Machina Research

White Paper

The Smart City is Open: the role of open systems as a key enabler of the smart city

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1 Executive Summary

Cities are increasingly aware of the benefits of an 'open' approach to becoming 'Smart'. It is already recognized that being locked in to an integrated solution from a single vendor is sub-optimal. However, there is insufficient clarity on the full implications of and challenges of 'open-ness', in terms of connectivity, interfaces between applications and city verticals, standards and procurement. This paper explores this and argues for an open eco-system that develops independently but integrates seamlessly at a higher level. This, it is suggested, is key to unlocking increasing value over time from different verticals and applications.

Making the city 'smart' requires the introduction of new technology-based systems to deliver these functions. The implementation of different applications should not happen in silos and requires a holistic approach. The new generation of systems needs to be capable of working together, to support some of the 'smart' use cases already envisaged, to allow the development of others as yet not conceived, and to enable the use of the new technologies and standards which are still evolving. Flexibility, and open systems, are the key to this.

In a mature, stable industry environment formal standards are the trusted method for ensuring interoperability between different vendors' offerings. In an evolving environment, though, where innovation is rapid and the technology is still being developed, open-ness is best delivered via interfaces. Smart cities are very much in this evolving stage. Business models, interconnection methodologies, sensor and connectivity technologies are all in a process of rapid change.

We do not yet know which models of interoperability will emerge, between cities, applications systems and providers. What is required from an open system, therefore, is the ability to inter-operate with others via defined interfaces. This is the case both with respect to existing systems and applications and future ones.

Such an open systems approach holds out the possibility of:

- Exchange of data with other entities.
- Synergies between applications.
- More open and competitive markets for systems and solutions.
- Developing new business models.

Pursuing an open approach heightens the importance of protection for both data privacy and security. An implementation of smart city technologies that depends on open interfaces to derive the maximum value by allowing for synergies between applications requires that security is enforced equally effectively across the entire network of partners.

Fundamentally all smart cities applications work in a similar way: an edge device exchanges data with a back-end IT system for the purposes of supporting a particular application. However, there are a number of possible different architectures.

- The various applications are developed on common Connectivity and Application Enablement Platforms. This would require the city to specify the platform(s) to be used.
- The applications are able to integrate with each other through open APIs as well as with the city platform.
- A single vendor is responsible for supporting multiple applications.

Each of these architectures have distinct advantages and disadvantages, discussed in detail in the full report.

We propose the following recommendations:

1. **Inter-operability should be a guiding principle in every project and every stage.**

2. **Forward compatibility with future decisions about inter-operability is more important than a once-and-for all platform choice.** In the early deployments of smart city applications, as municipalities test the waters, it is best to focus on deploying specific vertical applications, e.g. street lighting, refuse collection or parking, rather than trying to implement overarching city platforms.

3. **Cities need to stay flexible and prepare for a future based on open standards and APIs.** During the current stage of smart city development, the key to remaining flexible is implementing open systems that enable interoperability via interfaces.

4. **Choosing open and recognized standards is a crucial element that is required to ensure open and durable systems and infrastructure.** Where no recognized standard exists yet, the ability to work via APIs is key to guaranteeing openness.

2 Contents

3 Scope

The purpose of this report is to examine the criticality of open systems as key enablers of smart cities.

Cities are increasingly aware of the benefits of an 'open' approach. It is already recognized that being locked in to an integrated solution from a single vendor is sub-optimal. But there is insufficient clarity on the full implications of and challenges of 'open-ness', in terms of connectivity, interfaces between applications and city verticals, standards and procurement. This paper explores this and argues for an open eco-system that develops independently but integrates seamlessly at a higher level. This, it is suggested, is key to unlocking increasing value over time from different verticals and applications.

'Smart cities' is a very broad subject in which a very wide variety of players are involved. These include, among others: national governments; international and regional inter-governmental agencies such as the EU and the UN; international standards bodies; regional and city governments; specialist smart city consultancies and other kinds of consulting organization such as engineering consultants, management consultants, and others; think tanks; ICT companies such as software vendors, systems integrators, start-ups, and telecommunications operators; specialist suppliers of operational systems, including lighting, water management systems, and traffic management systems; transport operators; car manufacturers; architects and planners; and academics and researchers. In preparing this report we have tried to engage with representatives of as many of these types of entity as possible so as to provide the most comprehensive examination of the issues within the scope of a brief document.

This report has been sponsored by Philips with the aim of investigating the relevance and value add of open systems within the smart city context. It aims to provide key smart city stakeholders with relevant insights on system requirements and highlight the importance of systems interoperability within a smart city ecosystem.

The report is based on interviews with:

- Bristol Is Open
- Digital Birmingham
- Future Cities Catapult
- SAP
- Israeli Ministry of Energy
- City of Cologne
- TM Forum
- Pacific Controls
- Vodafone
- FlowCity
- Pacific NorthWest National Laboratory
- World Council on City Data
- Philips Lighting
- AT&T
- Telefonica
- US Department of Energy
- Sierra Wireless

4 Smart city as a global trend

The concept of the 'Smart City' is one of the key emerging technology trends of the 21st century. Cities around the world are turning to technology to solve their problems. The first question we should ask ourselves is: what is a smart city and why are we seeing such a flurry of activity now?

4.1 What is a smart city?

There are almost as many definitions of 'smart city' as there are smart city projects[1]. Nevertheless, some common threads run through all of the definitions. These are:

- Information and communications technology as a key enabler
- Efficiency of urban systems, including both the operational functions of the city government, and of systems which the municipality does not control but which exist on the territory under its administrative jurisdiction
- Sustainability, including reducing carbon emissions and improving air quality
- Quality of life for citizens, through better public services and improved governance
- Economic development, through improved access to communications and new business models enabled by new technology

There are a wide range of different application areas that are all part of the broader smart city concept, including:

- Smart Lighting - Outdoor lighting accounts for 40% of a municipality's electric utility bill. Moreover, maintenance is labour-intensive and represents a significant cost. In smart cities, lighting becomes increasingly sophisticated and municipalities are implementing measures to reduce costs and energy consumption without compromising public safety. This includes smarter systems to adjust light output to meet seasonal or local conditions, flexibly adjusting to varying needs, and more advanced asset monitoring, fault reporting and workflow management. The trend goes to simplified implementation of plug and play systems, like in the City of Los Angeles with the world's largest street light inventory connected via CityTouch.
- Smart parking – A variety of cities, including San Francisco's SFpark scheme, have tried to implement smart parking systems to reduce congestion, reduce CO2 emissions, increase occupancy of spaces, and even increased revenue from more targeted charges.
- Smart traffic management – Incorporates road tolling, connected road signs, traffic lights and traffic volume monitoring. Often a complex deployment as part of an Intelligent Transport System. A good example is the Sydney Coordinated Adaptive Traffic System (SCATS).
- Smart public transport – Connecting public transport vehicles, and infrastructure, for the purposes of better passenger information, route optimisation, payment and authorisation, and the provision of in-vehicle WiFi, amongst other things.

[1] The ITU-T Focus Group on Smart Sustainable Cities, in its paper 'Smart sustainable cities: An analysis of definitions' (https://www.itu.int/en/ITU-T/focusgroups/ssc/.../TR-Definitions.docx) found 116 definitions before offering its own synthesis.

- Smart CCTV - Surveillance using video cameras is used for monitoring public spaces such as high streets where banks and retailers are located, airports, public buildings, town squares and any areas which are associated with high crime rates. Surveillance using CCTV cameras is common in large cities around the world.
- Smart Waste - Streamlining waste collection in the city. One company, Big Belly Solar, dominates this sector. The barriers to entry are relatively low and the application is not a complex one to deploy.

A smart city incorporates many of these applications, but it is certainly not limited to these.

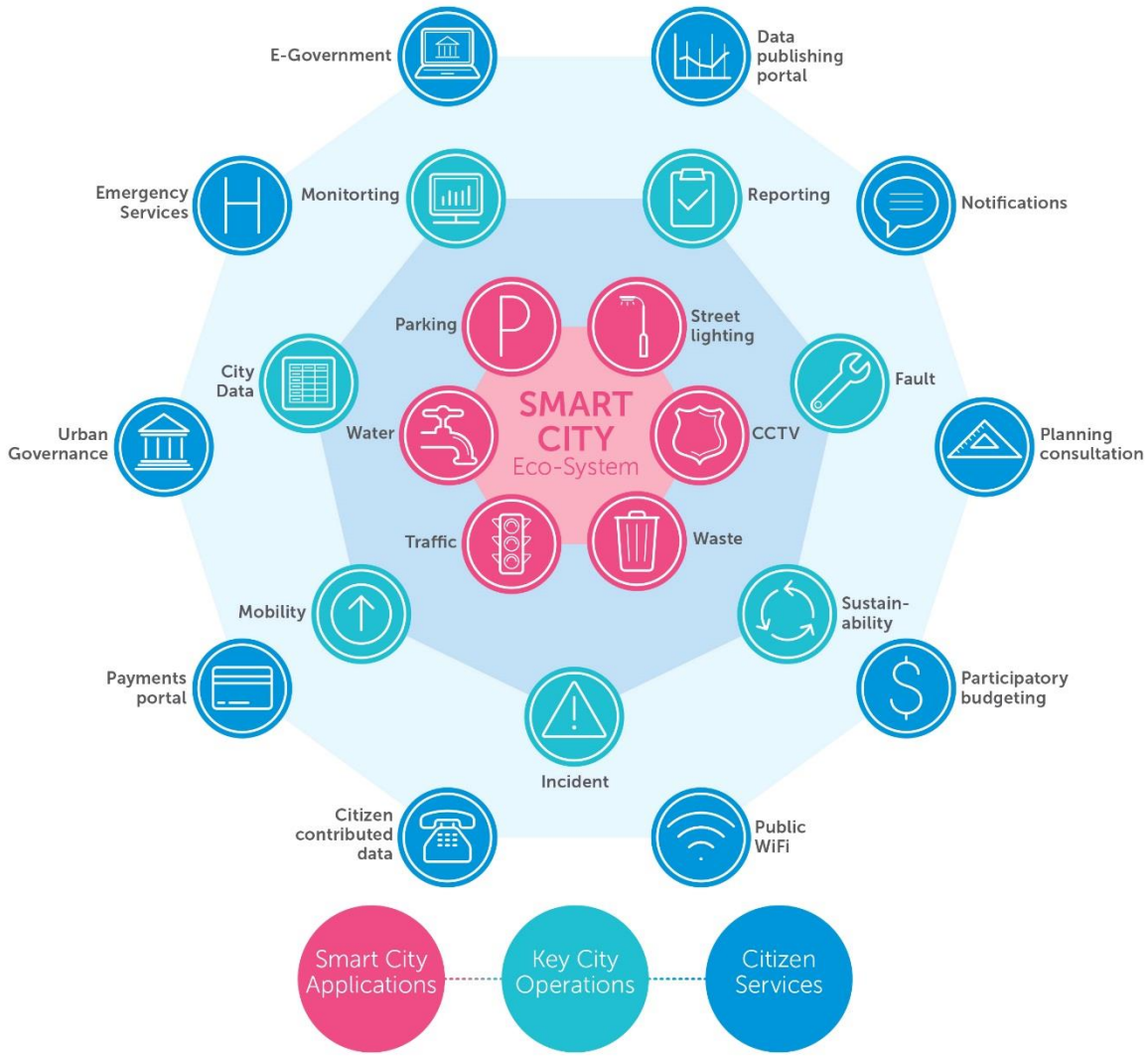


Figure 4-1 Smart City Functions

Municipalities may also include as part of their smart city initiative services that are somewhat distant from IoT deployments or operational services, such as the provision of public municipal WiFi, or the publication of the city's data, even if it is derived from conventional collection methodologies or IT systems. Some cities include citizen facing services, including on-line consultation and mobile apps

which provide planning notifications or information about planned road closures, and citizen-to-citizen 'community building' and 'sharing' applications. Essentially it is anything that improves the running of the city through the application of technology.

The relationship between smart versions of 'core' urban operations, and these other citizen-facing functions is shown above in Figure 4-1.

Note also that urban 'business models' and administrative responsibilities vary widely. In France the elected mayor of a provincial city may be responsible for the police force; in Britain many 'core' urban functions are provided by central government or contracted out to private organisations, so that the function of the municipality is limited to procurement.

4.2 Key drivers for smart cities

Smart Cities are high on the political agenda around the world. In its 12th Five Year Plan, the Chinese government allocated CNY1.6 billion (USD260 billion) for smart city investments, and had since created over 300 smart cities[2]. The Indian government has put aside USD1.2 billion for the creation of 100 smart cities[3]. Singapore has invested substantially in its Smart Nation Platform. And it is not just in Asia that the transformation can be seen. Across Europe[4] and the Americas[5] cities are implementing schemes for connecting various aspects of everyday life. Why? There are a number of major drivers, which break down into five main categories: Demographic; Environmental; Financial; Technology Enablers; Business and Application Models. These are summarised below in Figure 4-2.

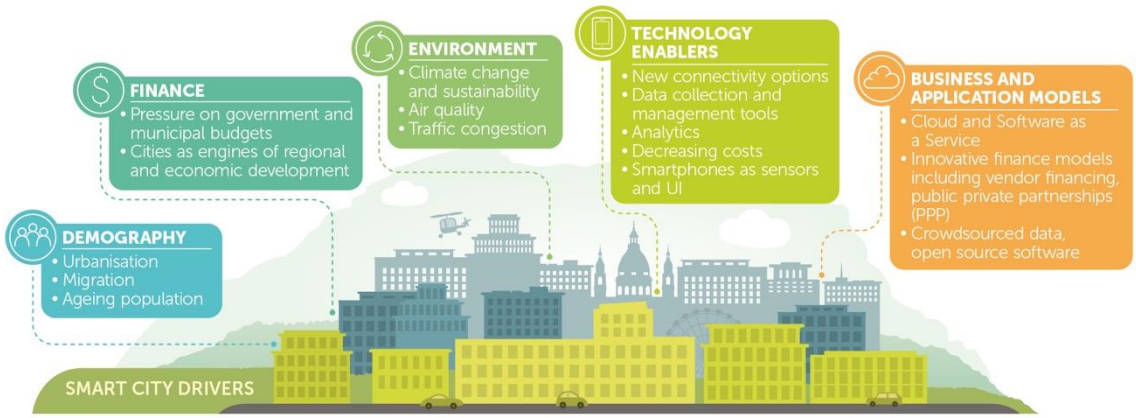


Figure 4-2 Smart City Drivers

[2] See Research Note "China's Smart City initiatives pick up pace and will have a global impact" (April 2014)
[3] http://edition.cnn.com/2014/07/18/world/asia/india-modi-smart-cities/
[4] Such as the European Innovation Partnership on Smart Cities and Communities (http://ec.europa.eu/eip/smartcities/) and the European Initiative on Smart Cities (https://setis.ec.europa.eu/set-plan-implementation/technology-roadmaps/european-initiative-smart-cities)
[5] For example, this initiative by the White House in the USA https://www.whitehouse.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help

5 The importance of open systems

This paper advocates an Open Systems approach to the development of the smart city as a way of ensuring the maximum degree of interoperability between cities, their systems, and the broader context in which they exist.

5.1 Moving beyond silos in the smart city

A municipal administration is a complex entity. It has lots of departments and processes. The city also has lots of internal systems. Most of these will have been developed and implemented at different times and may use old, proprietary technologies. They will not have been designed to share information or work together.

> challenge of the cities is that information gathering is happening in silos
>
> Marlyn Zelkowitz
> SAP Solution Director Future Cities

Making the city 'smart' requires the introduction of new technology-based systems to deliver the functions described (see Section 4.1 above). To derive the maximum value from these, the implementation of different applications should not happen in silos and requires a holistic approach. The new generation of systems needs to be capable of working together, to support some of the 'smart' use cases already envisaged, to allow the development of others as yet not conceived, and to enable the use of the new technologies and standards which are still evolving. Flexibility, and open systems, are the key to this.

5.2 Classification of "open systems"

While support for 'open-ness' is universal, there is a lack of clarity as to what this means and how best to achieve it. Some cities, and some vendors, insist that the only sure road to an open environment is through formal published standards. Others argue for open-ness via defined APIs which are in effect translators between otherwise incommensurable systems. Still others emphasize 'open data', in terms of availability of data sets, and the *licences* under which they are provided. Open source, in essence a method for creating and distributing software, is yet another way of defining open-ness.

> In the Smart Cities of tomorrow, more than in any other typical IoT deployments, openness and interoperability are key.
>
> Remy Marcotorchino
> SierraWireless

The difference between these approaches comes down to context. In a mature, stable industry environment formal standards are the trusted method for ensuring interoperability between different vendors' offerings. In an evolving environment, though, where innovation is rapid and the technology

is still being developed, open-ness is best delivered via application programming interfaces (APIs). This dynamic is illustrated in Figure 5-1 below.

Smart cities are very much in the evolving stage. Business models, interconnection methodologies, sensor and connectivity technologies are all in a process of rapid change. Here an open system means one that can inter-operate with others via defined interfaces such as APIs. This is the case both with respect to existing systems and applications and future ones.

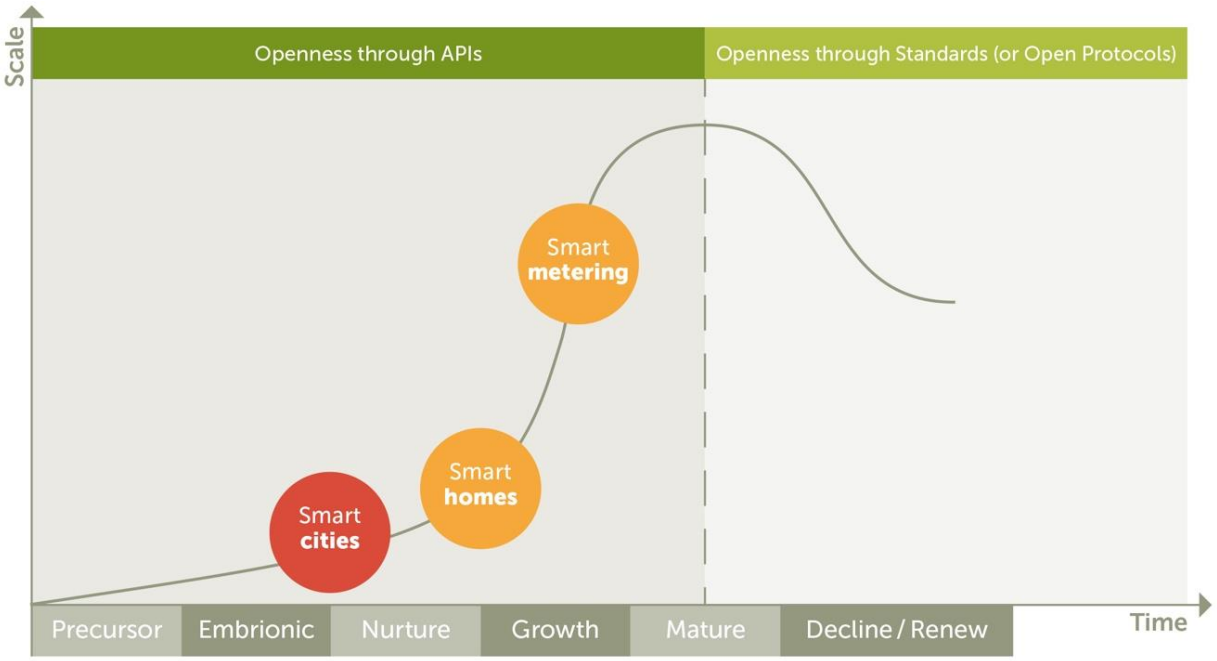


Figure 5-1 Industry Life-Cycle Smart City

5.3 The relevance of "open systems"

In the current development phase of the smart city industry and its dynamic and flexible environment "open systems" hold out the possibility of:

- **Exchange of data with other entities.** Cities are rarely 'islands'. Most need to share data with other local government entities (in London, for example, the city government is responsible for only 5% of roads, with most of the rest being managed by lower-level boroughs but motorways the responsibility of the national Highways England agency), national governments, and private companies including transport operators, utility companies, contractors, among others.

- **Synergies between applications.** Some of the most interesting and potentially most significant implementations of smart city applications involve using

> To be able to get good data insights you need to combine different sources of information.
>
> Marlyn Zelkowitz
> SAP Solution Director Future Cities

data from sub-system in an entirely separate domain. This might include using traffic data to allow street lights to adapt according to the number of vehicles on the street. Similarly, Paul Wilson of Bristol Is Open described to us a use under consideration which involved using air pollution measurements as inputs to a dynamic price system for public transport, so that the latter would become more attractive when air quality was low.

- **More open and competitive markets for systems and solutions.** Vendor lock-in creates markets, which are not competitive; open interfaces allow for wider and fairer competition between players who are downstream of applications that create data sets. This helps to ensure cheaper prices and better solutions for the cities. Vendor lock-in also ties the customer cities in to their chosen vendors' road maps, preventing them from looking elsewhere for more up-to-date solutions and restricts their choice of application and use case going forward.

> Greater interoperability offers users more choice and reduces their risks. Most importantly, it facilitates the installation of best in class solutions, which ultimately results in improved system performance, increased user satisfaction, and more adoption
>
> Michael E Poplawski
> Pacific Northwest National Laboratory

- **Developing new business models.** City governments and their agencies will inevitably create more data than they are able to use. Even if they were able to think of all the possible uses for such data, resource constraints would prevent them from exploiting all the opportunities. Open interfaces and data formats allow data to be used by third party developers. This can be used to create new business models, including compensating and rewarding the city agencies for collecting and processing the data; and cities can choose to make their data available as a way of stimulating economic development.

> Cities can avoid high costs of updating, running and managing the IT themselves.
>
> Marlyn Zelkowitz
> SAP Solution Director Future Cities

5.4 Respecting privacy, ensuring security

Pursuing an open approach heightens the importance of protection for both data privacy and security. An implementation of smart city technologies that depends on open interfaces to derive the maximum value by allowing for synergies between applications must, of necessity, create additional exposure. A more open ecosystem means that access to critical interfaces, and data sets, is distributed more widely. This requires that security be enforced equally effectively across the entire network of partners.

While critical systems are deployed within closed silos based on proprietary technologies the risk of unwanted intrusion is reduced. This makes the requirement for an overall security framework even more important. In the words of Chris Stock, Director, Security and Privacy Management Programs, TM Forum: "You do need to think quite carefully about how secure the major systems in your smart cities are, because they are increasingly interconnected. The more you link together, the more you need to make sure all the links in the chain are secure."[6]

A detailed discussion of what measures are needed to ensure privacy and security of smart city deployments is beyond the scope of this document[7]. However, security requirements of an open system can be summarized as follows:

- Dedicated user roles, so that users are assigned different levels of access depending on authorization. This means that customer-specific data cannot be accessed by unauthorized users, and every user is granted exactly the access rights needed so that they only the data specifically for their needs and can only execute authorized operations (the 'Least Privilege Principle'). In addition, data from individual customers is kept strictly separated.
- Strong passwords and two-factor authentication, enforcing the use of strong passwords for login. (Two-factor authentication prevents logging into the system from any unauthorized computer).
- Forward secrecy, so that today's data transmissions also stay confidential in the future. During a session, potential threats such as long user inactivity or the change of the user's IP address are detected and the user is logged out automatically
- Full encryption of all data throughout the system
- Tamper-proofing, so that only authorized and registered devices can communicate with the system. This prevents unauthorized third parties from tapping the communication and tampering with data during transmission. Traffic to and from the registered devices is monitored closely by the system to automatically detect any possible attacks, such as Denial of Service, or misusage, such as theft. All data is regularly backed up and stored encrypted.
- Input validation, on the basis of pre-defined data types, avoiding input of wrong data formats (for example, numbers, string fields, etc.).
- Secure communications, so that there is proper authentication and integrity while making efficient use of data traffic. There should be strict firewall rules between the communication device and central server in place, and filters should include port, protocol, source IP and destination IP.

[6] Quoted in 'Smart cities: Up close and too personal?' as above.
[7] For a longer discussion of this see
http://smartcitiescouncil.com/sites/default/files/public_resources/Smart%20city%20security.pdf

6 How to make your smart city future proof

6.1 Role of standards

Machina Research is committed to open standards as a necessary part of the process for ensuring inter-operability, in the IoT generally and in the Smart Cities domain specifically. We support the development by Standards Development Organizations (SDOs) of 'top-down' standards frameworks for smart cities, including the ISO/IEC Joint Technical Committee work on a reference architecture and the 'International Technical Working Group on IoT-Enabled Smart City Framework' being led by the US National Institute of Standards and Technology (NIST). We also see value in the 'bottom-up' initiatives of industry groups, such as AllJoyn/AllSeen, OneM2M, FiWare, HyperCat, and others. We look forward to the future meeting point of the top-down and bottom-up efforts in a coherent reference architecture and common set of standards for smart cities.

However, in the current phase of smart city development, where there is a real need for integrated and inter-operable solutions but where the standards framework is by no means complete, standards of themselves are of little use. We agree with Carl Piva of the TM Forum that:

"Standardization is less important in the innovation phase. It's better to document agreed practice, so as to create de facto standards. In this way best practice can become widely spread. We favour a Darwinian approach to standards. There will be areas that are perfect for standardization, e.g. physical sockets. But if you're doing things that haven't been done yet, starting with standards doesn't allow the flexibility to pivot."

At the higher levels of abstraction standards define the relationships between different entities and the interfaces between them. At lower levels, in the absence of an end-to-end framework, they can be unnecessarily prescriptive, locking cities in to technology choices that may be rapidly outpaced by events, and potentially discouraging innovative approaches.

Within this context, a city is both like and unlike an enterprise. The city government is a relatively strong point of control, but it is not the whole of the city, and it is a compound entity with multiple separate silos. Unlike an enterprise, it has multiple goals and objectives, some of which are defined externally (for example, by national governments or regulators). Ensuring an open systems approach is therefore both more challenging and more critical.

Open standards are reliable as they are developed through a consensus-driven process with all stakeholders of the industry: they are more thoroughly reviewed, evaluated and tested than proprietary solutions and are seen as neutral between particular vendors. In principle everyone can supply to a specification based on an open standard. But it can take a lot of time until a global formal standard has been developed and accepted through ought the industry.

Depending on the maturity phase of an industry, the role of different standardization layers can vary. The standard protocols for the "Application" layer of the Open Systems Interconnection (OSI) model[8],

[8] The OSI project at the ISO, ISO/IEC 7498-1

such as widespread HTTP and HTTPS, as well as CoAP (Constrained Application Protocol) are globally used and accepted top down standards, and new systems that are being implemented in the smart city environment should support these protocols. Standards at the “Transport” and “Internet” layers, however, are mainly bottom up de facto standards developed by industry groups and alliances within the current flexible smart city environment.

In an industry environment that is mature and stable, formal global technology standards work well to assure interoperability across a system as a whole. However, the smart city industry is not yet in the mature phase of its development (see figure 5.2.) but rather in a very dynamic, rapidly evolving phase, where not all required standards have been developed and accepted thorough the industry yet. Nor is there an overall framework of layers, as described above, into which the individual standards can be fitted.

At such a stage of development there is typically a host of competing technologies, protocols and ‘standards’, often defined by industry groups or single vendors. Some of these may eventually become formal, open standards, but it is hard to know which ones. This presents would-be suppliers, and customers, with a stark choice; either pick one set of technologies in the hope that they will prove to be winners, or remain flexible, implementing open systems that allow inter-operability via APIs.

6.2 Different options for connecting applications

> We see the potential and benefits we can derive from connecting different smart verticals.
>
> Paul Wilson
> Bristol Is Open

Fundamentally all smart cities applications work in a similar way: an edge device exchanges data with a back-end IT system for the purposes of supporting a particular application. However, there are a number of possible different architectures. Most critically smart cities applications are typically characterised by the substantial potential benefit for the city manager of managing multiple applications. The benefits include a simpler user interface, easier data sharing with third parties, and the potential for building applications that relate to multiple sensor types. An example might be to adjust street lighting levels on roads where there is a lot of traffic.

Beyond this, Machina Research believes that there are some potential benefits from trying to implement a common environment earlier in the process than simply the point at which data is delivered to the city. Having a common interoperable and open system should speed innovation and will also allow for more real-time interchange of data. It is easy to get carried away with the expectations here, however. It is questionable the extent to which real-time applications might be necessary, once we apply a healthy dose of reality. For instance, is it really feasible for refuse collections agencies to act in real time according to when public bins are full? This seems unlikely given

> It is important not to create dependence on one certain company.
>
> Phil Skipper
> Vodafone

the way that the collection of refuse is currently managed. Many city functions have to work within other real world restrictions that might make real-time use cases less useful, and shift the focus onto predictive analytics rather than real-time reactive analytics. With that caveat considered, there are still benefits to ensuring different applications can interact directly, rather than exclusively through the central management platform.

Carl Piva of the Tele Management Forum commented that the industry should be in favour of "designing something that can integrate in all directions, both vertically and horizontally, North, South, East and West. Independence is a useful asset, but you need the ability to interconnect with a wider network."

There are a number of ways that we might implement such a system, and three examples are presented in Figure 6-1 below. We take it as understood that allowing each application to remain in its own silo, with no interaction at all with other city applications, is not a good approach. We have therefore not depicted this 'Option Zero' on the graphic.

- Option 1: In the horizontal city-wide platform various applications are developed on a common connectivity platform. This would require the city to specify the platform(s) to be used.
- Option 2: Vertical end-to-end system envisages applications being able to integrate with each other through open APIs as well as with the city asset management platform.
- Option 3 assumes that a single vendor is responsible for supporting multiple applications.

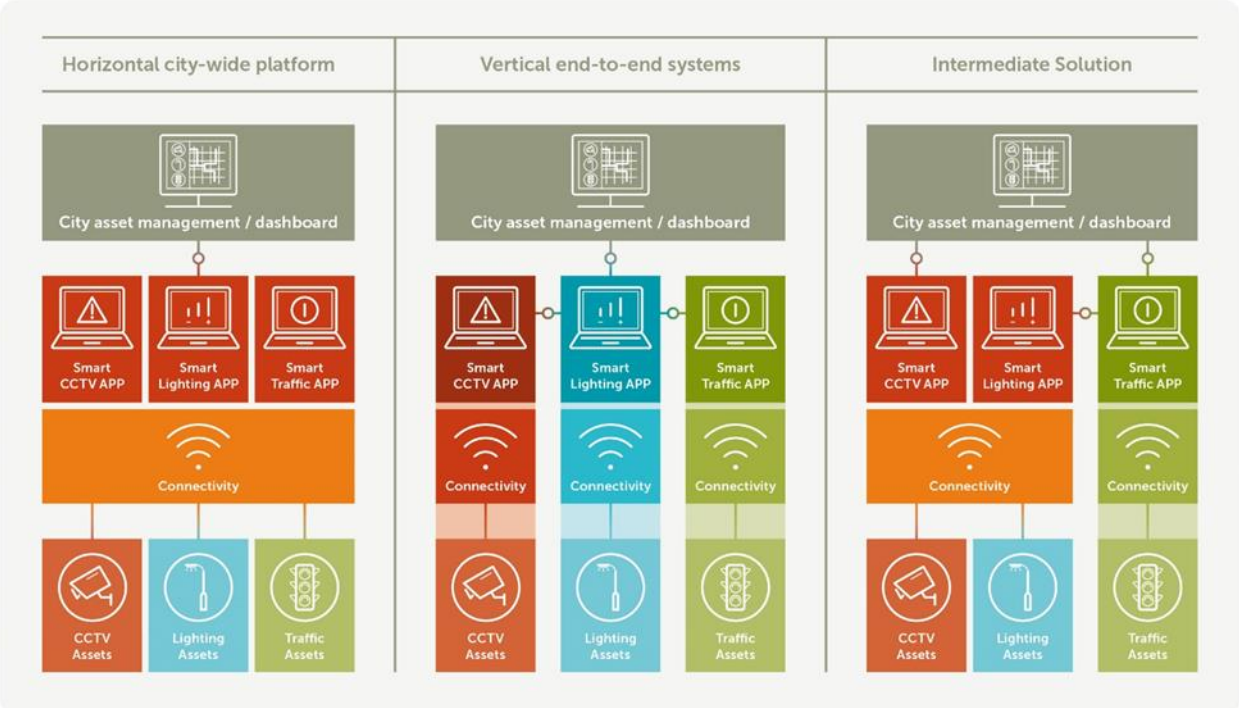


Figure 6-1 Options for interconnecting applications

Figure 6-2 assesses the relative merits of the three options listed above. While Option 3 has the benefit of allowing quick deployments, it represents a developmental dead-end with a lack of interoperability with other applications and vendor tie-in.

> We have three IoT platforms already, and we would be happy to have more. We don't want one platform to rule them all
>
> Paul Wilson
> Bristol Is Open

As a result, the long-term options really divide between connecting all applications through a central abstraction platform (Option 1) or ensuring that each application is interoperable with every other (Option 2). The single central platform approach benefits from relative simplicity, but offers its own risk of a central point of failure, vendor lock-in (i.e. from the platform manufacturer) and additional cost. Option 2 is more complex to specify and implement, but ultimately offers the highest degree of long-term flexibility.

Figure 6-2 below illustrates the advantages and disadvantages of these three options.

	Option 1	Option 2	Option 3
Description	Connect all devices to one platform	Focus on vertical and best solution in vertical and then make available to other verticals and to horizontals.	Go into a few verticals themselves.
Pros	▪ Easier to manage upgrades, especially to translators/APIs ▪ May be contractually easier to manage	▪ Network provider could be changed. Also cloud provider. ▪ No lock-in. ▪ High flexibility short and long term ▪ No dependency from one vendor	Ease of deployment
Cons	▪ Single point of failure – high dependency on a single vendor ▪ Risk of lock-in ▪ Costly and complex to establish ▪ Not available at present ▪ May reduce chances of synergies between applications/devices	▪ Complexity – upgrades and changes may require lots of hands-on effort ▪ Diffused responsibility for interoperability – danger of suppliers pointing fingers at each other when it fails	▪ Not open to other network or cloud providers. ▪ Costly and complex to establish ▪ Risk of vendor lock-in

Figure 6-2 Advantages and disadvantages of the different approaches

6.3 Key elements of an open approach

Based on the different architectures, we can characterise smart city applications as having three different types of interfaces as illustrated in Figure 6-3 below. This assumes that connectivity and cloud are integrated into the application via the system provider, using a leading industry partner.

1. The **City Management Interface**, which provides the overall 'dashboard' and mediates between the system-facing and administrative/human aspects of the application.
2. The **Inter-Vertical Interface**, which allows the direct exchange of data between verticals.
3. The **Intra-Application Connectivity,** which enables interoperability between providers of software and hardware within a given application.

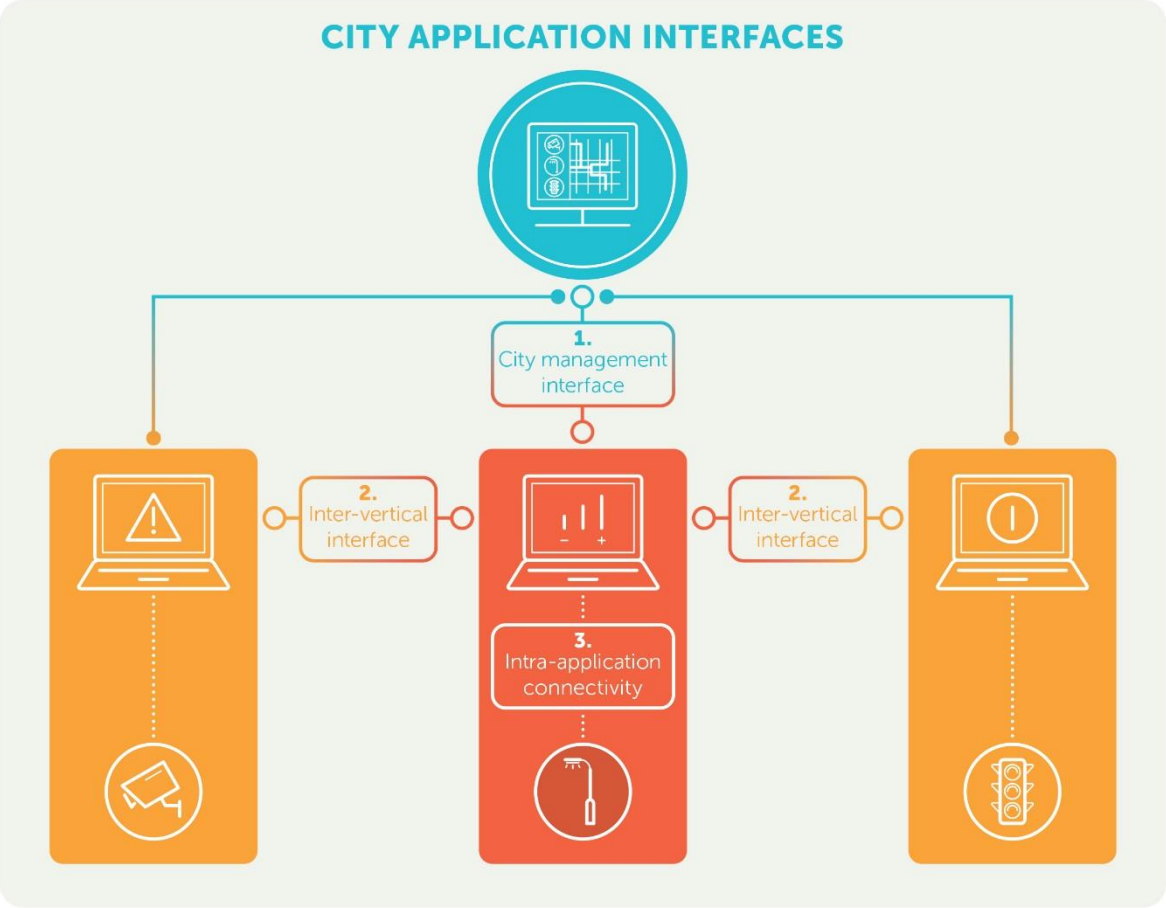


Figure 6-3 City application interfaces

According to Andreas Knobloch of Philips, the Inter-Vertical Interface is the most rapidly evolving of the interfaces: "Cross-vertical interfaces is the next area of growth, and it's only just starting to evolve today. There is a requirement for a broader horizontal view across vertical applications. This will account for more and more value over the next 10 years". The last is the city management interface, where data on the various applications is presented to the city to be analysed, combined and acted upon.

> Cross-vertical interfaces is the next area of growth, and it's only just starting to evolve today.
>
> Andreas Knobloch
> Alliance Manager, Philips Lighting

The relevance and potential value-add associated with each of these interfaces is discussed in Figure 6-4.

Interface	Relevance	Value-add
City management interface	▪ Cities need to be able to get an overview of all their city assets to be able to react fast if something is not working	▪ Transparency of all city assets at a glance ▪ Quick info and quick reaction on faults of city assets ▪ Better public service ▪ Less citizen´s complains
Inter-vertical interface	▪ Smart vertical can realize much stronger effects and provide greater value when they are interconnected	▪ Tremendous quality increase of public services ▪ Direct exchange of data between verticals
Intra-application interface	▪ Cities have assets of hundreds of various vendors in place. Therefore, they need a system that works with all different asset providers.	▪ No vendor lock-in ▪ Flexibility and freedom of choice for new installations

Figure 6-4 Value add from different city application interfaces

7 Case studies

7.1 Case study: Connecting lighting vertical and city IT horizontal platform.

The city of Buenos Aires has implemented a solution jointly provided by Philips and SAP to integrate data from smart street lighting with information from other public systems including traffic lights, geospatial information for management of storm drains and waste bins as well as citizen complaints, which are all displayed on a map. This is illustrated in Figure 7-1 below. All of the information is available to city officials via a single dashboard. The solution uses the SAP HANA Platform® to integrate elements from the Philips CityTouch software platform with SAP Enterprise Asset Management and with geospatial information.

The benefits of this include greater transparency of city assets and operations, a 360-degree view of data for better decision making, and faster access to information on defects on city assets. This in turn leads to faster reaction times and thus an improvement in the quality of public services. Over time, the city will gather baseline information on asset performance and will be able to better predict maintenance.

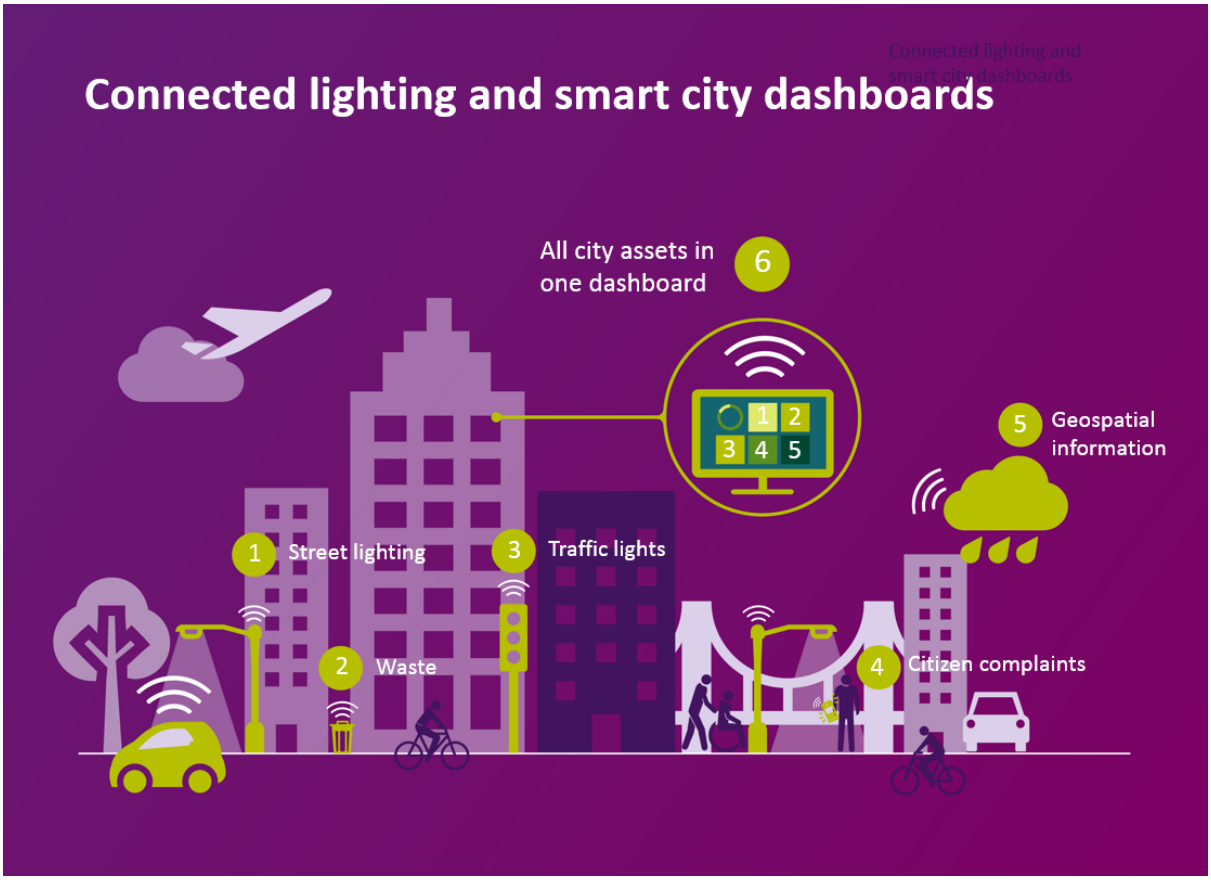


Figure 7-1 Integrated lighting and public asset management in Buenos Aires

7.2 Case study: Connecting between two verticals

A pilot project in Eindhoven allows the city police to over-ride the automatic controls on the city's public lighting system, run by Philips CityTouch so as to literally shed more light on an incident as it is taking place. For example, control room operators who see a crime or public disorder taking place via CCTV cameras can turn up the lighting so as to get a better view and improve the quality of the camera recording. Moreover, the manual over-ride allows other lights to remain under the control of the scheduled automated routine, so continuing to save energy and minimize light pollution. The pilot solution is illustrated in Figure 7-2 below. The interface is simple and easy to use, which allows trusted operators and third parties, such as police, who are not lighting specialists to take over the lighting settings on this defined temporary basis.

Figure 7-2 Integrated lighting and CCTV camera solution

8 Conclusions and recommendations

Forward compatibility with future decisions about inter-operability is more important than a once-and-for all platform choice. Cities have learned that a series of disconnected point solutions for specific verticals and systems is sub-optimal. They are also beginning to understand that a 'one-platform-to-rule-them-all' approach is, potentially at least, another route to vendor lock-in. In the early deployments of smart city applications, as municipalities test the waters, it is best to focus on deploying specific vertical applications, e.g. street lighting, refuse collection or parking, rather than trying to implement overarching city platforms. However, cities must ensure an open systems approach to ensure that these verticals will be able to inter-operate with others, and with whatever more general platforms are eventually selected.

Inter-operability should be a guiding principle in every project and every stage. It is not enough to ask for a verbal commitment to open standards or an open approach. Getting vendors' overlapping products and solutions to work together will be the biggest challenge and should be planned for from the very start. This will require, inter alia, an inter-operability test regime and processes, and appropriate contractual safeguards against non-compliance (even though these will probably not be invoked).

Cities need to stay flexible and prepare for a future based on open standards and APIs. In the current immature stage of the smart city, and in the dynamic and rapidly-evolving environment, the market is characterized by many different bottom-up de facto standards. The required open protocols have not yet been fully developed, agreed and accepted thorough the industry. During the current stage of smart city development, the key to remaining flexible is implementing open systems that enable interoperability via APIs. This will enable those solutions which are adopted to work with other systems and thereby build up a broader, more sophisticated architecture for the future.

Choosing open and recognized standards within these layers as well as between the layers is a crucial element that is required to ensure open and durable systems and infrastructure. Where no recognized standard exists yet, the ability to work via APIs is key to guaranteeing openness within the layers as well as between the layers.

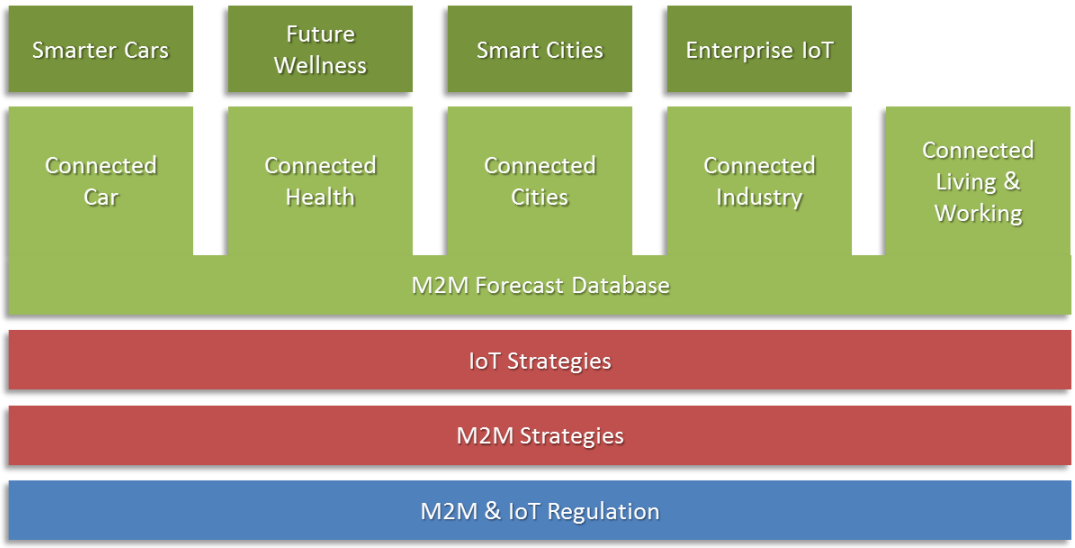
9 About Machina Research

Machina Research is the world's leading provider of market intelligence and strategic insight on the rapidly emerging Machine-to-Machine (M2M), Internet of Things and Big Data opportunities. We provide market intelligence and strategic insight to help our clients maximise opportunities from these rapidly emerging markets. If your company is a mobile network operator, device vendor, infrastructure vendor, service provider or potential end user in the M2M, IoT, or Big Data space, we can help. We work in two ways:

- Our **Advisory Service** consists of a set of Research Streams covering all aspects of M2M and IoT. Subscriptions to these multi-client services comprise Reports, Research Notes, Forecasts, Strategy Briefings and Analyst Enquiry.
- Our **Custom Research and Consulting** team is available to meet your specific research requirements. This might include business case analysis, go-to-market strategies, sales support or marketing/white papers.

Machina Research's Advisory Service provides comprehensive support for any organisation interested in the Internet of Things (IoT) or Machine-to-Machine (M2M) market opportunity. The Advisory Service consists of thirteen Research Streams (as illustrated in the graphic below), each focused on a different aspect of IoT or M2M. They each provide a mixture of quantitative and qualitative research targeted at that specific sector and supported by leading industry analysts.

Advisory Service Research Streams [Source: Machina Research, 2014]



Machina Research's analysts also have a wealth of experience in client-specific consultancy and custom research. Typical work for clients may involve custom market sizing, competitor benchmarking, advice on market entry strategy, sales support, marketing/promotional activity, and white papers.

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