
# New Service-provider and Business-model Disruption in the Industrial Internet of Things (IIoT)

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# 1. INTRODUCTION

Horizontal IIoT platforms will proliferate once organizations implement multiple IIoT applications across different business units within a single corporation, for example, and in communal environments, such as smart cities and multi-modal transportation systems. Two other factors that will fuel this trend are the favorable economics of shared platforms and the innovation potential of interoperable IIoT applications. This paper illustrates such a future from the perspective of a large-scale, intelligent transport systems trial (ITS). It involves four customers using a single, horizontal, standards-based IIoT platform to deploy six, interoperable IIoT applications. One disruptive objective of the trial is to enable different Data-as-a-Service business models. These allow device, sensor and transportation-data owners to monetize their assets through incentives for independent IIoT application developers and data-processing service providers.

# 2. NEW SERVICE-PROVIDER AND BUSINESS-MODEL DISRUPTION IN THE INDUSTRIAL INTERNET OF THINGS

Thanks to low-cost electronics, miniaturization and near-ubiquitous wireless connectivity, the Industrial Internet of Things (IIoT) opens up new commercial opportunities in both industrial and consumer sectors.

Many of the early-stage applications focus on point solutions for high-value industrial assets. Examples include remote monitoring and diagnostics for jet engines and industrial machinery. The same principles apply to assets that operate in groups. Thus, a logistics manager can optimize delivery routes for a fleet of vehicles while a beverage vendor has better information for stock control and replenishment schedules across its collection of connected vending machines.

To deliver reliable and high-quality services, these types of applications depend on IIoT service-enablement platforms for three key functions.

- Firstly, they manage network-connectivity services. These are necessary for attaching devices to networks in ways that conserve network resources while enabling identity and security services, for example.
- Secondly, they help to maintain devices over their operating life cycle. Supervisory capabilities ensure that devices are performing within design specifications while remote updating helps to fix software problems and to deliver new functionality.
- Thirdly, service-enablement platforms include features and tools to implement and manage IIoT applications themselves.

The first two sets of functions typically map onto connected device platforms (CDPs).The third category maps to application-enablement platforms (AEPs).

Together with the IIoT applications they support, these two platform elements (CDPs and AEPs) constitute the end-to-end IIoT application stack.

Several IIoT applications may share infrastructure components such as communications networks, data centers and cloud computing services. This is the commercial model for many IIoT service providers which support tens or hundreds of enterprise customers and their individual, silo applications.

## 2.1 What Characterizes Future IIoT Systems?

Future IIoT applications and systems will extend the boundaries of these silo approaches. The one-dimensional IIoT stack will evolve orthogonally to support interoperability. Not only does this add value [1] to individual applications, it is also the basis for innovative, cross-silo opportunities.

The following illustration shows a simple scenario of two separate testbed environments, each supporting two IIoT applications comprising application logic (App #n) and associated connected devices.

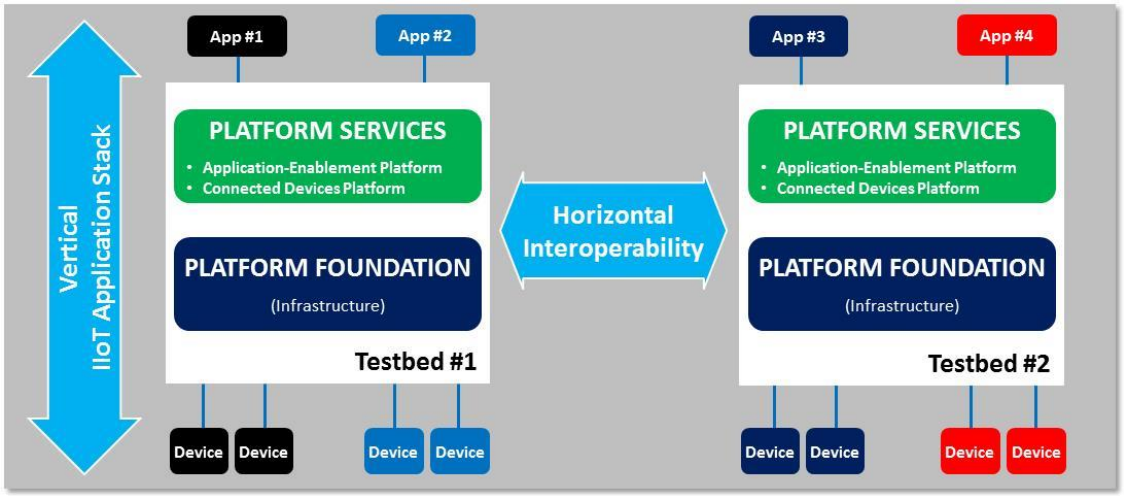


*Figure 1: Vertical and horizontal dimensions of IIoT solutions*

In the absence of custom designs or systems-integration shortcuts, there is no scope for silo applications to cooperate. This means that sensors from one application are inaccessible to other applications. In the accompanying illustration, App #1 may technically be able to communicate with devices associated with App #2 and certainly not with App #3 or #4 or their respective devices.

[1] **The Internet of Things: Mapping the Value Beyond the Hype**, McKinsey Global Institute (June 2015)

This is economically inefficient as measured by device (or sensor) duplication and associated management overheads. It also hinders service and business-model innovation by narrowing the opportunity to create value either through proprietary gateway designs or systems integration activities.

One of the early conclusions from the Industrial Internet Consortium's (IIC) pioneering testbed activities is that testbeds exhibit a high degree of commonality among IIoT service-enablement functions, independently of vertical use-case specifications. This is a general characteristic of future IIoT application delivery models. The logical conclusion is the need for open horizontal platforms for which the IIC established its Open Horizontal Test-bed Program (OHTP ).

For a horizontal platform to be effective, participating service providers have to work to a standard. At one level, this ensures technical interoperability. On another level, individual platform users benefit from a set of standard operating procedures. This ensures a coherent and communal set of rules for resource sharing, data/service monetization and the application of privacy and security-management policies.

Just like the Internet and its many backbone service providers, the IIoT market will support multiple horizontal platforms for competitive reasons. Geographic and regulatory factors about data governance will also play a role.

Some platforms will specialize in key verticals such as communications services, intelligent transport services and smart city services, for example. However, by adhering to a common standard, there is no technical reason to prevent these platforms and their IIoT applications from interoperating. This means that smartphone-based applications from the telecommunications sector could interact with environmental sensors or smart-utility applications. Similarly, platforms for consumer-oriented, connected-car applications could interoperate with intelligent transport and smart city platforms.

Future IIoT systems will support interoperability and common service-enablers for IIoT applications. These will enable multiple organizations to cooperate through common operating procedures and multi-sided, commercial models.

## 2.2 Common IIoT-service Enablers for Interoperability

Upon activating multiple IIoT applications and their associated devices via associated AEPs and CDPs, there are two sets of requirements to support interoperability. The first is a set of basic functions for data producers (devices and sensors) and data-consumers (IIoT application logic) to publish, subscribe and process data streams within a coherent operating framework. In relation to Figure 1, a device belonging to App #1 can publish its data stream and have App #1 and App #3 subscribe to it.

The second set of requirements corresponds to a group of common service capabilities. These standardize basic functions such as data collection, data storage and data publication. Alongside

these functions are a more complex set of services such as data discovery, data brokering, protection of data-ownership rights and tools to track data- and resource-usage for charging purposes.

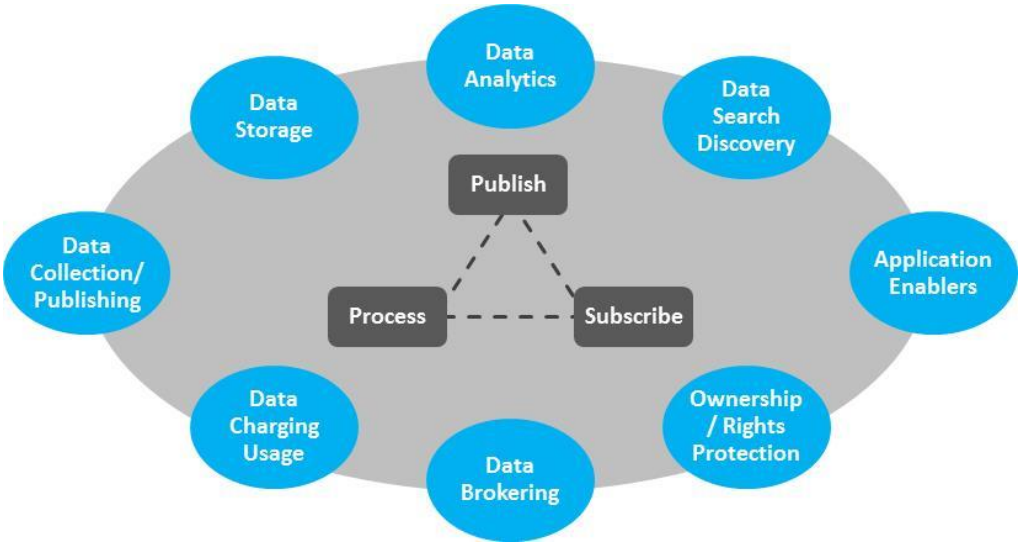


*Figure 2: Common services for IIoT data-management and application enablement*

Once data belonging to different IIoT application owners enter a common environment, there are new opportunities for application service providers to share data on commercial terms. This leads to another important feature of next generation IIoT platforms. This is the capability to support a data brokerage, which functions as an open marketplace for data and for data services, through a Data-as-a-Service (DaaS) business model.

## 2.3 Business, Operational and Technology Drivers of IIoT Solutions

Interoperability and horizontal platforms satisfy some of the practical aspects of IIoT solutions. However, enterprises do not make design and deployment decisions in isolation. This means that post-pilot IIoT solutions have to align with corporate priorities along business, operational and technology dimensions.

All but the simplest of IIoT applications will involve multiple sensor types and devices sourced from a broad supplier base. Some devices may conform to industry standards while others will include proprietary features. Almost certainly, IIoT applications will straddle legacy information technology (IT) and operational technology (OT) systems as well as new device and sensor deployments. Heterogeneous IIoT environments such as these favor open standards solutions.

As companies embrace IIoT strategies, they will manage multiple applications in one or more business units. Strategically, this favors technologies that are adaptable and re-usable. Adaptability matters in several respects. It means using a core set of technologies, design- and operational-management tools across multiple applications and business units. Adaptability,

through easily configurable components, means that companies don't fall into the trap of creating bespoke solutions for each and every use case.

There are multiple dimensions to the re-use requirement. It may involve sharing a group of devices and sensors to support multiple applications in order to lower implementation costs. In other respects, re-usable hardware platforms are commercially more appealing to drive economies of scale. And, software re-use reduces the need for multiple pools of expertise and the risk of losing institutional knowledge.

Many enterprises frame their investment decisions around an initial IIoT application to address a pressing use-case or application requirement. This approach is blind to the innovation potential second and even third generation services. The capacity for new services is inherent to many IIoT applications and carries a value that traditional business cases often fail to capture.

As an example, consider how an application for a particular industrial problem might generate data relevant to a different market segment. A vehicle manufacturer's connected car application, to track wear and tear for example, can feed data into a usage-based insurance application for a marginal cost. This is an example of a multi-sided business model where the economics of one application create data to support new service innovation at a cost that undercuts traditional business models.

IIoT applications can also have a business transformation impact. This may be the case of a manufacturer creating a consumer-oriented service on top of an established enterprise-market product. A medical device supplier, for example, supplies diagnostic equipment to hospitals in a business-to-business (B2B) model. One avenue of innovation around the diagnostic device is to create a variant for the consumer segment or to make the data from the hospital device accessible to patients in an extended business-to-business-to-consumer (B2B2C) model. IIoT technologies and platforms make this possible. By selecting the right technologies, standards and partners for the very first IIoT application and service-enablement environment, each organization either opens up or closes down the prospect of future business opportunities.

Extended and multi-party business models drive the need for interoperability which characterizes many IIoT applications in communal operating environments. These situations are very common connected vehicles, office buildings and manufacturing facilities, for example. They also apply to distributed environments such as transportation networks and smart cities.

As a practical example, we illustrate the different IIoT challenges that multiple cooperating partners have to overcome in the context of an intelligent transport system.

## 2.4 IIoT Interoperability Viewed in the Context of Everyday Travel Journeys

People who are traveling to their homes, meeting venues or places of work care foremost about their entire journey which may involve multiple modes of transportation and associated services.

A typical journey might begin with road travel in a private vehicle, followed by parking at a train station, then travel by train and possibly a public-transit bus service at the end of the journey. If there are travel disruptions then traffic update services, based on recommendations from transportation and police authorities, become part of the end-to-end journey.

In today's transportation industry, there is no easy solution to link different private and public sector agencies involved in an end-to-end journey. Point solutions and proprietary products limit the opportunities for cross sector integration and have a detrimental effect on citizen end-users.

Multiple proprietary solutions to common needs are a recurring feature of today's transportation industry. For example, a local authority transportation services manager seeking an IIoT parking solution faces a choice of more than a dozen different solutions. All of them offer similar capabilities, but each implementation is different, with differing benefits, costs and (importantly) a lack of compatibility with neighboring county authorities and existing legacy systems. All these issues lead to a very fragmented experience where only partial information is available for travel journeys.

Transportation service providers are beginning to recognize that they are part of a larger eco-system involving public and private sector organizations. No single organization owns the citizen end-user's problem and no single organization has the expertise or investment capacity to deliver an intelligent transport experience. This is where the role of a standards-based, open horizontal platform becomes so important. It enables a common technical, operational and business environment to facilitate collaboration between different agencies and associated service providers and to deliver a better intelligent transport experience.

## 2.5 Innovative Implementation of a Large-scale, Multi-party, Intelligent Transport System

oneTRANSPORT is a large-scale, intelligent transport system (ITS) trial[2], partially funded by Innovate UK. It involves eleven public and private sector organizations with an operational footprint that covers about 10% of the population of England.

The trial is a useful reference model for future IIoT applications due to its target use-cases and system architecture. Specifically, several different user groups share a common IIoT platform and service-enablement capabilities. This offers significant commercial, technology-management and interoperability benefits. There are obvious commercial benefits from platform sharing and the pooling of expertise across different disciplines. These are important priorities for budget-

[2] **oneTRANSPORT Open Marketplace for Data**, http://onetransport.uk.net/

constrained public sector agencies whose core mission does not extend to significant capital investments in IIoT technologies[3].

Within the trial, five organizations represent the customer viewpoint. These include four English counties, Buckinghamshire, Hertfordshire, Oxfordshire and Northamptonshire, as well as the Highways England transport agency. The counties in the project outsource the management of their transportation services and have no immediate inclination to own or manage their own IoT platforms. Other trial participants include ARUP (transportation sector expertise), Traak (traditional analytics methods) and Imperial College London (research-based analytics).

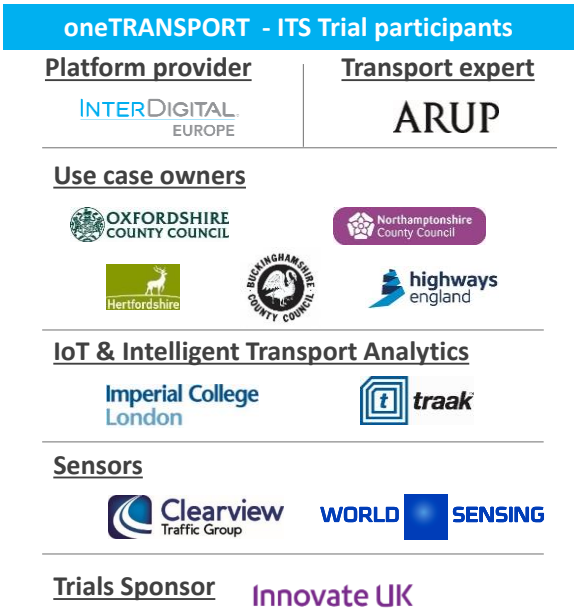


*Figure 1: oneTRANSPORT, multi-party IIoT eco-system*

InterDigital's role in the trial is to provide a oneM2M™ standards-based horizontal IoT platform. One of the factors driving the choice of the oneM2M™ standard[4] is to anticipate future growth as the system absorbs or interoperates with platforms belonging to neighboring counties or other transportation-sector agencies.

Standardization delivers additional technology-outsourcing benefits in terms of supplier diversity and a long-term features road-map which is inherent to the standardization process. Interoperability is central to the operational philosophy and underlying platform. This simplifies the process of creating cross-silo applications and lays a foundation for new business innovation.

The trial makes use of over 200 types of data assets belonging to the five customer organizations and to two other transportation system and infrastructure managers, Clearview Traffic Group and WorldSensing.

Connected devices and sensors, of course, are not the only source of data for this trial or most other large-scale IoT applications. A journey-planning application, for example, uses information about planned road closures (e.g. at peak traffic times or on public holidays) as well as occasional lane closures due to planned and emergency roadwork. The platforms requirements for such IoT applications include common service functions to source data from back-end, enterprise IT

[3] **Connect It – oneTRANSPORT: using open IOT standards to connect UK counties, IEEE Communications Society webinar,** http://www.comsoc.org/webinars/connect-it-%E2%80%93-onetransport-using-open-iot-standards-connect-uk-counties

[4] www.onem2m.org, **oneM2M™** is a trademark of the **Partners Type 1** ARIB (Japan), ATIS (USA), CCSA (China), ETSI, TIA (USA), TSDSI (India), TTA (S. Korea), TTC (Japan)

systems, from electronic spreadsheets and even from notes in handwritten manifests. This diversity of data sourcing comes close to the notion of a 'web of things.' It means that IoT platforms need the versatility to handle new and increasing numbers of data-input formats.

It is common to characterize transportation systems in relation to commuters, public and private sector transportation agencies and service providers. An important aspect of the trial is to extend the base of participants, initially through a set of developer hackathons, to evaluate the commercial viability of specialist service providers. These may provide IIoT applications in a competitive business framework, or data cleansing services in the form of tiered services and pricing schemes for raw, clean, high-accuracy and meta-data, for example.

The commercial and operational viability of such businesses depends on having access to generic capabilities such as data brokering, data search/discovery, data usage charging, data storage and rights enforcement within a horizontal IIoT platform.

Federation and scalability capabilities are also essential for future eco-system growth, which is addressed by a Transport Data Initiative group. It hosts regular workshops to inform other local authorities about new, IIoT possibilities; encourage better transportation system solutions; and promote the integration of currently fragmented solutions at a local and cross-county scale.

## 2.6 Innovation Opportunities: IIoT Data Market-places and Data Monetization

Currently, many public sector authorities make little operational or commercial use of the data coming from their transportation-infrastructure assets. In some cases, they make such information freely available through open-data portals, often incurring data management and publishing expenses in the process. One of the disruptive benefits of oneTRANSPORT is to create mechanisms for these authorities to monetize their data assets, while stimulating multi-system, multi-region integration and economic growth.

A ground breaking element of the trial is a brokerage structure. This allows device owners to feed their data to specialist data management service providers in order to produce clean and value-added forms of data. The different forms of data from a single source open up the possibility for differential access and pricing schemes. In this case, the underlying IIoT platform has to facilitate data management, access control and charging functions to support multiple business models. This type of innovation is an important aspect of the oneTRANSPORT trial and its business case which trial participants will evaluate in three phases.

**Phase 1: In-Field Trials** - The first phase in the business model is an equity-sponsored two-year trial. This start-up phase will generate minimal revenues so funding for the trial relies on a private-public equity funding model.

For this phase, multiple local transportation authorities open their data assets to the software development community through a oneTRANSPORT broker, who manages data access and

transactions above the horizontal IIoT platform. Some of the key activities in this phase involve the integration of existing data assets belonging to the local authorities, installation and integration of new sensors from the project partners (parking and journey-time estimation sensors), development and testing of mechanisms for charging and usage, development of embedded analytics by project partners, creation of an exemplary software application and deployment of initial data filtering tools.

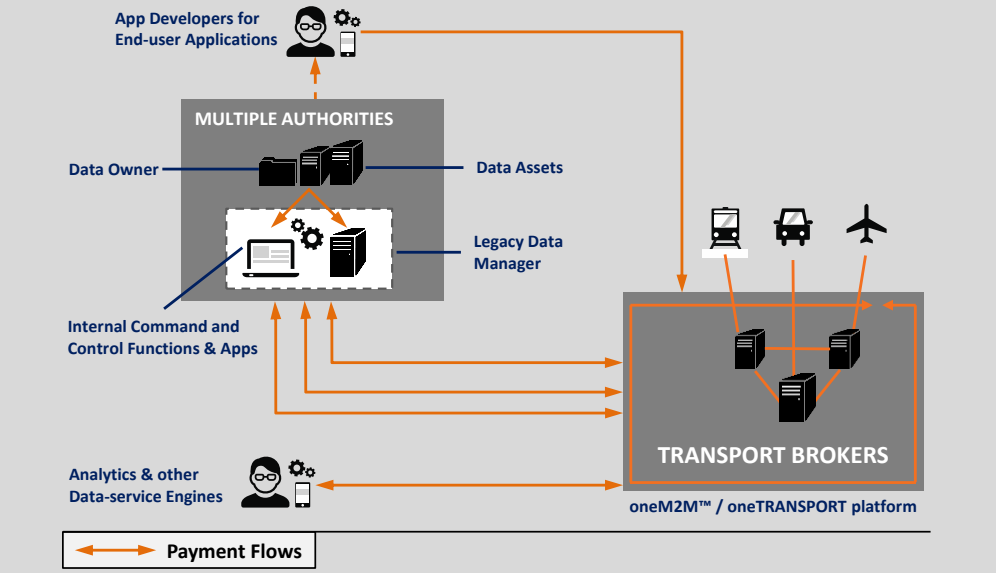


*Figure 4: oneTRANSPORT Phase 1: Connect transportation authority assets to software developer community*

In this phase, local authorities may take the role of oneTRANSPORT brokers by administering the platform and taking full charge of providing their data to the public.

A second objective of this phase is to create the tools that grant data access to application developers. These developers will use an interface to the exemplary application to speed up the creation of their own software applications. They will also profit in the future from advertising and/or payments for application sales and in-application purchases.

**Phase 2: 1st Commercial Stage** - The second phase of the trial corresponds to the first stage of a commercial rollout. In this phase, mobile application developers pay the local oneTRANSPORT broker for accessing data from a proxy server connected to data assets belonging to multiple, county authorities.

A key element of the second phase is to offer a more comprehensive, fee-based Data-as-a-Service (DaaS) capability to application developers. This will contain enhanced analytics and data in premium formats.

This phase will initiate an open marketplace for data and data-services, which will allow different mobile applications to be offered to users from a large number of software developers.

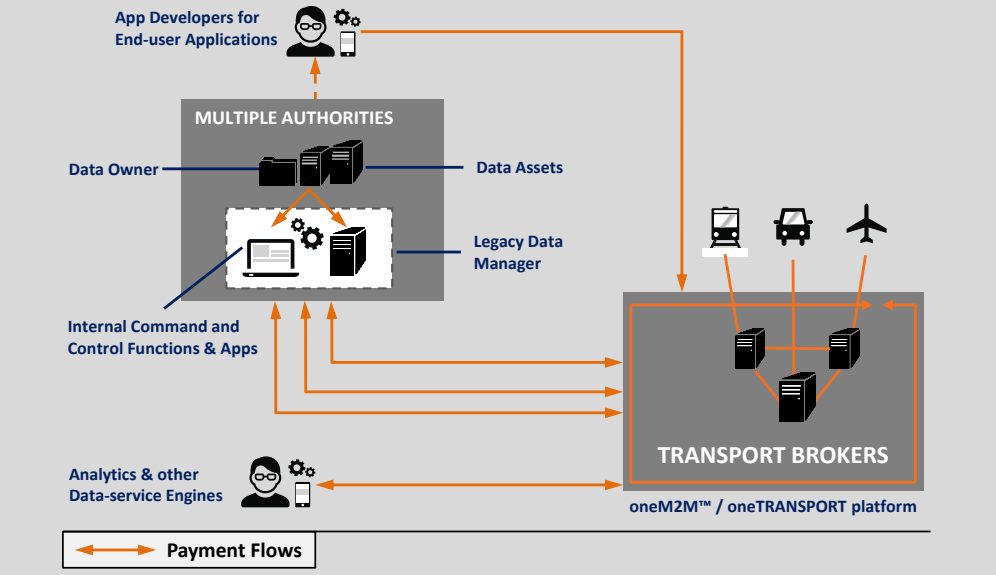


*Figure 5: oneTRANSPORT Phase 2: Initial commercial rollout for access via oneTRANSPORT broker*

At this point, local authorities will profit from users accessing their data assets, via mobile software applications, subject to charging (very modest) data access fees. In turn, an appointed local oneTRANSPORT broker will start deriving profits through licensing fees. A portion of these fees will support a growing eco-system of subcontractor partners and multiple brokers.

The oneTRANSPORT brokers can be the platform vendor, partners, local authorities or third parties. These transportation brokers may specialize in different modes of transportation, or coordinate data from different geographical areas.

**Phase 3: 2nd Commercial Stage** – The third phase, a full commercial stage, has multiple brokers that provide a rich set of data, analytics and data services to software developers and data/services consumers. In this stage, several brokers might offer different analytics and data filtering service covering local, national or international data assets and multiple industries.

This third phase will involve a higher degree of integration among multiple proprietary, open and standardized platforms and the full offering of services from multi-sector brokers to additional local authorities and software developers.

Revenues will increase progressively due to more data users accessing the platform, the availability of more software applications, external data users using the system and a large variety of analytics and premium data services from a competitive market of several brokers. Software developers generating new solutions for mobile application developers will offer a variety of data services in the platform.

The plan for this phase is to offer a scalable business solution with large national rollout, which becomes possible because of modest investment contributions from local authorities and competitive market pressures.

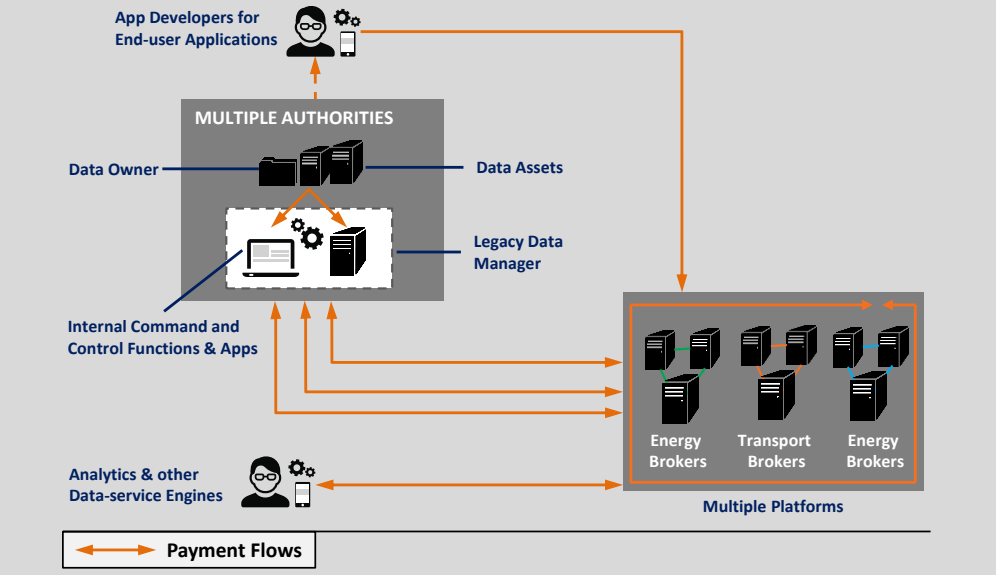


*Figure 6: oneTRANSPORT Phase 3: Extended commercial model involving multiple brokers and rich, data-sets*

Additional direct benefits to the local authorities will increase over time, coming from savings in transportation subsidies and reduction in health services for pollution-related illnesses.

Indirect benefits to counties include reduced commuter journey times, a lowering in pollution related expenditure and increased interest in local investment.

The multiple transportation brokers in this phase can coexist in one or multiple platforms targeting specific sector needs.

## 2.7 Organizations can Expect Business-model Disruption from IIoT Platform Innovations

Suppliers and users of IIoT solutions face a more complex business future, characterized by closer interaction between businesses via partnerships and service-delivery eco-systems. In addition, the magnitude of the IIoT opportunity will introduce operating-scale challenges, beginning at the level of connected devices, gateways and sensors and the data they produce.

IIoT platforms will consequently be essential to automate service-enablement processes in order to deliver high-quality IIoT applications at cost-efficient price points. IIoT platforms will also be essential to support interoperability and to contain the impact of systems integration investments each time two organizations or a company's different business-units wish to collaborate.

Standardized IIoT service-enablement plays a pivotal role in heterogeneous IT, OT and multi-vendor environments. The oneTRANSPORT trial, and its eleven participating organizations, typifies such an environment. The trial also addresses many of the business, operational and technical challenges arising from a matrix of multiple applications and multiple users. Under such

conditions, the trial highlights the value of open standards to enable IIoT applications that span multiple organizational boundaries.

Beyond the very real challenges of enabling multiple IIoT applications, oneTRANSPORT illustrates the disruptive potential of open, horizontal IIoT platforms. In particular, Data-as-a-Service and data-marketplace concepts allow public- and private-sector organizations to create new services and generate incremental revenues from their assets. These innovations also encourage new-entrant businesses to provide data-management services and to foster differential pricing models for data.

Over time, oneTRANSPORT will develop into a federated platform for multiple public- and private-sector organizations. Its standards based framework will foster IIoT collaboration in a commercially sustainable and geographically-scalable manner.

The evolution of oneTRANSPORT's phased deployment plan progresses from enabling a single user-entity to multiple cooperating entities and eventually to multiple use-cases on a shared platform. This journey is one that many enterprise users will copy once they deploy their own IIoT applications and progressively become involved in cross-silo and partnering application opportunities.


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