Senseview, allows clients to view data from the sensors in real time. The data can be exported, and API's allow the data to feed into numerous databases, and management software, including SWARCO's MyCity.

From the outset, SWARCO worked with Wolverhampton as a 'lighthouse customer'. Leading us along the journey to fulfil their technology needs and helping to shape the final solution they needed. Working directly with the key users within Wolverhampton we identified how the data sources were being used internally and what they wanted to gain from them. Using this as a guideline we made a wireframe of the potential solution so that the users could check the viability and highlight any deviations from the way they wanted to interact with it. This incremental process kept the key users engaged in the whole design and ensured the delivered product worked exactly as expected.

Running in parallel to this project, SWARCO had just opened the Solution Center, located in Berlin. The Solution Center is a hub for SWARCO software and platform development where we were working on a modular and flexible traffic management system. One that offers a new kind of flexibility compared to existing traffic management systems on the market, that are often under-utilised. This modern and scalable traffic management system became MyCity.

One of the core elements of MyCity is pollution reduction through enhancing traffic flows to reduce congestion and integrating with pollution monitors to create effective traffic strategies. The solution could provide the team at Wolverhampton with the ability not only to identify where air quality is below or within their planned thresholds, but also allow creation of dynamic strategies that can use the data collected and apply targeted actions before the level becomes a critical problem.

Source Data

Having the right source data available is always key to making the best decisions. The MyCity platform had already been built to use a wide range of data sources and integrated easily with the NOW Wireless sensors and detectors.

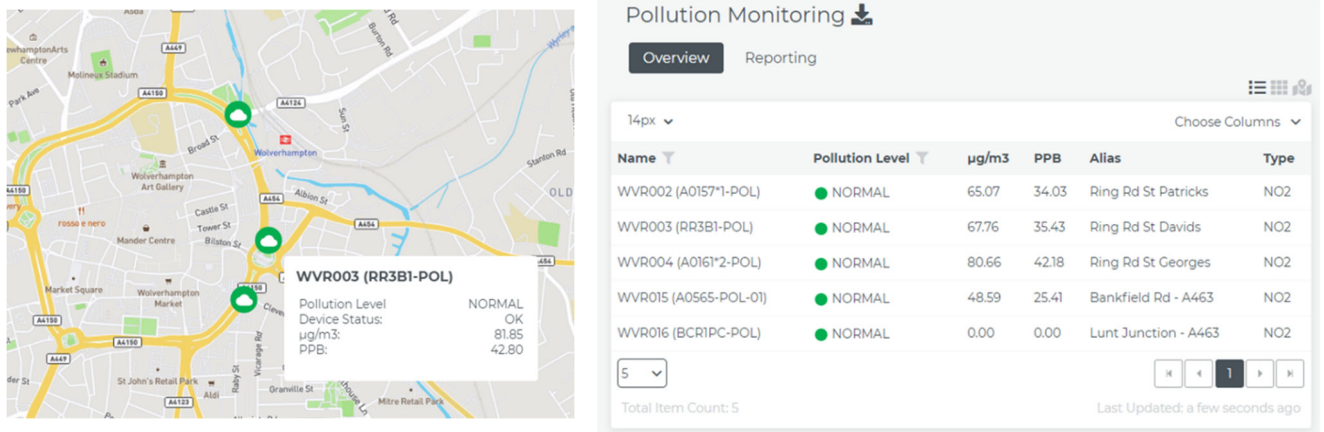
The NOW Wireless NO₂ detector is a cost-effective gas sensor for pollution detection. It is a highly sensitive detector, designed for mounting onto Traffic Lights and Lamp Columns. With alert functions and real time data for traffic management it provides a complete pollution solution.

The NO₂ detector samples the gas sensors every 60 seconds recording the data to a database. An average of the data is compared to pre-set values set on its web interface. If it detects a peak above a pre-set value (Web Interface setting), then it can send an email, trigger text messages or write to a URL with a data update. A web server allows the data to be extracted by a central computer in an asynchronous operation, this process can be Cloud or WAN based. This information is then fed into a database for analysis of Gas levels. Consequently, a real-time XML data feed is prepared, allowing information about pollution to be used in traffic modification of timing of signals or VMS sign warnings. The data from the sensor is also available directly from the NO₂ detector to the in-station or OTU via a simple web page.

Using CCTV and Video analytics, we can count and classify vehicles including any number of transport methods from bicycles to buses, and pedestrian counting.

Monitoring Air Quality

Once data has been collected and processed, the task of understanding how the city is being affected and where the hotspots are, was designed to be intuitive. The team working on the project at Wolverhampton could set their own threshold levels, and the data, status, and impact of changing conditions can be viewed in real-time.



Figures 1 & 2: MyCity screenshot showing a 'heatmap' of air quality at sensor locations - Green icons indicate air quality at acceptable levels

The large variety of data sets is visualised in real-time via different layers on top of the City's map utilising heat maps and performance-dependent colouring of the road network. Users who want to take a more detailed look into it can also access a suite of pre-configured reports on the status of the data sources as well as the raw data. From these reports it is also possible to easily export the data for further separate analysis.

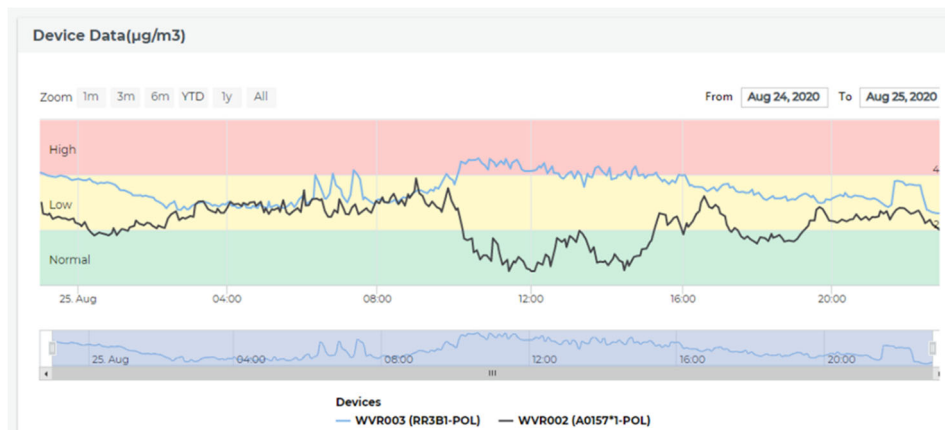


Figure 3: Report showing level of air pollutants at two locations over a 24-hour period

4 Challenges

During initial discussions with Wolverhampton we noted several key issues that they faced in their daily routines:

- Time/resources required for collecting data from numerous sources
- Human error introduced in collating the data into a coherent format
- Time/resources required for presenting the data for internal and external use

MyCity provided a way to automate the data collection across numerous feeds, processed all the inputs into a coherent format and then output reports that were suitable for internal and external users.

5 What was the result?

MyCity was updated to cater for all the data feeds from Now Wireless. Given the modular nature of the platform this means that any clients already working with these devices are now automatically catered for. The automated data collection significantly reduces the data collection time, eliminates the need for manual manipulation of the data and ensures the reliability of the stored results. Internal and external report generation is also automated thus eliminating the need to manually process data and simplifies the whole process to a button click.

Analysis

The data collected during the lockdown period from both an overview, and from individual sites shows a clear drop in Pollution Levels.

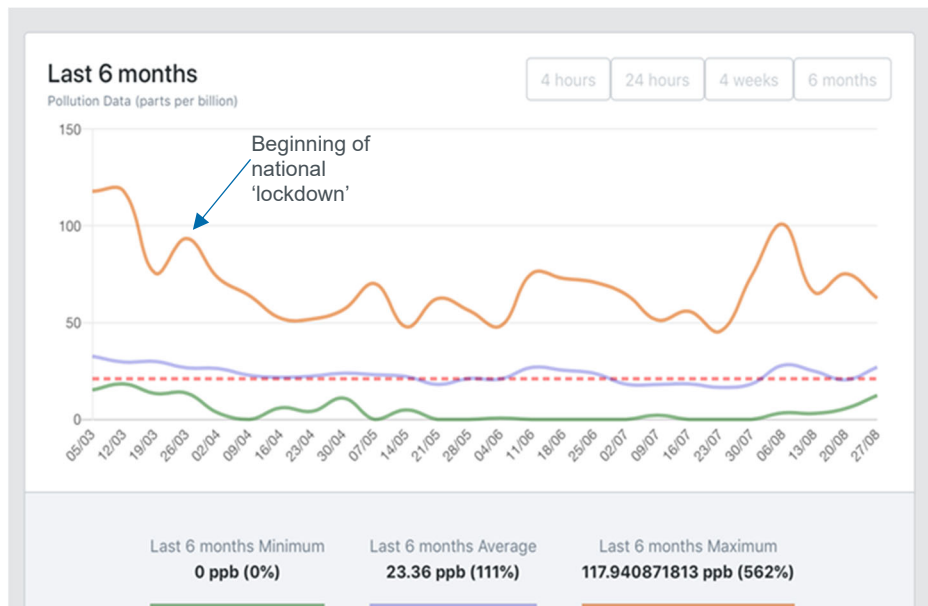


Figure 4: Report from Senseview displaying a significant drop in pollution at one location after the 'national lockdown' began.



Figure 5: Report from Senseview displaying the data for all locations over the last six months, again a drop can be seen at the point of 'lockdown'

As the lockdown eased, the pollution levels can be seen to increase. This trend was also replicated in the number of journeys taking place. Reducing over lockdown, only to start picking up again as it eases.

Next Steps

The City of Wolverhampton Council have installed around 70 Bluetooth detectors across both Wolverhampton and Walsall, with the aim to look at all routes on their network. More pollution monitors will also be added to the areas of concern initially, and then on a larger scale along significant routes in the area.

Through collaboration and integrating our data, we can improve the quality of the air in the critical areas around Wolverhampton and improve route performance across the whole city.

At every stage, any actions taken must be consistently monitored by the sensors to make sure we are moving in the right direction, and not making matters worse. The initial actions would be to change traffic plans (timings etc) and look at gating traffic outside the areas of concern. We would also inform drivers in several ways. By letting drivers know of the quickest routes or informing drivers of pollution levels, specifically around school environments to hopefully change driver behaviour and mindset. We would also look to inform drivers of the best time to travel by informing drivers at journey times through-out the day.

During the first phase of integration only a subset of the detection devices were integrated into MyCity, this included:

- 5 Pollution Sensors
- 72 Bluetooth Journey Time Sensors
- 28 Vehicle Counters

The feed data was sampled every 5 minutes which resulted in roughly 30K data points collected each day. The second phase of integration will bring in the remaining detectors giving a total 200 detection devices resulting in 60K data points per day and an overall 22M data points per year.

6 Future Use Cases

'Call for Action' notification

To make an impact the monitored levels need to inform targeted actions to actively reduce the level of air pollution in the city.

Whilst the monitoring aspect of MyCity gives users the ability to see what is happening at any moment in time, it is vital to use the information to take targeted, balanced actions if the air quality levels are to be restored to their acceptable levels. Wolverhampton will be able to use the Strategy Manager service to provide them with the ability to configure 'actions' that do just this. 'Actions' can be set-up to be automatically applied, thereby taking away the need for constant supervision.

'Actions' can also be set up to be presented as 'suggestions,' which are then presented through the user interface or can be distributed by email or text, before the user chooses the most suitable for manual deployment while monitoring the different data sets. Via user-configurable thresholds, the team will get notified when the air quality exceeds the defined level, via email and text message, so further actions such as road closures, rerouting traffic via variable message signs, or limiting access to certain vehicle classes can be implemented immediately, manually or automatically.

Reroute traffic

External pollution has a direct correlation with traffic volume and type of vehicles, so one of the first and most impacting factors that can be changed is to reduce the number of vehicles on the road. The Strategy Manager service is able to trigger new scenarios where traffic is steered away from highly congested areas by adjusting signal plans, displaying messages, and changing dynamic signs to restrict

access to specific areas either generally or for specific vehicle types (environmental badge or electric vehicles only etc.). Commuters travelling by car who have not yet made their way onto Wolverhampton's infrastructure inside of the ring-road can also be informed of the changes that have been made and be directed to Park & Ride services so that they can travel the last miles using other modes of transport. The dynamic component of the strategy manager then allows the city to apply different sets of actions as the air quality level improves, e.g., re-open areas to all traffic.

Adjust speed of traffic

Traffic speed and particularly unnecessary braking and acceleration is another factor recognised as being linked to pollution levels. Moving vehicles create higher levels of pollutants as speed increases, but they also have an impact when stationary as exhaust emissions concentrate around traffic queues. In urban areas moving vehicles help to disperse high levels of pollutants, but when traffic becomes stationary this effect is lost, and dangerous levels of pollutants quickly build up.

The ability to dynamically manage traffic speed can be a highly effective tool to make streets safer, specifically in times of an increasing share of vulnerable road users. Depending on the modality prioritisation, dynamic traffic management can also become one of the primary motivators for drivers to switch to other modes of transport.

Using the Strategy Manager, Wolverhampton will be able to smooth traffic flows which not only enhance the driver experience but also helps to minimise travel times and reduce emissions, prioritising the health of its residents. As air quality changes, traffic signal plans can be dynamically changed and with the introduction of variable speed limit signs on key routes drivers will be quickly advised of the most optimum speed to use to get to their destination, balancing emissions with time. In this specific use case, Variable Message Signs (VMS) will display a new speed limit with an optional warning messages until the air quality has dropped below the threshold.

Adjust traffic

Traffic signal coordination is vital for a reduced number of stops and emissions. Adaptive traffic control will handle coordination at a regional level and adapts local control to prevailing traffic conditions. The objective function of network-wide optimisation aims for an optimal flow ratio based on a utilised function for every scenario. In addition, rule-based decision making can be placed on a higher level to support signal plan selection based on emission levels.

Real-time data sharing

The combined Pollution Monitoring and Strategy Manager services are not just limited to managing systems that are directly supplied by SWARCO. There are a number of open API's available that provide the city with all the tools they need to also share the data collected, as shown with the integration with the NOW Wireless equipment.

7 Conclusion

The original challenge was to improve Wolverhampton's air quality using only existing street equipment. The solution has seamlessly integrated all of the existing data feeds into one platform to give a more coherent outlook on the whole problem and not just the sum of the parts. This collaboration has automated the data collection and collation process to reduce the time/resources required while also removing any inaccuracies incurred during the manual handling of data.

With a view to the future, the strategy manager will be used to define key performance indicators that can monitor the whole of Wolverhampton's traffic management infrastructure while multiple new strategies and scenarios are evaluated. The resulting information can be formatted for internal business processes and be made available to external customers for further analysis.