Data-Driven Smart Cities

A Quick-Start Guide to Data Marketplaces

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oneTRANSPORT
Open marketplace for data

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Introduction

When implementing smart city solutions, where do municipal agencies, application developers and service providers begin? How do they go about making sound investment decisions? The aim, after all, is to scale up their pilots and first-generation applications and prepare for a bigger pool of hundreds and thousands of application opportunities.

This guide explains the strategic, organizational and technical steps in handling data for smart city services. These apply equally to private enterprises and public-sector agencies.

The implementation steps draw on practical experience to test new smart city concepts in a two-year field trial known as the oneTRANSPORT initiative. The initiative began as a pre-commercialization trial in the UK that de-risked the launch of an operational system. The trial phase involved a large-scale deployment involving several cities and regions in a public-private partnership. Participants in this collaboration tested several different use cases and the technologies necessary to enable smart city, regional, and intelligent transport solutions.

One aim of this guide is to help private and public-sector organizations figure out their role in a smart city ecosystem. In ten easy steps, the guide then explains the resourcing, organization and technical activities that data marketplace users can follow to launch data-driven smart city services. Before getting to these recommendations, it is first important to think ahead about the future of smart cities and the merits of a collaborative, data-centric and scalable approach.

The Future of Smart Cities – Horizontal Thinking and Big Data

Citizens and businesses expect municipal authorities to meet a wide variety of needs. These range from smoothly functioning public services to an economic environment that supports economic growth and inward investment. Smart city solutions offer new ways to leverage massive quantities of data and new technologies to address these goals. The combination of ubiquitous connectivity and big data analytics (e.g., descriptive, predictive, and prescriptive) is a powerful enabler of services that will significantly improve urban living.

However, many city administrations and their private sector service delivery partners are poorly equipped to take advantage of these technologies. No single entity has all the answers when it comes to delivering even the simplest of smart city applications. Many cities and their service delivery partners lack the

SMART CITY DESIGN PRINCIPLES

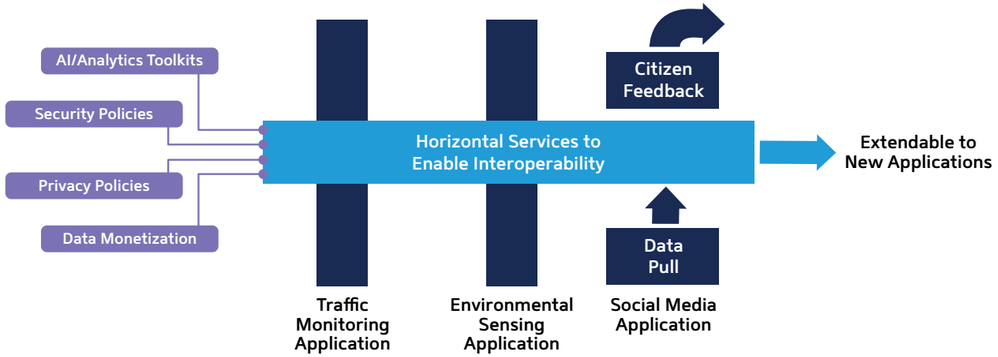
- **Anticipate Scale** - plan for hundreds and thousands of applications and services
- **Plan to Collaborate** – plan on working across departmental and geographic boundaries as smart cities become smart regions
- **Think Horizontal** – leverage commonality across applications, avoid silo investments, share expertise
- **Employ Open-standards** - avoid vendor lock-in, future-proof your design for tomorrow's technologies
- **Foster an Open Ecosystem** - encourage innovators and public-private partnerships from the outset
- **Share Data in Usable Ways** – make data discoverable, machine-readable and licensed for use in downstream services
- **Operate a Multi-sided Model** - accommodate the needs of citizens and those of local businesses and connected assets

finances to make large and transformative investments on their own. These are some of the reasons for a collaborative and open eco-system approach among small and large, public and private sector participants in the smart city environment.

Municipalities and their operational partners also need to prepare for the future since there is no fixed destination to a smart city journey. There will always arise new citizen requirements. Budgetary pressures will drive the need to improve operations. And, new technologies will open unforeseeable service innovation possibilities.

Horizontal Thinking – Minimize Silo Solutions

A smart city approach also depends on truly horizontal thinking. This means looking beyond sectoral silos, to reimagine applications and services that cross organizational and technical boundaries. It implies the need for a set of common tools that are shared across multiple applications. This is a necessary approach to achieve economies of scale.



Source: The 4th Industrial Revolution and the Municipal CEO, ETSI City Digital Profile, 2018

Data, whether it comes from individuals or devices, or from private or public-sector sources, sits at the heart of this new approach.

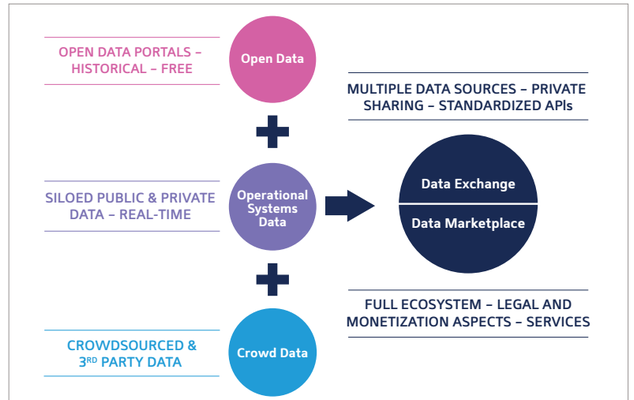
By establishing a common approach across functional areas under dependable licensing terms, cities can publish their data systematically. Independent application developers will have greater certainty about data sourcing, which is likely to encourage innovation and smart city solutions that build off a strong commercial footing.

One definition of horizontal thinking success is when several departments in a municipality, or a group of neighboring counties, share a cross-cutting platform to exchange city data and enable a limitless number of smart city applications.

Managing Big Data from Multiple Sources

Most smart city journeys begin with a trial or an initial application that targets a pressing need. This may involve publishing some historical data through an 'open data' initiative. Or, it might be an operational application to manage waste collection more efficiently through a just-in-time strategy.

As municipalities embrace the many ways to deliver smart city services, they will have to deal with a wide universe of data sources and destinations. These include open data, operational and crowd data sources. Bringing these data sources into a shareable environment begins with the implementation of a data exchange. This applies horizontal thinking to ensure common formats and technical tools that users can apply to access data. The next progression is a data marketplace which extends the exchange concept through the addition of legal and monetization capabilities. The legal element provides a data licensing framework, allowing municipalities to exercise control over their data. The monetization framework lets municipalities decide which data they wish to supply for free and which other data resources are offered on a fee-paying basis.



Source: Adapted from ATIS, Smart Cities Data Sharing Framework, March 2018

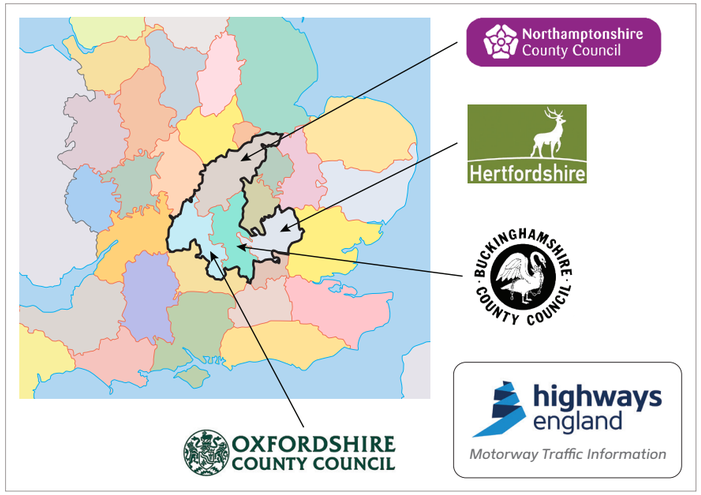
An Example Application – oneTRANSPORT™ Data Marketplace

The oneTRANSPORT™ data marketplace functions as an environment to manage a wide variety of data associated with smart city, smart region and intelligent transport solutions. The solution underwent a two-year field trial in the UK with four UK counties, Buckinghamshire, Hertfordshire, Northamptonshire and Oxfordshire and a set of private sector partners.

These partners contributed expertise in city planning and transportation economics, internet of things (IoT) technology, sensor network management and advanced analytics (e.g., via machine learning and artificial intelligence approaches).

The four public-sector bodies, in effect the customers, defined three use cases, details of which are provided in an Annex to this document.

By design, these use cases differed in scale for testing and evaluation purposes. The small-scale use case served a park-and-ride for the city of Oxford.



The mid-scale use case dealt with ring-road congestion and car-park availability to handle an influx of over 20,000 spectators on match days for the town of Watford and its Premier League football team.

> "Couldn't live without this now"
>
> **Silverstone Traffic Control Manager**

The large-scale use case helped the site managers of Silverstone racetrack to cater for over 250,000 trips, involving spectators and race personnel, over the Formula 1 race weekend. Silverstone resides at the intersection of three counties. Effective event planning depends on adapting to traffic diversion decisions taken in each county. This use case illustrates the value of a smart region approach. The solution was further enhanced by the participation of Highways England, the country's strategic road network agency.

Over the course of the trial, the implementation partners fed data from over 300 asset types through the marketplace. This demonstrated its ability to manage a wide scope of data sources and protocols.

Following successful trials, the oneTRANSPORT data marketplace is now available as a commercial, cloud-based service.

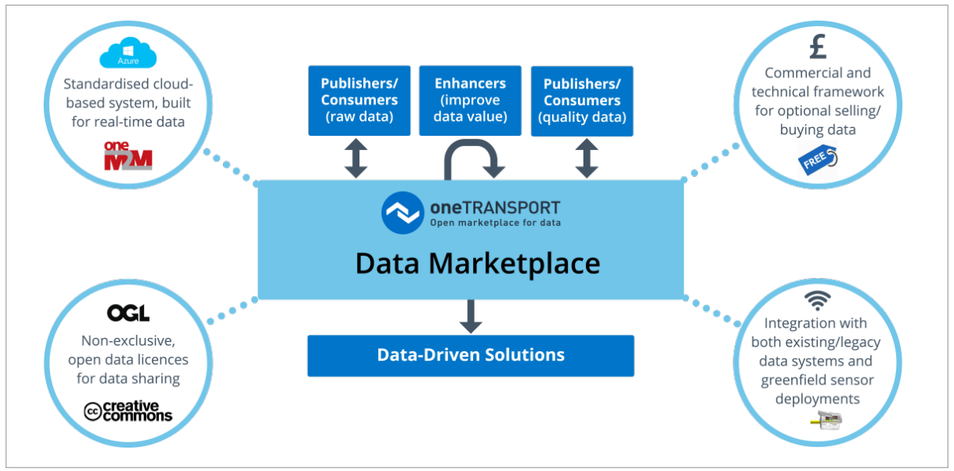
A mix of public and private sector organizations are already using it across the UK. They benefit from an operational service without having to deploy new technology of their own.

EXAMPLE DATA TYPES

- **Local traffic (live):** individual vehicle speed (SCOOT & ANPR), average speed, congestion detectors, VMS displays, roadworks, diversions, flows, incidents, occupancy, travel times, etc.
- **Local parking status (live)**
- **Air quality measurements (live)**
- **Geospatial data (static):** lanes, roads, parking restrictions, asset locations, etc.

Operating Model and Key Features

The oneTRANSPORT™ data marketplace connects suppliers and consumers of data who seek to deploy data-driven solutions. Data suppliers are public or private sector organizations looking to share data within their organizations or with others. Such data may be offered "free" or assigned a "fee" of the data publisher's choosing. Data may be in its raw or refined forms (e.g. improved data value or higher quality data).



Data enhancers are service providers that take existing data in the oneTRANSPORT data marketplace and enhance it to provide more value. For example, they may clean it up to remove anomalies, combine it with other data, or apply specific data schemas or analytics.

Data consumers are public or private sector organizations, individuals, universities, and other educational and not-for-profit organizations that download existing data in the marketplace, to deliver solutions and services.

There are four differentiating features to the oneTRANSPORT™ data marketplace.

1. The marketplace is a standardized cloud-based system, built for real-time and non-real-time data, using the oneM2M™ standard. Any organization that builds products and services based on the oneM2M standard can interface to the marketplace, discover data resources and apply them to develop new applications.

2. The oneTRANSPORT data marketplace facilitates data sharing through the UK's Open Government License (OGL). This framework permits anyone to copy, publish, distribute, transmit and adapt marketplace data for commercial and non-commercial uses. Users can choose alternative approaches including Creative Commons (CC) and derivative licensing models. These approaches allow data suppliers to license raw data for third-party use but not for further sharing.

3. A commercial module within the oneTRANSPORT data marketplace provides data suppliers with the tools to control whether they supply data at no charge or for a fee. This framework publishes pricing information and tracks consumption patterns for billing and revenue allocation purposes.

4. An important design feature of the oneTRANSPORT data marketplace is to integrate data from legacy and greenfield systems. This means that municipal authorities and established service providers get to preserve the value of past investments with a road-map that lets them integrate future additions.

Data Protection

Data is secured in transition, encrypted when at rest, and hosted in the cloud. Strict permission controls allow users to share only the data they want, with whom they want.

Data Marketplace Stakeholder Value Proposition

The data marketplace serves the needs of several stakeholders:

- Private and public-sector organizations can make their data systematically more accessible within their own organizations and with third party partners. In addition to extending full control to data suppliers, it opens new revenue possibilities for municipal authorities among others.
- By lowering the barrier to entry for application developers, value-added data service providers and data-asset brokers, it fosters innovation and economic development. A single interface to the application development community simplifies data licensing agreements through an 'open once, sell to many' model.
- As a turnkey Open Data solution, it can implicitly provide compliance with any current or emerging regulatory requirements regarding open data.

In a data marketplace environment, data publishers enjoy unified and easy ways to publish data. They also benefit from tools that provide control over the way that data assets are shared, with which business and operational partners, and under what licensing conditions.

For data consumers, the availability of a single way to access data assets enables a faster pace of technology development. It also expands the opportunity for solution developers who can design and deploy new services at both a national and an international scale.

Standardization, in the form of the oneM2M™ standard, is an important feature of the data marketplace solution offered by Chordant™ especially for the unified data marketplace access. oneM2M™ is an internationally recognized open standard that simplifies the design, deployment and operational support of IoT applications. This has important implications for innovation, economies of scale and risk-management against vendor lock-in.

Benefits of an open Standard Approach and the oneM2M™ Standard

The fundamental problem that the data marketplace addresses is the fragmentation of data assets which constrains data sharing and operational collaboration across organizational silos. Our data marketplace approach solves this through a horizontal platform, using the oneM2M™ global standard. Using an open standard implies that multiple vendors can develop standard-based solutions because they have access to specifications and documentation. This creates competition and interoperability of solutions from multiple vendors, minimizing 'lock-in' problems.

The oneM2M standard defines a horizontal architecture that enables data, collected from any IoT device or IT system and via any type of communications infrastructure, to be discoverable and consumable via open, standardized APIs (Application Programming Interfaces).

The technical specifications for the oneM2M standard define a set of 'common service functions'. Think of these as the tools that application developers use to build and operationally manage smart city applications. Examples of these common service functions are real-time data discoverability, network abstraction, security and semantic interoperability. As a result, the oneM2M standard provides a comprehensive and internationally compatible approach to realizing an open data marketplace for cities, regions and other forms of built environment.

The oneM2M standard also allows the federation of platforms from multiple vendors, which ensures high scalability and a future-proof digital infrastructure.

Making the Adoption Decision

The adoption process begins when an organization decides to create an environment targeting multiple smart solutions. This might be a department within a municipal authority, seeking to leverage internal data and then progressively collaborate with other departments and even with external partners. It might be the facilities owner of an office building, a sports arena or an industrial factory.

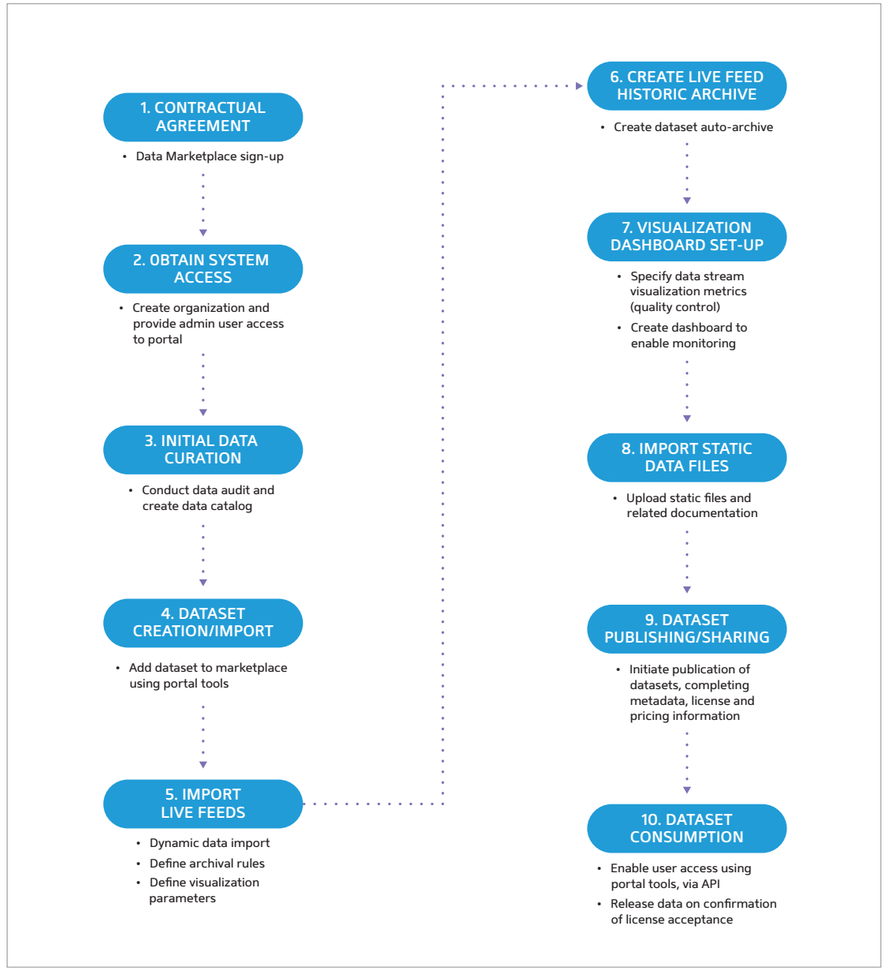
Small organizations and others that are suppliers to a larger system of organizations don't have the capacity to initiate a horizontal platform strategy. In this case, a group of smaller organizations might proposition a larger, host organization to make the case for a horizontal platform strategy. They may see opportunities to save costs, to deliver services more efficiently and to create the conditions for delivering innovative services in the future.

Whichever route is taken, the adoption decision generally begins with a policy statement. The lead organization will also outline a strategic roadmap (e.g. priority application areas, longer term direction), implementation principles (e.g. in-house vs. externally managed) and an allocation of resources. Next comes the implementation process.

Getting Started – a 10-Step Process

For organizations that choose to use the oneTRANSPORT data marketplace, there are ten steps to getting started and demonstrating an operational impact.

The first few steps deal with contractual and administrative issues as illustrated below. At Step 3, participating organizations perform an initial data curation, typically focusing on assets and data sources linked to a priority use case. Strategically, this needs to be a process that can accommodate new sources as the initiative is expanded broadly across the organization and its service delivery partners.



Steps 4, 5 and 6 deal with activities to bring in datasets and archive them in the data marketplace. All users learn something about their datasets when they can visualize them. They may see dynamic patterns and extremes of use, for example. An important goal from the visualization step is to formalize metrics to characterize good-quality data. Step 7 takes this information as the base for setting up a monitoring dashboard to monitor data entering the system in the future.

Step 8 deals with importing static data files and related descriptive documentation. This might apply to data sets that are typically associated with Open Data or Freedom of Information release requests. Once there is a reliable supply of static, time-series, archived and live data, Step 9 represents the point at which these are published and shared.

Finally, Step 10 deals with data consumption activities. These primarily involve the provision of access to users and confirmation that users have accepted the marketplace licensing terms.

Next Steps

This guide illustrates the relatively straightforward steps that public and private sector organizations can follow to implement data-driven smart city solutions.

www.oneTRANSPORT.io contains more information about the data marketplace framework, operating principles and the commercial offering in the UK. Visitors to the site can also study available datasets through a simple sign-on process.

ANNEX 1: Use Cases, Customer Benefits and Recommendations

Each county in the oneTRANSPORT trial had different needs, and each focused on its priority use case. Working collectively, the team picked use cases of varying degrees complexity, geographic reach and scale.

- For the first, Oxfordshire County Council implemented a park-and-ride scheme to help visitors to the historic town of Oxford.
- The town of Watford in Hertfordshire handled the second use case. This applied to weekends when the local football team was playing a Premier League match. In addition to managing shoppers and tourists, the match added over 20,000 spectators to the city-center crowd. The solution for this use case helped city managers to marshal traffic flows and parking capacity by posting real-time advice on electronic displays. This information directed drivers to available parking spaces via less congested routes.
- The third use case involved the Formula 1 Grand Prix event at Silverstone race track. Over the course of a 4-day race weekend, there are over 250,000 spectator and race personnel trips to the Silverstone site. Traffic and parking management is challenging because the race track sits at the intersection of three counties. It demands a collaborative approach to take account of temporary road diversions in each county.

Author: Oxfordshire County Council

Date: October 2017

OXFORDSHIRE COUNTY COUNCIL

Keywords: Park & Ride, Buses, Journey Planner

Oxfordshire Park & Ride Use Case

Through this use case, the oneTRANSPORT solution used a wide range of datasets to inform users of fast public transport options available to them when travelling to their destination.

- Oxford's Park & Rides contain a significant pool of data, such as car parking availability.
- The project also secured Park & Ride bus service data from the bus operator to allow predictions to be formed regarding bus journey times.

Pulling all these resources together into a web application allowed journey time savings to be promoted via trips from the Park & Rides system while demonstrating one of the many potential uses of the oneTRANSPORT data marketplace.

Our Key Transport Challenge

Oxford is an old city with numerous protected buildings and landmarks of historical significance. This severely limits the improvement of the city's road network because the street layout and protected infrastructure are not easily modified.

Due to Oxford's historic reputation and high-quality aesthetic nature, the city attracts vast numbers of tourists whilst the two universities bring thousands of students from all over the world. With traffic congestion rapidly increasing, there is a huge demand to find innovative solutions to the rise of congestion in the City Centre.

Managing traffic congestion without compromising the city's historic built environment is a very difficult task requiring innovative ideas and careful management of the existing infrastructure.

Several different methods have been used to try and curb the number of cars entering Oxford including the introduction of high parking charges in the City Centre combined with maximum permitted stays. Perhaps most importantly has been the push to increase uptake of Oxfordshire's Park & Ride system, often cited as the largest of its kind in the UK.

Oxfordshire's Park & Ride sites have recently been the subject of a £6.7m investment. 20 new hybrid buses have been introduced with another 10 being deployed in the near future. In addition, with demand for travel into the city set to rise with the opening of a significant retail development, the Westgate Centre, there is a growing need to provide solutions to Oxford's congestion.

Our Approach

Our aim for this project was to use transport data to aid in the development of an 'app' for remote use by our user groups. The 'app' provides a means for external parties to access live data, with the potential to cover a wide range of travel information needs. This data is used to inform the initial journey suggestions presented to users before departing for their destination.

Due to the amount of congestion on Oxford's roads and the high-quality coverage of bus lanes running from the Park & Rides into the city, Park & Ride journey times are often the fastest method of accessing the central urban area.

The data consumed includes predictions based on live traffic and congestion monitoring to enable greater accuracy in journey time planning. Similarly, predictions coming from live updates on parking availability help to decrease unnecessary circulation of traffic and reduce frustration.

Benefit Impact

Park & Ride usage tends to be promoted by the application as this is often the fastest method of accessing the City Centre during peak times. Increased uptake potentially boosts revenues for the Local Authority Park & Ride owners and the bus operators.

Users of the application can avoid driving directly into congestion, so they benefit from improved journey times when accessing the City Centre. Furthermore, should usage be increased sufficiently, there are also significant benefits regarding the reduction of air and noise pollution and the conservation of Oxfordshire's local environment.

The application represents a new method of shifting people to different modes of transport using existing infrastructure. This makes it relatively cheap to implement and has the potential to shift people away from less sustainable modes of transport. This is particularly useful in cities like Oxford where, due to a high number of historical buildings and landmarks, it is difficult to make large scale changes to infrastructure.

Future Actions & Recommendations

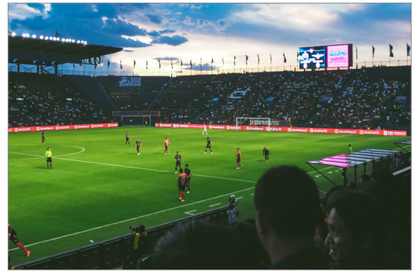
This use case has demonstrated an approach local authorities from other historic cities facing similar problems to Oxford might consider in order to boost Park & Ride uptake. This is just one example of the kind of development that the oneTRANSPORT data marketplace enables because of the increased accessibility of datasets. Future projects could easily extend this approach to journey planning by utilizing data from the platform to provide predictions for local buses, trains and other forms of public transport.

Author: Hertfordshire County Council

Date: October 2017

Keywords: Major Events, Interventions, Open Access

Watford Football Club Traffic Management



Watford Football Club is a UK Premier League side which has its stadium in the heart of Watford. Their home matches regularly have attendance figures of 20,000, bringing an influx of private vehicles into Watford's town center.

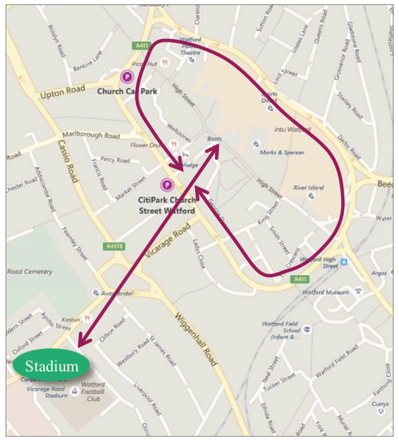
Watford is already a busy shopping destination due to the presence of an Intu shopping mall in the town center. This means when a home match is on the weekend, the combined match day and shopping traffic can increase congestion and create parking problems.

Our Key Transport Challenge

As a local transport authority Hertfordshire County Council is always looking to improve the journeys of both those travelling within its borders as well as those travelling into the surrounding local authorities.

To this end, Hertfordshire County Council wanted to provide a better and more consistent travel experience for those travelling into Watford on a weekend home match day.

Our Approach



Hertfordshire County Council used the oneTRANSPORT solution to easily inspect travel to and from Watford on match days. The platform allowed the council to bring all the relevant data into a single location where it could be reviewed with ease.

Through this process, specific issues that were occurring on match days became apparent. One example is the case where fans were using one particular carpark in preference to others, causing queuing on the main road.

Once the issues were identified, it was then possible to put in place an intervention plan, whose impact could also be monitored. The intervention in this case was to use the variable message signs leading into Watford to inform drivers when specific car parks were reaching capacity and directing the drivers to other parking alternatives.

The council also implemented a custom traffic signal timing profile that gave greater priority to traffic leaving a problematic car park. This meant the car park had a more consistent exit rate and there was a reduced chance of conflict between exiting vehicles and those already on the main road.

Benefit Impact

By being able to identify where parking issues were occurring it was possible to put in an intervention that specifically facilitated smoother traffic flows into and out of this car park. This allowed for more efficient use of car parking in the Watford town center and addressed potential congestion concerns before and after a match.

In terms of 'citizen' benefits, commuters, shoppers and spectators travelling to and from Watford on a match day would experience more consistent journeys. There would also be less concern around parking once they arrived at their destination.

One of the council's benefits is driven by the fact that it tailors its own systems using open source solutions. Previously, if the council had wanted to have such systems created for them they would have had to gone out to tender and have these services supplied externally. This leads to an overall cost saving to the council when they have staff with the appropriate skills available.

Future Actions & Recommendations

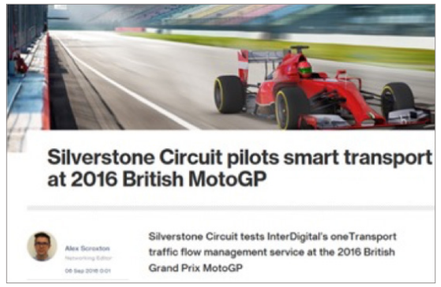
Hertfordshire County Council will be continuing with the oneTRANSPORT data marketplace as it has created new opportunities for reviewing and sharing our data. This is both within our own organization and, more importantly, with others outside the council.

The oneTRANSPORT data marketplace has created new ways for authorities and their partners to work together to build better transport supply chains.

Author: Northamptonshire County Council

Date: October 2017

Keywords: Major Events, Silverstone, F1 Grand Prix, Traffic Management



Silverstone Circuit Traffic Management Use Case

The British F1 Grand Prix at Silverstone is the largest sporting event held in the UK each year. The F1 Grand Prix alone contributes over £50m to the local economy. The full event, including practice sessions, runs over four consecutive days. Roughly 120,000 people journey to the arena for the race day itself.

The Grand Prix and other major events held at the circuit bring an influx of vehicles. Although Park-and-Ride operates during the F1 Grand Prix, the majority of visitors travel by private car as there is no direct rail link. This means that traffic associated with Silverstone has a major impact on both the local road network and the UK's strategic network, particularly the A43. This inevitably causes congestion and associated problems.

The characteristics of Silverstone and the F1 Grand Prix as a use case include the following:

1. The major economic impact – both positive in terms of income generated and negative in terms of the costs of congestion;
2. The different challenges it presents because of the rural location and reliance on road access;
3. The wide impact on several local transport authority areas, including both the strategic and local road networks;
4. The high-profile of this global sporting event;
5. The learning is transferable to other events, including major concerts and outdoor sports venues.

Our Key Transport Challenge

As the local transport authority, Northamptonshire County Council is keen to work with Silverstone Circuit and other stakeholders to improve traffic management through an intelligent approach. This should provide real-time information enabling operational and tactical decision making both in the run-up to and during events.

Furthermore, it should enable the travelling public to make real-time informed decisions on the use of the alternative diversion routes. It should also provide time-series information to inform post-event reviews (including reported delays) and strategic decision making.

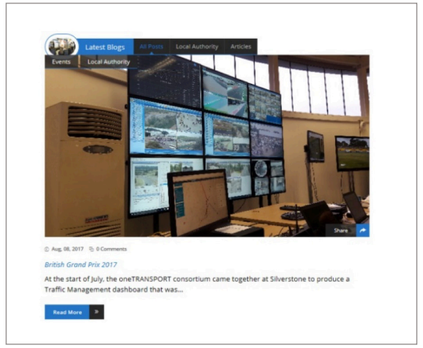
Our Approach

Northamptonshire County Council's approach to the use case involved the following steps:

1. Identify potential beneficiaries of the use case (race organizers, event visitors, transport authorities, other travelling public);
2. Identify the available data (static and live) and aggregate on a single open access platform;
3. Agree specific requirements associated with the use case – principally traffic flows, journey time and car parking data;
4. Deploy journey time and parking sensors to address key gaps and provide more granular information to supplement existing data;
5. Work with traffic managers, ARUP and InterDigital to develop a 'real-time' event dashboard.

This project approach included two key review stages. Firstly, the lessons learnt from the 2016 review were used to identify improvements, many of which were implemented before the 2017 F1 Grand Prix. These included deploying additional journey time and parking sensors.

Secondly, the 2017 review drew conclusions and recommendations that informed enhancements for the post-trial implementation of the oneTRANSPORT data marketplace.



Benefit Impact

At an operational level, being able to identify where parking issues were occurring during the event meant it was possible for the Silverstone Circuit Traffic Manager to put in an intervention that specifically facilitated smoother traffic flows in to and out of the various car parks. This allowed for more efficient use of parking through the distribution of vehicles. It also addressed potential congestion concerns before and post-race. This meant that those travelling to and from Silverstone would have experienced more consistent journeys as well as less concern around parking once they arrive.

At a strategic level, having the data available in an open and usable format enabled a more informed and comprehensive post-event review and evaluation of the traffic management plan and its effectiveness.

This will inevitably lead to improvements in the management of events in the future, with benefits for both the local and strategic networks, the public, businesses and specific event stakeholders including Silverstone Circuit.

Future Actions & Recommendations

Northamptonshire County Council will be continuing with the oneTRANSPORT data marketplace as it has opened up new opportunities for reviewing and sharing data, both within our own organization, but more importantly with others outside the council, including Silverstone Circuit.

About Chordant™

Chordant, an InterDigital business, is part of a global company passionate about innovation and a standards-based approach that stimulates thriving global ecosystems. Solutions powered by the Chordant platform address the fundamental challenges in Smart City deployments.

Like a perfect chord of musical notes, the Chordant platform brings harmony to diverse devices, data and services. We have created one of the largest Smart City deployments integrating hundreds of transport data sources into a transport data marketplace. Our Smart City solutions have also been recognized by leading analyst firms and organizations.

We invite you to experience our standards-based future-proof platform and meet our experienced and friendly team!

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