Internet of Things

Addressing Air Quality with IoT & Big Data

A Value Generation Guide for Mobile Operators

October 2017

About the GSMA
The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai, Mobile World Congress Americas and the Mobile 360 Series of conferences.

For more information, please visit the GSMA corporate website at **www.gsma.com**

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Everimpact
Everimpact is an innovative company that monitors air pollution in real-time using a combination of satellites and ground sensors. Using Everimpact's IoT platform allows cities and companies to access new financing and investment opportunities emerging from the booming green finance markets.

Digital Greenwich
The Royal Borough of Greenwich in London, is one of Europe's leaders in smart city innovation. Greenwich was one of the first to realise that the challenges cities face - traffic congestion, environmental pollution, pressure on services and infrastructure etc - cannot be solved through traditional methods alone. Greenwich instead realised that smarter approaches, making use of new technologies and digital services, are needed to cope with urban challenges. Greenwich has a comprehensive smart city strategy in place and linked to it, a range of strategic and scalable smart city initiatives; delivered by its Digital Greenwich department and wholly owned subsidiary DG Cities Ltd. Central to Greenwich's approach is a comprehensive and integrated strategy which seeks to capture the opportunities from recent advances in technology, data capture and analysis, and apply them at a city scale.

Ordnance Survey
Ordnance Survey provides the location referencing framework upon which Great Britain relies. Its spatial data and services are used to underpin a wide range of policy and business processes including planning, asset management, routing, logistics and risk analysis activities. Its mission is to improve decision-making and operational effectiveness across multiple sectors by delivering services built on authoritative and maintained geospatial information. OS underpins all aspects of national infrastructure, and its expertise is heavily relied upon by government and commercial operators in all sectors to run efficient operations and make effective decisions.

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Executive Summary

Air quality within cities represents a global challenge for governments, regulators, city administrators and citizens. Much of the huge investment in green energy, electric vehicles, and the electrification of rail services is driven by the need to reduce air pollution.

There is an increasing focus by all stakeholders on understanding the levels and causes of air pollution in order to enable interventions to combat it. Today's air quality monitoring infrastructure in most cities is limited due to high installation and operational cost of fixed monitoring stations. This means that data is sparse, making it difficult to understand the levels of pollution experienced by citizens in their daily lives.

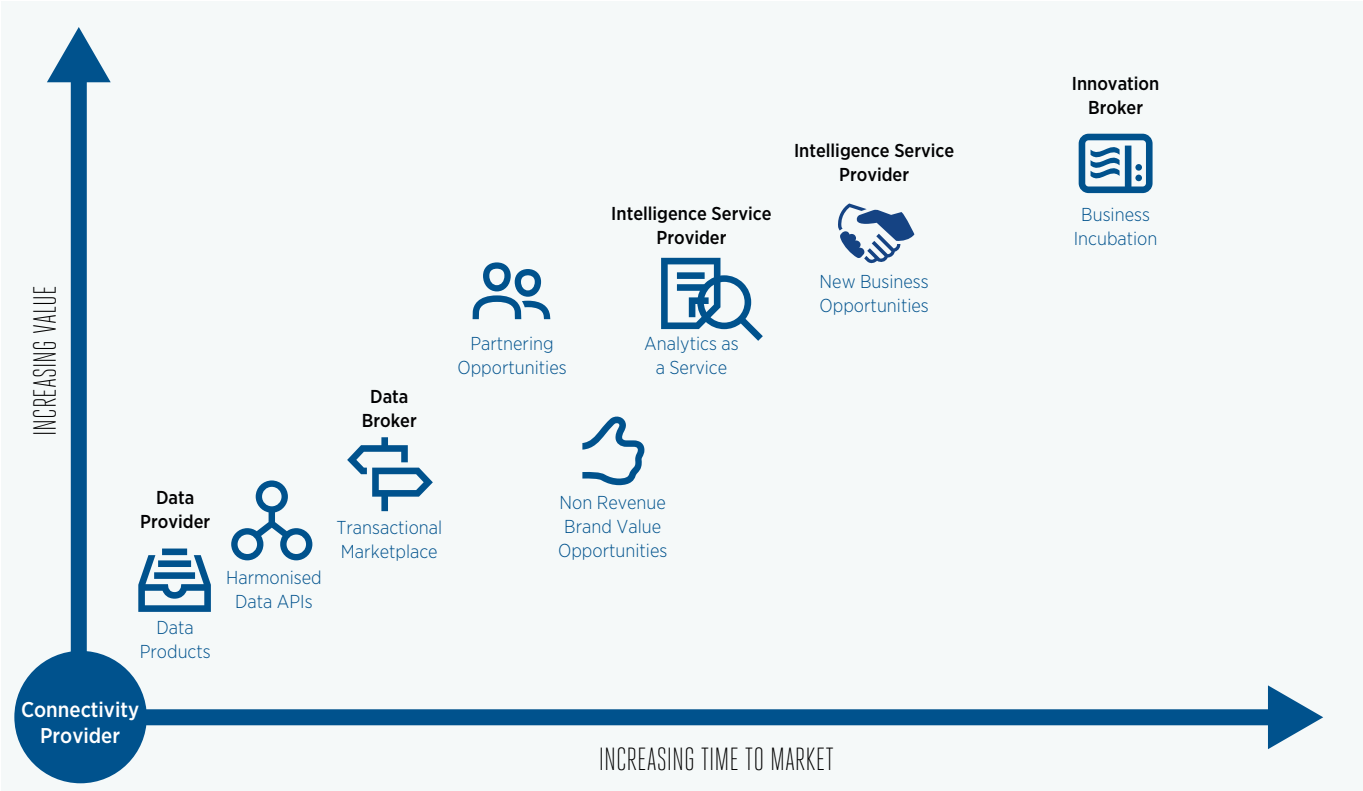
Advances in sensors, IoT and mobile communications technologies have led to the emergence of smaller, portable, low cost, mobile-enabled sensors that can measure and report air quality to cloud-based platforms in near real time. Big data capabilities, such as analytics and machine learning, can then be applied to this and related data sets, such as weather and traffic, to understand the causes and fluctuations in air pollution.

To illustrate the potential value of deploying IoT air quality sensors within cities, the GSMA is working with the Royal Borough of Greenwich (Greenwich) in London on a Proof of Concept project to trial a range of sensor and data types to measure air quality and gain further insights into the levels and causes of pollution. Other initiative partners are Everimpact, who are making air quality data and environmental data available from a combination of satellites and sensors and Ordnance Survey, who are providing OS map zone data for Greenwich.

This guide explores how a mobile operator can monetise these types of air quality, IoT and big data opportunities, including the roles they could undertake and the types of products, services and solutions that they could offer to create additional value. The guide illustrates a number of potential roles for operators including:

- **Connectivity Service Provider**
- **Data Provider**
- **Data Broker**
- **Intelligence Service Provider**
- **Innovation Broker**

Operators can select the roles and opportunities that match their strategy and capabilities. Electing to take one of the higher-value roles moves the operator in the direction of delivering a tailored and optimised solution for a specific market.



The guide also highlights many different potential customer segments for air quality services including:

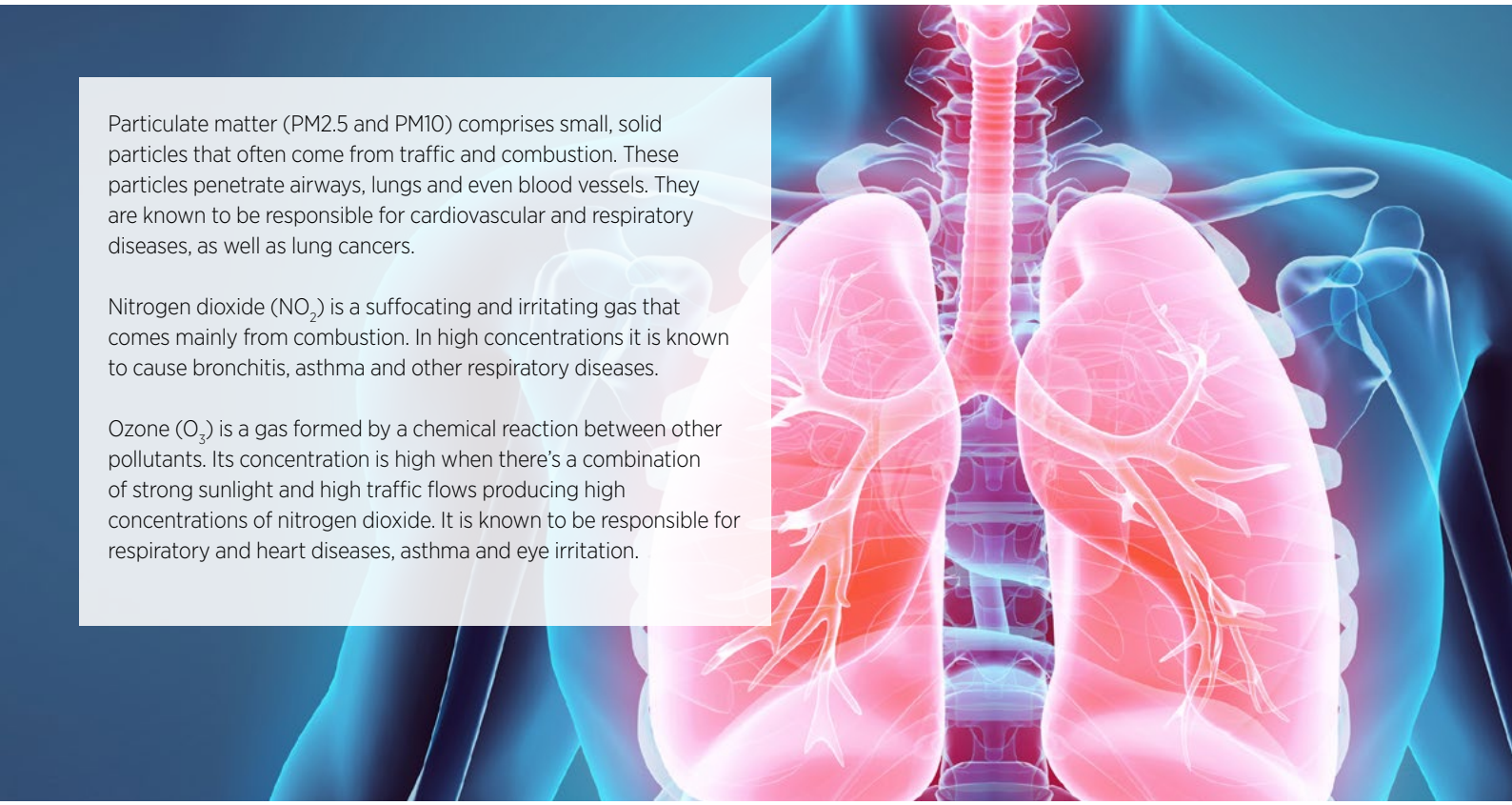
- **Government**
- **Regulators**
- **Science & Environmental organisations**
- **City Administrators**
- **Hospitals & Health Professionals**
- **Schools & Education Professionals**
- **Third Party solution developers**

There are also likely to be opportunities to use air quality data that may not generate revenue but could enhance the value of the operator's brand. As an example, sharing air quality data with health professionals may result in insights that influence the delivery of health services, patient treatments and beneficial patient outcomes. Associating with these societal benefits is likely to improve the consumer's perception of the operator's brand and ultimately deliver value for the company.

Although this paper uses air quality as the proof of concept domain, similar opportunities exist in a number of different vertical markets all underpinned by mobile communications, IoT and big data technologies. This paper illustrates a route opened up by IoT, big data and mobile communications to new revenue streams and additional value.

Introduction

Air quality is in the news globally, whether the context is regulatory breaches[1], poor visibility[2], traffic congestion[3] or health impacts[4]. Air pollution levels in many cities exceed legal and World Health Organisation (WHO) limits for particulate matter and gaseous pollutants and can be found in concentrations which are hazardous to health. Poor air quality is causing a public health problem, since breathing polluted air increases the risk of debilitating and deadly diseases such as lung cancer, stroke, heart disease and chronic bronchitis. Air pollution is now the world's fourth-leading fatal health risk, causing one in ten deaths in 2013[5].



Particulate matter (PM2.5 and PM10) comprises small, solid particles that often come from traffic and combustion. These particles penetrate airways, lungs and even blood vessels. They are known to be responsible for cardiovascular and respiratory diseases, as well as lung cancers.

Nitrogen dioxide (NO_2) is a suffocating and irritating gas that comes mainly from combustion. In high concentrations it is known to cause bronchitis, asthma and other respiratory diseases.

Ozone (O_3) is a gas formed by a chemical reaction between other pollutants. Its concentration is high when there's a combination of strong sunlight and high traffic flows producing high concentrations of nitrogen dioxide. It is known to be responsible for respiratory and heart diseases, asthma and eye irritation.

1. https://www.theguardian.com/environment/2017/jan/06/london-breaches-toxic-air-pollution-limit-for-2017-in-just-five-days
2. http://timesofindia.indiatimes.com/city/delhi/Air-quality-very-poor-but-visibility-may-improve/articleshow/55760195.cms
3. http://www.bbc.co.uk/news/world-europe-26599010
4. http://www.scmp.com/news/china/society/article/2056553/smog-linked-third-deaths-china-more-deadly-smoking-study-finds
5. https://openknowledge.worldbank.org/bitstream/handle/10986/25013/108141.pdf?sequence=4&isAllowed=y

Elevated levels and/or long term exposure to air pollution can lead to serious symptoms and conditions affecting human health. This mainly affects the respiratory and inflammatory systems, but can also lead to more serious conditions such as heart disease and cancer. People with existing lung or heart disease are generally more susceptible to the effects of air pollution and are likely to experience effects at lower concentrations than the general populations.

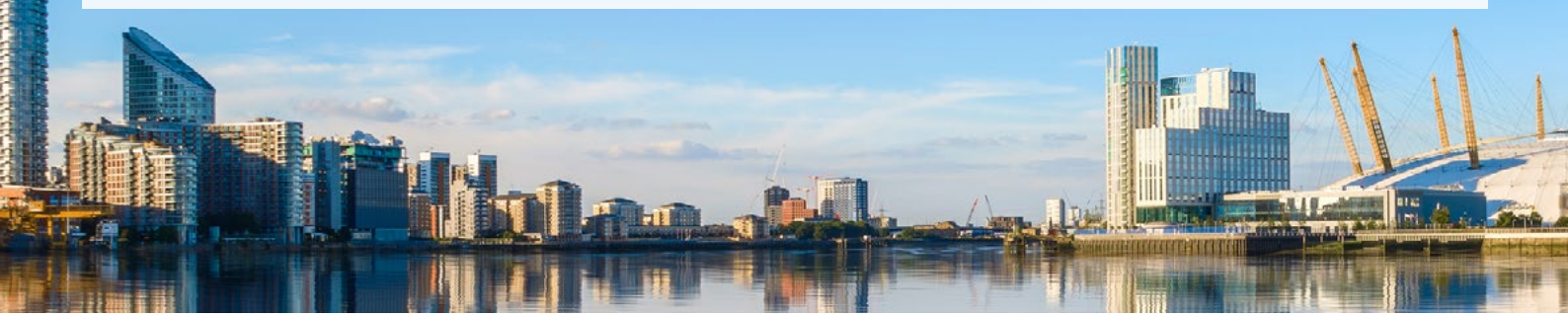
Conventionally, air quality monitoring is performed by large, expensive scientific instruments permanently installed and professionally maintained, at a chosen location. The global market for air pollution control equipment is expected to increase from over $14 billion in 2016 to over $20 billion in 2021 a compound annual growth rate (CAGR) of 7.8%[6]. Government agencies manage and often publish the data collected from country, regional or citywide environmental monitoring networks[7]. Typically this data is verified and aggregated, often resulting in at least a 24-hour lag before publication, offering no opportunity for citizens to avoid or reduce their unseen risks from poor air quality conditions.

Cities around the world are working with emerging technologies in innovative ways to address air quality problems and improve citizens' quality of life. A new generation of lower-cost sensor devices, benefiting from advances in communications technologies, create an opportunity for cities to connect both their infrastructure and their citizens together through the Internet of Things (IoT) and to equip their cities for current challenges and future growth. In August 2017, Machina Research[8] forecast 30 billion connected IoT devices by 2026, representing an opportunity for transformation and innovation. The IoT is generating a huge amount of data and there is untapped potential, globally estimated to be around $44 billion per annum, for the creation of new businesses, products and services enabled via rich sets of IoT-generated Big Data[9].

The GSMA is working with the mobile industry and ecosystem partners to develop common IoT and big data technologies to facilitate the next generation of data-driven IoT solutions. Together, the GSMA and the Royal Borough of Greenwich in London are utilising these enabling technologies to monitor air quality at a more granular level, often in near real time. This air quality proof of concept combines the interests of mobile operators, city administrators, citizens and other stakeholders in further understanding how the IoT and big data can assist in air pollution understanding for the benefit of Greenwich residents, commuters and visitors.

Globally, other cities face similar challenges and many other air quality initiatives are underway, for example China Mobile is working with Chongqing City in China, while Telefonica and Orange are working with cities in France, Spain, Portugal and Brazil.

> One of the challenges the Royal Borough of Greenwich is concerned about is air pollution; and it has clear commitments to tackling poor air quality. The Royal Borough has an existing network of large static monitoring stations; but exploring ways we can supplement this with data from different situations and locations; and understanding the data behind the air quality in our Borough is important to help us introduce measures to lower the impact of air pollution for the citizens of Greenwich. This is why we're working with the GSMA and the mobile industry – to make this happen. Collaboration with industry partners such as the GSMA is allowing us to understand how we can use new technology to gain detailed information about the factors which influence air quality in the Royal Borough of Greenwich.
>
> **Cllr Danny Thorpe,** Royal Borough of Greenwich 's Deputy Leader and Cabinet Member for Regeneration and Sustainability

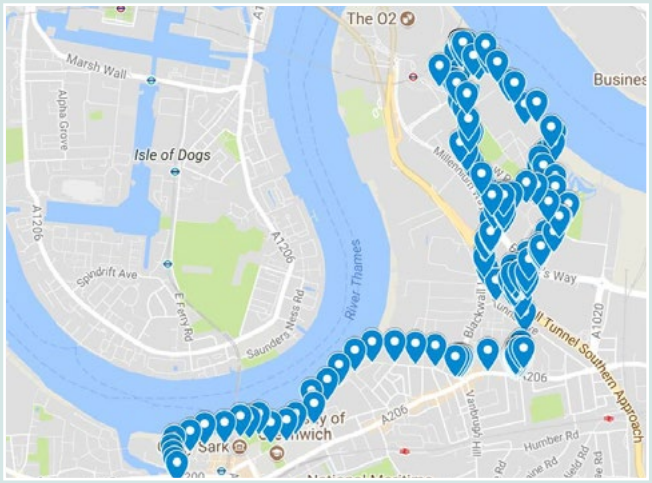


6. https://www.bccresearch.com/market-research/environment/air-pollution-control-equipment-markets-report-env021b.html
7. UK's Automatic Urban & Rural Network (AURN) monitoring stations : https://uk-air.defra.gov.uk/networks/network-info?view=aurn
8. https://machinaresearch.com/
9. https://www.gsma.com/iot/wp-content/uploads/2015/12/cl_iot_bigdata_11_15-004.pdf

Proof of Concept Overview

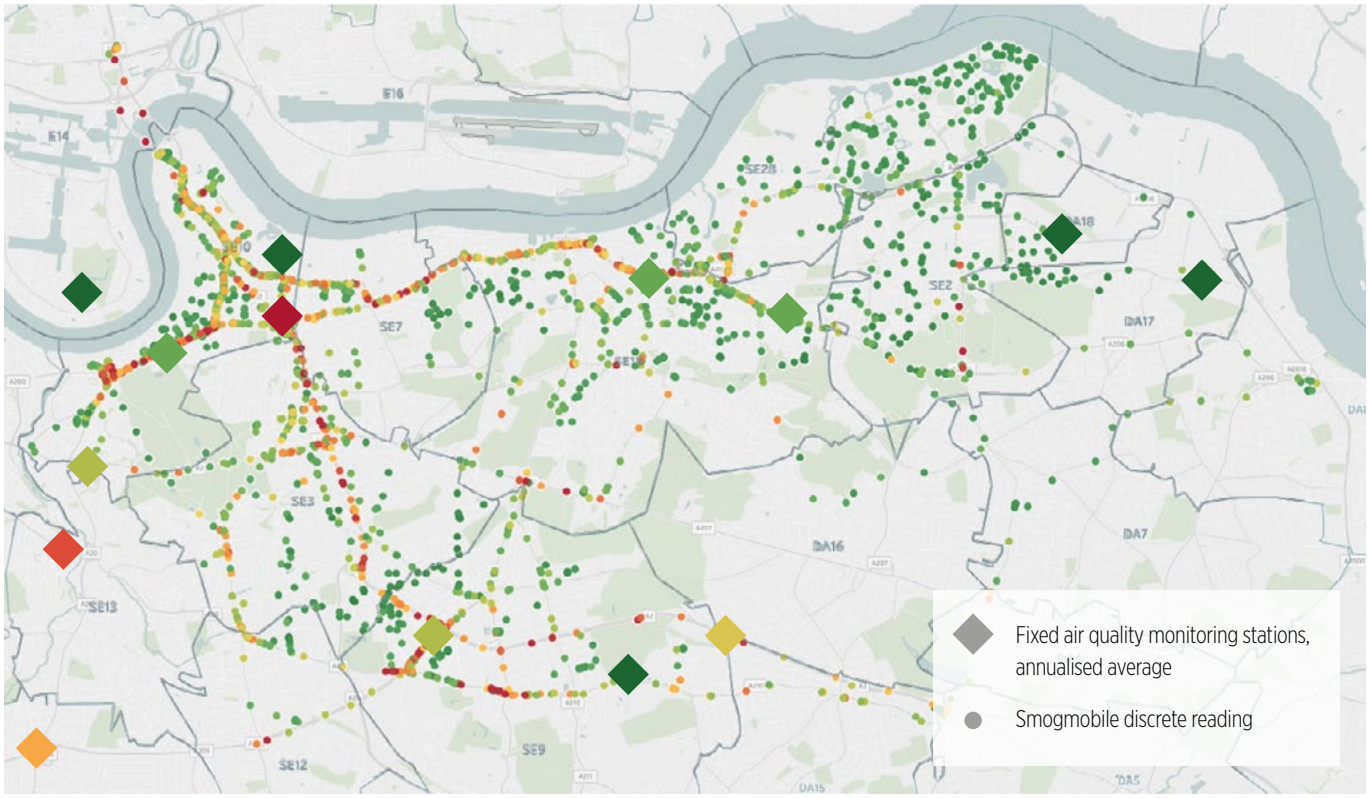
As part of this proof of concept, the GSMA and Greenwich deployed a range of low-cost static and mobile IoT sensors in different ways (e.g. carried by people, on bikes, on buildings) to measure local air quality. All the IoT sensors included mobile communication capabilities and reported data several times a day. A typical journey taken on an electric bike equipped with an IoT sensor is illustrated below.

These portable IoT sensors can travel freely anywhere within Greenwich including; across parks, along footpaths, pedestrian routes, major roads and side roads. As they assess air quality in 'real-time' we expect they will provide much more granular data on the air quality in different locations throughout the day.



The initiative undertook roadside data collection using a high quality mobile air quality laboratory called "The Smogmobile[10]", which sampled and measured the air quality every minute as it was driven around Greenwich for eight days during two consecutive weeks in July 2017. A number of stationary monitoring locations were selected by Greenwich along selected routes through the borough. Additional circular routes were designed by Ordnance Survey which connected points of interest such as local schools and particular roadways of interest.

MOBILE AIR QUALITY MEASUREMENT LOCATIONS IN GREENWICH DURING THE PERIOD 19TH TO 29TH JULY 2017



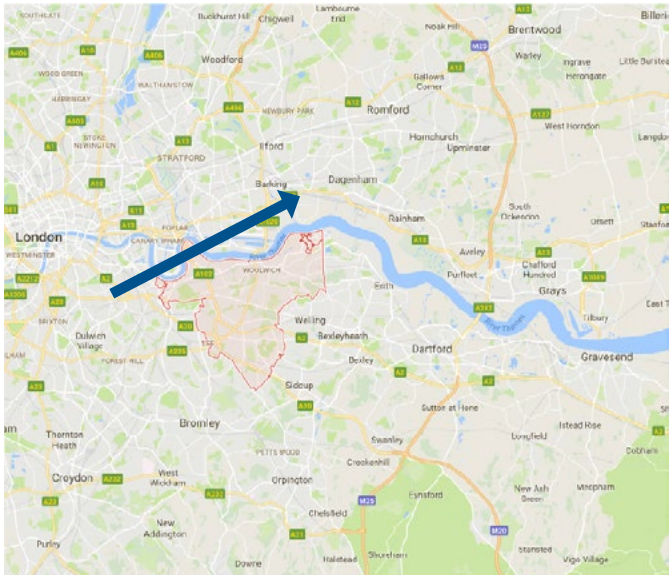
Source: Enviro Technology Services Ltd on behalf of GSMA – http://www.et.co.uk/the-smogmobile

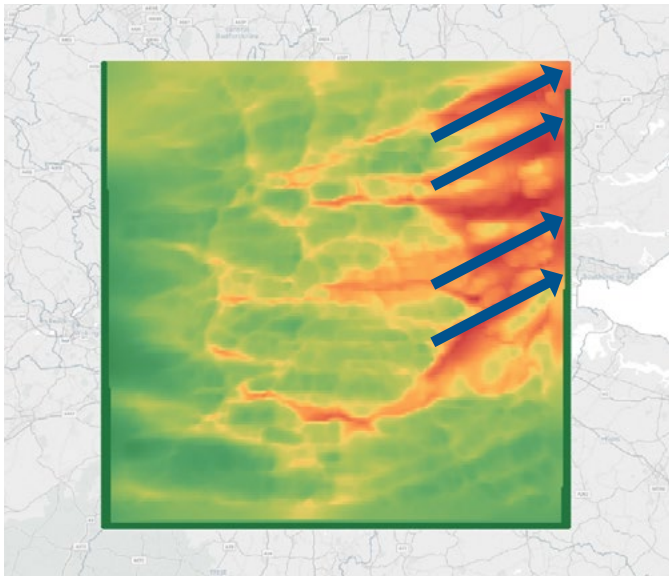
Roadside measurements of air quality reveal how nitrogen dioxide, particulate matter and ozone levels varied along traffic routes. Higher levels of nitrogen dioxide and particulate matter were recorded where vehicles accelerate and at more congested locations, where slow or stationary vehicles with idling engines were found.

Everimpact also supplied the proof of concept with pollutants and greenhouse gas data. The data on pollutants was processed from satellites, emissions databases, atmospheric models and machine learning. Greenhouse gas data was obtained from satellite and environmental sensors and complimented the more granular roadside IoT data. The satellite instruments measure components of the earth's atmosphere by measuring spectral reflections of sunlight as the satellite orbits the earth, flying in a polar, sun-synchronous orbit, providing global coverage with a 16-day repeat cycle.

10. http://www.et.co.uk/the-smogmobile

The satellite data reveals the influence of the prevailing westerly winds on gaseous pollutants such as nitrogen dioxide driven by the wind across London as illustrated by the visualisation below. The annual average wind direction from London City airport being shown superimposed on the nitrogen dioxide trails.





With so much data being generated, conventional analytical techniques become difficult to apply to the data and this is where the 'Big Data' approach including 'Machine Learning' becomes vitally important

The initiative also utilised open air quality data from the London Air Quality Network (LAQN) (hourly data, reported daily) which monitors air pollution in and around the Greater London area. Within Greenwich, an area of 47.35 km^2 (18.28 sq miles) in which there is a residential population of over a quarter of a million people, there are just eleven permanent air quality monitoring stations stations which form part of the LAQN, and data is only available from nine of these via the 'londonair' website.

Context data including weather observation data[11] from static monitoring sites (hourly data, reported hourly), zoning data from Ordnance Survey and the UK Government open data portal[12] was also accessed.

The data from all these sources has been ingested and stored within an analytics and machine learning (deep learning) platform established by GSMA. Big data techniques, including analytics and machine learning, are being applied to the data in order to understand the fluctuations and causes of air pollution in Greenwich.

Air quality is difficult and complex to understand and predict, as it is determined by a wide range of factors including traffic levels, industrial activity, weather conditions, temperature, wind speed and direction, local topology and the local built environment. The analysis of the data gathered during this phase of the proof of concept will be ongoing for some time, and the insights developed will be published separately.

In this proof of concept we are taking a small step towards measuring at a granular level the local air quality within Greenwich, providing city administrators the data and insights that will help them assess pollution levels and consider how to improve conditions for citizens. A similar collaborative approach using IoT and big data technologies could be used to gain insights into the air quality within any other city.

11. National Oceanic and Atmospheric Administration: National Weather Service http://www.aviationweather.gov/metar
12. https://data.gov.uk/dataset/schools-in-england/

Deriving value from Air Quality, IoT & Big Data

There are a number of different of potential customer segments for IoT and Big Data air quality services, including:

- **Government**
- **Regulators**
- **Environmental groups**
- **City Administrators**
- **Hospitals & Health Professionals**
- **Schools & Education Professionals**
- **Environmental Scientists and Researchers**
- **Third Party solution Developers**

There are a variety of roles that mobile operators can take to provide IoT and big data services related to air quality to these customers, as described in the diagram below.

APPLICATIONS OF AIR QUALITY DATA

REGULATORY REPORTING
ENVIRONMENTAL MONITORING
URBAN PLANNING
SCIENTIFIC STUDIES
PUBLIC HEALTH
EDUCATION

Connectivity and device management	Data provider / broker	Intelligence service provider	Innovation broker
■ Connectivity services utilising 2G/3G/4G including Mobile IoT ■ Device management such as monitoring devices status, issuing alerts	■ Monetisation of network and IoT data ■ Cleansing, harmonisation and aggregation of different data sources, including context data	■ Run analytics and machine learning across data sources to provide intelligence as a service	■ Run portal / programme enabling partners and developers to easily access data, intelligence and app development tools

INCREASING VALUE

Different approaches an operator can use to create value from IoT generated air quality data include:

- **A data product approach – selling data products via a transactional marketplace where the buyer has the opportunity to add further value, create and sell new applications;**
- **A partnering approach – partnering with selected third parties who provide the domain expertise, create and monetise new applications or solutions and share revenue with the operator;**
- **A 'New Product' approach –creating and investing in a new product, business and/or brand with new resources that have the required domain expertise to exploit new opportunities.**

CONNECTIVITY & DEVICE MANAGEMENT SERVICE PROVIDER

The core business of mobile operators is supplying efficient, reliable and secure communications, connectivity and device management services underpinned by licensed spectrum. Mobile operators deliver a wide range of communication services such as 2G/3G/4G over extensive territories that encompass all the major cities across the globe. In addition, many operators now offer Mobile IoT connectivity services, utilising new cellular low power wide area network technology (LPWA), to support the growing deployments of IoT devices across cities.

Operators have sophisticated device management platforms and often offer these as part of a service package. Operators have the opportunity to provide consultancy services around communication, connectivity and device management and may choose to develop additional consultancy services focused around IoT, big data and air quality. The customers for these type of services are typically sensor device manufacturers or solution providers who need their devices and solutions to work "out of the box", with zero configuration, as soon as they are powered and switched on; a ubiquitous mobile communications network forms a core component of their solutions.

Mobile IoT networks from mobile operators support low cost, long battery life, low bandwidth connections in high volumes within licensed spectrum. These technologies benefit environmental and air quality monitoring. Features of Mobile IoT include:

- **Very low power consumption, with up to ten year battery life**
- **Low module costs**
- **Better indoor coverage and extended outdoor coverage**
- **Secure and scalable connectivity**
- **Optimised data transfer, supporting small intermittent messages**
- **Low risk of network congestion (due to licensed spectrum)**
- **Simple integration to IoT platforms**

DATA PROVIDER AND DATA BROKER

In the role of the data provider, operators offer the air quality data they have gathered from their network of connected IoT sensors, typically as a paid-for service with access provided through an API. In the data broker role, operators harmonise their own data assets and optionally also data from third parties and make those data sets available via suitable APIs. These are then offered in paid-for, transactional arrangements via a digital marketplace. Operators may work with selected partners to trade access to their data in return for data harmonisation and brokering services. These data sets generally have a higher value than the raw data as they have been preprocessed and harmonised to conform to a common standard to enable developers to use them easily. The GSMA API Directory[13] lists examples of these types of data products and additional examples of how they may be used to create useful applications. For example, in the context of air quality, combining, cleansing, aggregating air quality data from a specific geographic location and time with the associated weather data into a single data set, accessed via a common API, provides more value to many customers than the individual data sets from different data sources.

Marketplaces for data sets and data products are beginning to emerge; for example, Dawex[14] is a global data marketplace where organizations meet, buy and sell data, directly and securely.

CONSENSUS ABOUT THE RISE OF DATA MARKETPLACES

FORRESTER®	"All companies are in the data business now..." "... In 2014 only 10% of enterprises took their data to market, but **32% reported in 2016 data commercialization efforts**" *
Gartner	"By 2020, 25% of large organizations will be either sellers or buyers of data via formal online data marketplaces" "... **We expect to see a sharp rise** in increasingly sophisticated and function-rich **data marketplaces**..." **
McKinsey&Company	"The overall revenue pool might add up to $450 billion to $750 billion by 2030" (for the sole car data monetization) ***
451 Research®	"The ability to monetize the vast amounts of data that ordinary businesses generate is an ambition held by many companies. **Dawex offers a mechanism to enable this to happen**..." "Across industry businesses, both sellers and buyers of data must have confidence in the transactional process. The security and legality of that process is critical to building the reputation of a data marketplace, so it makes sense that **this is the focus for Dawex, and, interestingly, this creates a point of differentiation from its competitors** ..." ****

* Forrester Data: Global Business Technographics® Data And Analytics Survey, 2016

** Gartner: Predicts 2017: Licensing, Legal and Language Lessons for Data and Analytics, 2016

*** McKinsey: Monetizing car data: New service business opportunities to create new customer benefits.

**** 451 Research - Dawex introduces a B2B data marketplace, focusing on security and legal aspects, 2017

13. https://apidirectory.iot.gsma.com/
14. https://www.dawex.com/en/

Offering a portfolio of standardised data products requires little domain knowledge of the market verticals in which the data may be used and is a relatively low-risk, low-cost way of generating revenue. Once operators have defined and put in place the processes to create their data products, operators may participate in this type of marketplace and tailor their offerings in response to market demand. Operators could create pricing strategies for data products that account for the age of the data, with near real-time products potentially commanding premium prices compared with historical data, thus differentiating their product offering and improving their sales revenue.

As an extension to the role of data broker, operators could also create and operate their own data and API marketplaces, crowd sourcing data from many different enterprises who wish to monetise their data assets. This would involve providing legal, commercial, security and privacy frameworks for all participants, from which they could earn a share of the transactional revenue.

Such a marketplace would typically provide:

- **Access to a library of harmonised data through common APIs;**
- **A channel through which other data brokers or data providers can make their data APIs available;**
- **Mechanisms that allow for commercialisation e.g. registration, billing and usage monitoring capabilities by data consumers.**

Operating or partnering with an existing data and API marketplace provider would enable operators to measure transaction volumes and identify opportunities for new combinations of harmonised data for which there is an identifiable market demand. Consultancy services can provide the opportunity to test and learn within emerging markets and could be included as an optional upsell opportunity. The marketplace also creates an opportunity for an operator to engage with many smaller innovative companies, some of which may be suitable candidates as partners to address a particular market niche or market vertical.

Operators may also have the opportunity to provide data products and to collaborate with organisations that are not producing commercial products where the final deliverables are for the benefit of society. In these cases there may not be a direct tangible payment or a viable conventional business case. However, there may be considerable gains in the operator brand value. As an example, sharing air quality data with health professionals may result in insights that influence the delivery of health services, patient treatments and beneficial patient outcomes. Associating with these societal benefits is likely to improve the consumer's perception of the operator's brand and ultimately deliver value for the company. The operators participating in the GSMA Big Data for Social Good[15] initiative are therefore likely to benefit from enhanced brand value.

15. https://www.gsma.com/betterfuture/bd4sg/

INTELLIGENCE SERVICE PROVIDER

Computing power, big data cloud platforms, analytical tools and feature rich visualisation platforms have all evolved rapidly. Many operators have invested in those technologies, platforms and capabilities to allow them to improve their core service delivery, those same platforms and capabilities allow them to offer new analytical services. An emerging approach is to productise those intelligence and insight services in an analogous fashion to a data provider role offering "intelligence as a service", or as a complementary "upsell option" to an existing data product or API. This approach enables operators to explore a market and over time to grow their share of the value chain as their domain knowledge and capabilities grow.

This proof of concept demonstrates that there are business opportunities to offer analytical services. For example, quantifying the aggregated air quality experienced in a given location over time, together with associated traffic dynamics, along with the associated hospital admissions and outcomes linked to air quality in that locality and time period.

Regulators are becoming more active with regard to setting air pollution limits and fines for breaching them. For example, in February 2017 the European Union threatened legal action against France, Germany, Italy, Spain and the UK for breaching limits[16]. Therefore, another potential business model is providing data and insights that allow governments and city councils to understand and manage air pollution to avoid these fines.

An additional opportunity for mobile operators is to offer intelligence based on their network data that is routinely collected for billing and network optimisation purposes. Mobile network data can be analysed to understand population movements across a particular geography, giving operators a unique insight into aggregated population movement patterns. In the context of air quality, aggregated population movement insights could also be correlated with aggregated air pollution data to 'better understand both the causes and impact of air pollution on citizens.

Clearly this more advanced type of analysis or service requires specific resource and expertise across different domains. Providing this as a transactional service could have many benefits for government, researchers, health professionals, regulators and other interested stakeholders. The delivery of 'Intelligence as a Service' allows end customers or partners to incorporate analytics into their own results or solutions without needing to develop the analytics from scratch – or where there is access only to the insights and not to original source data.

These analytical products and services are typically delivered as a custom, one-off service today,[17] with individual contract values ranging from tens of thousands to low millions depending on scope and duration, and are likely to evolve towards standardised or customisable products offered on a transactional basis as the market matures. Most analysts[18&19] predict year-on-year growth in this sector for the foreseeable future. IDC[20] predict worldwide revenues for big data and business analytics will grow from $130 billion in 2016 to more than $203 billion in 2020 a compound annual growth rate (CAGR) of 11.7%.

INNOVATION BROKER

As the IoT big data market develops, there is expected to be an increasing number of developers, both organisations and individuals, who will wish to develop data-driven IoT services. At the same time, many governments and other publicly-minded organisations are predicted to wish to tap in to the innovations possible in the wider community. By becoming an Innovation Broker, a mobile operator is providing a service whereby it offers a range of business incubation[21&22] facilities such as business consultancy, office and meeting space and an online platform, along with relevant datasets, development and analytics tools, to enable innovative third parties to develop applications. In the realm of air quality, this may mean offering datasets on air quality, climate, transport, health and other relevant areas. In addition, intelligence based on datasets could be offered as an "upsell". Offering a development platform to third parties means that they do not need to have the vast computing storage and processing power that is often required to develop Big Data applications. By using this kind of service, a customer such as a government or city council will be able to tap in to a wider range of innovation and also promote business opportunities and economic growth in the community.

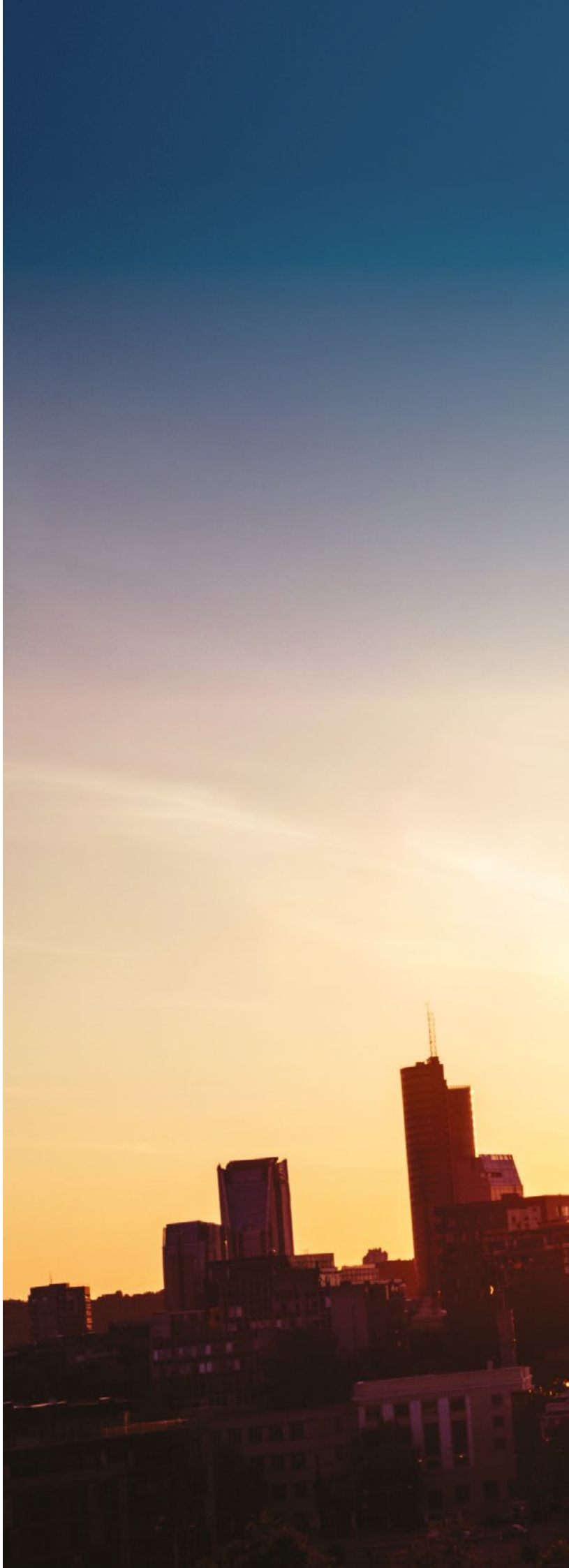
16. https://www.euractiv.com/section/climate-environment/news/five-countries-face-fines-after-breaking-eu-pollution-laws/
17. http://abstracts.aetransport.org/paper/index/id/4881/confid/21
18. IoT Platforms and Software 2016, Berg Insights, www.berginsight.com
19. http://www.marketsandmarkets.com/PressReleases/advanced-analytics.asp
20. https://www.idc.com/getdoc.jsp?containerId=prUS41826116
21. http://cdn.news.o2.co.uk.s3.amazonaws.com/wp-content/uploads/2014/12/02_WAYRA_Report_121214.pdf
22. https://wayra.co.uk/

Conclusion

There is increasing interest from the public, city administrators and regulators in the quality of air within cities across the world. Advances in computing power, big data and the IoT, coupled with emerging mobile IoT communications technologies, create opportunities for operators to develop new revenue streams from data products, services and solutions. We have illustrated that there are multiple roles that operators can take and many related air quality services they can deliver to a range of different customers. Our work with Greenwich provides valuable experience that can be shared with operators and solution providers who have similar IoT air quality sensor deployments planned or underway across the globe.

Mobile operators are well-placed to deliver these new services as they have extensive technical, commercial and delivery capabilities. Although this paper uses air quality as the domain, similar opportunities exist in a number of different vertical markets all underpinned by mobile communications, IoT and big data technologies.

Often the first step for an operator is to become a data producer, creating harmonised IoT big data sets so that they may be offered through a transactional data marketplace. The roles taken by an operator will depend on many factors but is intrinsically linked to their business strategy. Some operators may only wish to test and learn; others may be fully committed to developing a new business offering or an extensive portfolio of harmonised data products and services. This paper illustrates a route opened up by IoT big data and mobile communications to new revenue streams and additional value.



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