

# A DATA DRIVEN APPROACH TO SEAMLESS AND EFFICIENT TRAVEL – IS IT REALLY PRACTICAL?

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## ABSTRACT

Intelligent (or Smart) mobility aims to use technology and multi-sourced data to support the efficient and seamless movement of people and goods through integrated, multimodal, user-focused and sustainable transport systems, delivering a better end-to-end journey experience. This has been an aspiration of planners and transport authorities since the introduction of technology in transport more than 30 years ago that has yet to materialize. Within South Africa the journey to seamless multi-modal travel requires a developed transport infrastructure as well as the availability of data to inform journeys and influence travel behaviour. The availability of transport data from multiple sources and geographic boundaries (open data, shared data, and closed data) is currently stifled by:

- Lack of common standards and interfaces
- Vendor lock-in on technology reducing data accessibility
- High cost of opening and maintaining data feeds
- Inter-departmental and geographical barriers.

This paper illustrates how an open marketplace for transport and associated data, similar to the one developed in the oneTRANSPORT project, can address some of these issues for travel in South Africa and realise economic, social and environmental benefits. The oneTRANSPORT project builds on recent technological advances to deliver an open, standardised, cloud-based transport data platform and marketplace; and develops innovative business models for the industry and transport authorities that lead to a financially sustainable ecosystem.

## 1 INTRODUCTION

The transport industry is facing many global challenges such as managing increasing demand and congestion, reducing its environmental impact, and improving safety. Globally, the number of cars and light duty vehicles is expected to triple between 2000 and 2050 (World Health Organization, 2015). This will lead to unprecedented levels of congestion. Furthermore, transport emissions accounted for around 23% of the global energy-related CO<sub>2</sub> emissions in 2008, with global transport energy use and associated emissions expected to grow by 80% in the 2002-2030 period (World Health Organization, 2011). The *Global status report on road safety 2015* reported a total number of road traffic deaths of 1.25 million per year around the world, with the highest road traffic fatality rates in low-income countries (World Health Organization, 2015).

Unlike most countries with a coastline, South Africa's industrial centre is located far inland. Furthermore, the distances between cities are vast. South Africa accounts for 0.4% of the world's total GDP, but 0.7% of the world's transport costs and 2.2% of the world's surface freight tonne kilometres (road and rail combined) (World Health Organization, 2011). In terms of the environmental impact, 2008 data suggests that the energy used in transportation in South Africa contributes about 46.3 MtCO<sub>2e</sub>, or 13% of total local GHG emissions. In terms of road safety, the country's road injuries and fatalities are among the highest in the world. Every year, around 14,000 people (38 people a day) die on South African roads. Pedestrians account for nearly 50% of the total road fatalities. According to a survey conducted by the University of Johannesburg's Institute of Transport and Logistics Studies, transport is the third-highest-rated national issue, with public transport, the quality of roads and the state of the mini-bus taxi sector being the three most prevalent issues in this sector.

The ITS industry is currently going through a renaissance period with the advent of many new technologies and concepts that have the potential to address transport challenges and lead to more seamless, safe and efficient travel. Such technologies include Internet of Things (IoT), smartphones and associated apps, and connected and autonomous vehicles. These technologies generate large amounts of data (i.e. Big Data) which, if utilised, can support the delivery of a number of new transport concepts including Intelligent (Smart) Mobility (IM), Mobility as a Service (MaaS) and shared mobility. IM aims to use technology and multi-sourced data to support the efficient and seamless movement of people and goods through integrated, multimodal, user-focused, efficient and sustainable transport systems. It can be characterised by being user centric, mode independent, intelligent, and commercially viable. MaaS, as a service model, aims to frame mobility systems around customer preferences. It can be defined as "using a digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer" (UK Transport Systems Catapult, 2016).

The aim of this paper is to highlight the benefits and challenges of a data driven approach to improving transport services in South Africa and illustrate how an open data platform and marketplace can address some of the associated challenges. Section 2 provides an overview of the different technologies that lead to the generation of data, as well as some

examples that illustrate the benefits of using such data to improve transport services. Section 3 discusses the challenges and barriers to delivering data-driven seamless transport services. Section 4 provides a brief overview of the oneTRANSPORT platform and its potential in addressing some of the challenges related to the opening and use of data. Section 5 discusses the practicality of delivering data-driven seamless transport solutions in the South African context. A set of concluding remarks are presented in Section 6.

## 2 TECHNOLOGY AND TRANSPORT

Recent advances in sensing, computing and communications technologies are paving the way to the development of many innovative solutions that will change and disrupt a number of industries including transport. Advances and take-up in mobile communications (2G, 3G and 4G) are evident by the large number of mobile phone and smartphone users with about 5 billion unique mobile subscribers worldwide with over 600 million subscribers in Africa (GSM Association, 2016). About 95% of the global population (7 billion people) live in an area that is covered by a mobile-cellular network with mobile-broadband networks (3G or above) reaching 84% of the global population. 4G has reached almost 4 billion people (53% of the global population), enhancing the quality of Internet use [5]. Within the Southern Africa region, South Africa is the largest mobile market, with 38 million unique subscribers as of June 2015 and over 95% 3G coverage, and is expected to account for more than half of new 4G connections over the next five years (smartphone adoption is 30% in 2016. (GSM Association, 2016). In terms of Internet usage, 47% of the World's population were using the Internet by the end of 2016 (25.1% of population in Africa with South Africa being above this average (International Telecommunications Union, 2016). Emerging IoT and Machine to Machine (M2M) communications technologies have great potential in addressing many transport challenges related to congestion, environment and safety. It is anticipated that as many as 100 billion connected IoT devices will exist by 2025 with a global economic impact of more than \$11 trillion. South Africa presents one of the highly advanced countries in the field of M2M communications where it is ranked 16th in the World in terms of M2M subscriptions, higher than Germany and South Korea (International Telecommunications Union, 2016).

These advances in sensing, computing and communications have led to the development of new technologies in the transport sector including Cooperative or Connected ITS (C-ITS) with vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication capabilities, Autonomous Vehicles (AV) which is currently a major area of research and development [6], and Unmanned Aerial Vehicles (UAV or drones) being used for the last mile delivery of goods (DHL International GmbH, 2016; Amazon, 2017 and BBC, 2014). Most importantly, the significant prevalence of mobile communications and sensing technologies has led to the generation of Big Data. According to De Mauro et al (2016) *"Big Data is the information asset characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value."* (De Mauro, A., M. Greco and M. Grimaldi, 2016).

The availability of such Big Data combined with novel data analytics bring a number of benefits to the transport sector. An example is the development of analytics techniques to gain insight about traveller's behaviour using automatic fare collection data (Oyster card in London and Octopus in Hong Kong). In Abidjan (Ivory Coast), IBM has exploited mobile phone data to better understand commuter journeys. This has led to modifications to the city's bus routes which has resulted in a 10% time savings for commuters (G. Di Lorenzo et al, 2015). Opening public transport data in London by Transport for London (TfL) has led to the development of a multitude of applications/solutions which enable public transport users to make informed decisions about their journeys. This has led to an estimated annual saving in the range of £15-58 million in terms of time saved by transport users (Stephan Shakespeare, 2013). The availability of transport-related data is blurring the boundary between the IT and transport sectors with smartphone applications such as Uber, Citymapper and Waze disrupting the traditional transport sector and its business models.

### 3 BARRIERS TO DATA DRIVEN SEAMLESS TRANSPORT

Data is one of the key enablers to the delivery of seamless transport and the realisation of the IM and MaaS vision. Other factors affecting the realisation of this vision includes the communications and transport systems infrastructure requirements (Orla O'Halloran et al, 2016). Section 2 has highlighted the importance of data to the delivery of improved transport services and provided a number of examples which illustrate some of the data benefits. However, delivering seamless and efficient transport requires access to data from multiple transport modes, transport systems, non-transport sources, and geographic regions. This is faced by a number of barriers which include:

- **Lack of standards and interfaces:** The delivery of great benefits usually stems from the integration of different technologies and systems over multiple geographical regions. Therefore, there is a need for clearly defined interfaces and standards for the different technologies, as well as common formats for data generated. This is to avoid vendor lock-in and a silo'ed approach to the delivery of services.
- **Unclear impact of some new technologies/concepts:** Some technologies while being innovative and exciting, have not yet clearly demonstrated benefits in relation to the transport industry. This might hinder the wider adoption and support for such technologies from both public and private sectors.
- **Transition to and adoption of new technologies:** While new technologies demonstrate a high potential in addressing many transport challenges, in a number of cases this might not be enough to guarantee their wide market adoption. Many factors can play against the adoption of new technologies including the transition

process towards such technologies, and backward compatibility with existing systems.

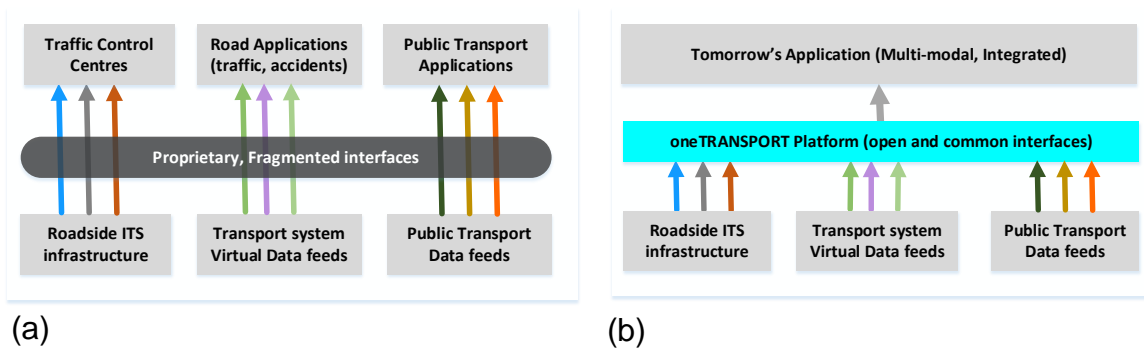
- **Privacy and data security:** Most of the new and emerging data sources are of a personal nature (e.g. mobile phone location data) and this brings a number of privacy and data security challenges that needs to be addressed at the device and system levels.
- **Commercial sensitivity:** The opening and sharing of data from different stakeholders (transport and infrastructure operators, App developers, Vehicle manufacturers, etc.) can be hindered by the commercial sensitivity of some data and there is a need for clear business models and mechanisms that address such commercial sensitivity issues.
- **New disruptive business models:** All new technologies and concepts need to demonstrate their capabilities and equally importantly make business sense. Therefore, new technologies and concepts such as MaaS need to be accompanied by business models.

## 4 ONETRANSPORT

### 4.1 Overview

oneTRANSPORT is an approach that is being developed in the UK but with global applicability, to deliver the benefits of IM through data sharing while addressing some of the associated technical and financial barriers (Khalid Nur et al, 2016). This is by developing an IoT open and standardized cloud-based data platform and marketplace based on the oneM2M standard. oneM2M is an open and scalable service delivery standard that enables the aggregation of data from different industry sectors (oneM2M, 2017). It is developed to remove sub-optimal IoT configurations and avoid having duplicated hardware, customised software and silo'ed data assets (oneM2M, 2017).

oneTRANSPORT introduces a new middleware layer of functionality as depicted in Figure 1. Figure 1a shows the current scenario with distinct data streams feeding specific applications leading to sub-optimal utilisation of resources and fragmented interfaces, hindering the realization of the IM vision. Figure 1b shows how oneTRANSPORT provides a standardised interface to access multi-modal, multi-geographical, and multi-sourced data and help developers build, deploy, and manage cloud-based applications and providing value-added functionality and services directly or via third parties (Larry Carvalho and Jeff Silverstein, 2015).



**Figure 1: Advantages of the oneTRANSPORT platform: (a) Status quo (b) oneTRANSPORT implementation.**

The oneTRANSPORT platform brings a number of features as it:

- (1) uses international-standardized technology to open up the global market and avoid proprietary systems;
- (2) supports existing as well as new sensing infrastructures, in order to operate across diverse legacy systems, support a smooth transition to new technologies, ensure future proofing and encourage interface standardization among suppliers;
- (3) enables data suppliers (e.g. local and national transport authorities, mobile phone operators, App providers, sensor providers) to publish their data on the platform/marketplace; and it then provides such data through a unified interface to data consumers (e.g. local and national transport authorities, App developers, data analytics providers, and information service providers);
- (4) provides a marketplace for data analytics service providers to access data and offer their products on the platform.

## 4.2 Use cases

The oneTRANSPORT platform has demonstrated some of its benefits in a real world context through a number of use cases in the UK. This is in terms of reducing the negative impacts on the transport network from major and local sports events and major developments and economic growth as well as traffic accidents and incidents. This section covers two use cases, namely the Silverstone Race Circuit and the Watford Match Day covering major and local sports events respectively.

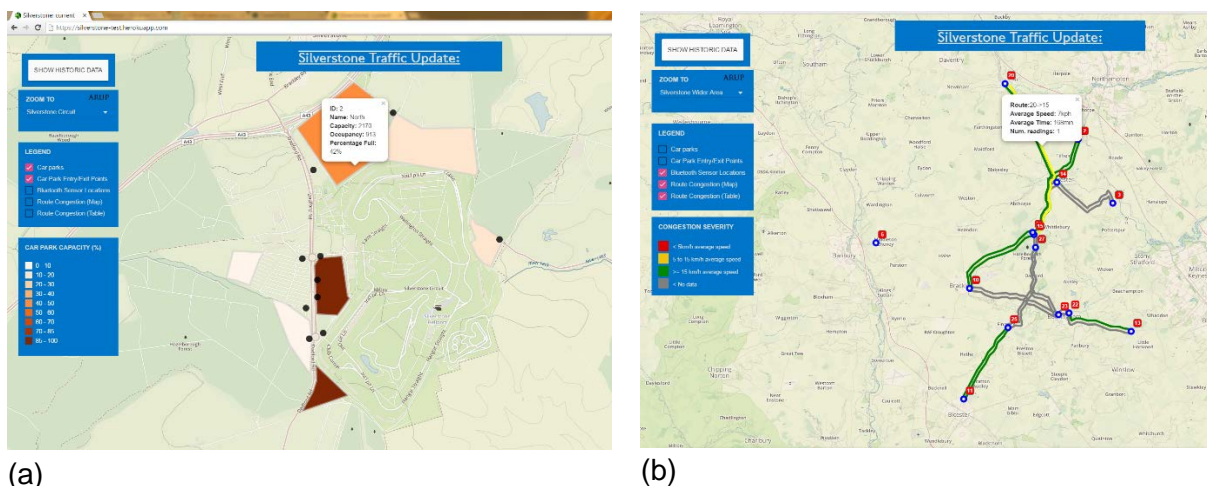
### 4.2.1 Silverstone Race Circuit

Silverstone hosts a number of sporting events including the Formula 1 Grand Prix which sees over 100,000 attendees in one weekend. Large events at Silverstone affect a wide range of users of local roads in Northamptonshire and Buckinghamshire as well as the national Strategic Road Network. This highlights the importance of data sharing among

local and national transport authorities to the successful understanding, predicting and managing of event traffic-related issues.

A number of datasets has been successfully integrated into the oneTRANSPORT platform including live roadworks, Variable Message Signs (VMS) and Automatic Number Plate Recognition (ANPR) cameras data from the surrounding road network. This data has been augmented with data captured by complementary Bluetooth traffic sensors installed at key locations on the road network in the region as well as data from parking sensors installed at the venue.

Access to these data sources through the unified oneTRANSPORT interface have enabled the development of a web-based tool for visualising the traffic status and car park occupancy (see Figure 2). This resulted in a more integrated and efficient approach to the management of traffic in and out of the venue and routing to suitable parking facilities. Furthermore, oneTRANSPORT characteristics have enabled the use of relatively cheap and easy to implement Bluetooth and WiFi traffic sensors (IoT) to cover areas that lack traditional traffic system infrastructure.



**Figure 2: Silverston Data Visualisation dashboard: (a) Car park occupancy (b) Average speed in surrounding routes.**

#### 4.2.2 Watford Match Day

Watford is a town in the Hertfordshire County and is also part of the Greater London Urban Area, with a population of over 100,000. The town is served by a number of bus and rail routes, as well as London Underground and Overground lines. The aim of this use case is to improve the management of traffic in Watford town centre on football match days which are hosted at the Watford Football Club stadium every two weeks during the football season, attracting over 20,000 attendees, and usually causing major disruption within the town centre and surrounding routes to the stadium.

Data from multiple traffic and parking systems/sensors is integrated into the oneTRANSPORT data platform. Access to such data through a single interface has supported the development of solutions that enabled better understanding of the network status and hence, active management of traffic around Watford on match days through the

implementation of a number of measures. Pre-match monitoring of car park fill rates and occupancy is used to trigger the use of VMS around the town centre to advertise alternative car parks for visitors to use. This is reducing the queues entering popular car parks prior to the match and the queues within the car park when trying to exit the car parks post-match. These interventions have already seen reduced queues pre-match and a more consistent exit rate upon egress, with no significant difference to the congestion on the town's inner ring road.

## **5 ROUTE TO SEAMLESS TRANSPORT (SOUTH AFRICAN CONTEXT)**

As discussed in Section 3, realising the seamless transport and IM vision requires transport and technology infrastructure. Despite the significant role of transport infrastructure, it requires large investments to develop and/or improve and usually takes long time to implement. The South African communications technology infrastructure is well advanced compared to its transport infrastructure. For example, while having 95% 3G coverage, South Africa has a total road network of about 750,000 km, 151,000 of which are paved, and an estimated 140,000 km of unproclaimed roads mainly servicing rural areas. Furthermore, South Africa has a large number of Tech Hubs (about 51 in 2016 raising a total fund of about \$54.6million in 2015 according to the GSM Association (GSM Association, 2016) which contribute to the development of many smartphone applications. Uber launched its service in the region in 2012, starting in South Africa, and has seen unprecedented growth (GSM Association, 2016). The benefits of developing smartphone applications are two-fold: they act as a major source of transport-related data, in turn providing better understanding of traveller behaviour, and they can be the main channel for delivering better transport services.

Given the above, the route to IM in South Africa should start by exploiting its existing advanced technology infrastructure to deliver improved transport services and efficient networks. As discussed in Section 2, technologies generate large amounts of data which can be harnessed to improve the efficiency, safety and environmental impact of the transport system and pave the way towards the IM vision. However, to achieve such benefits, there is a need for a mechanism that enables the sharing and exploitation of data while addressing the barriers identified in Section 3. A oneTRANSPORT platform functionality has the potential to address issues related to data sharing and support innovation related to data exploitation. Such a platform will deliver many benefits to a number of stakeholders by providing one-place for both data suppliers and consumers to realise direct (i.e. financial) and indirect (economic, environmental and social) benefits.

Providing App developers with access, through a unified interface, to an open data platform and marketplace will enable the development of innovative solutions addressing the local transport challenges. Furthermore, such a data marketplace will enable App developers to share/sell anonymised data they collect through their apps on the platform which provides them with potential new revenue streams.



Local and national transport authorities are expected to highly benefit from access to multi-sourced data in a unified interface through an open data platform/marketplace. Such data, which may include mobile phone data and smartphone App user data, can be used by transport authorities to have better understanding of travellers' behaviour and help identify better ways to address their needs. An example is the use of mobile phone location data in Abidjan (Ivory Coast) which, despite its low granularity, has enabled the optimisation of bus routes in the city (G. Di Lorenzo et al, 2015). Accessing anonymised GPS data from App providers on the platform (with significantly higher granularity), has the potential to deliver better insight in terms of travellers' behaviour. For example, better understanding of pedestrian behaviour through data can address some of the pedestrian safety issues in South Africa and help transport planners and infrastructure designers to efficiently minimise pedestrian fatalities.

The ability of the platform to integrate data from existing traffic systems and new IoT sensors will support the use of a multitude of sensing devices to cover gaps on the network and provides better network visibility as illustrated in the oneTRANSPORT use cases in Section 4.1. This will not only benefit transport authorities through relatively quick and easy implementation of IoT sensors, but will also provide a fast market route for sensor providers into the transport sector.

The journey to data-driven Intelligent Mobility is already underway in South Africa with transport open data platforms such as the WhereIsMyTransport platform (WhereIsMyTransport open transport data platform) which is currently collating a number of transport datasets from seven cities in South Africa. It is important to note that while the use of data and an open data platform and marketplace will be a key enabler to the delivery of a seamless transport system, significant transport infrastructure investment is required. Nonetheless, a data-driven approach is not only practical, it will also lead to an economic and efficient delivery of the seamless transport vision as it will support informed transport infrastructure investment decisions.

## **6 CONCLUSIONS**

The paper has highlighted the benefits of a data driven approach to the delivery of improved transport services, identified the technology barriers to realising a seamless and efficient transport vision in South Africa, and proposed a route to the delivery of such vision through an open data platform and marketplace.

The delivery of the seamless transport vision requires extensive transport infrastructure investments. However, there is a huge potential for the use of data to improve transport services given the existing and fairly advanced technology infrastructure in South Africa. In order to address the barriers associated with the sharing and exploitation of data, the paper proposed the introduction of data platform/marketplace functionality similar to the successfully demonstrated oneTRANSPORT platform. oneTRANSPORT aims to address the technical and financial challenges of sharing and using transport-related data by developing an open and standardized cloud-based data platform and marketplace.

Following a data driven approach to seamless transport through a data platform and marketplace will deliver a number of short and long-term benefits and help deliver the Intelligent Mobility vision in a more economical way.

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