Second EU FI PPP
Usage Area Workshop

EC FI PPP

Paper: A European Smart City

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Paper: A European Smart City

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Ove Arup & Partners Ltd
13 Fitzroy Street, London W1T 4BQ
Tel +44 (0)20 7636 1531 Fax +44 (0)20 7755 2211
www.arup.com

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Contents

1 The European Smart City

The challenges of climate change, population growth, demographic change, urbanisation and resource depletion mean that the world's great cities need to adapt to survive and thrive over the coming decades. Slashing greenhouse gas emissions to prevent catastrophic climate change while maintaining or increasing quality of life could be a costly and difficult process. There is an increasing interest, therefore, in the role that information and communications technologies could play in transforming existing power-hungry metropolises into low-carbon cities of the future. But, as yet, no one city has fully grasped the possibility of becoming a 'smart city'...

Arup has been working with several industry and city partners on the possibilities of a 'smart city' in terms of reduction of greenhouse gas emissions as part of a broad urban sustainability agenda.

Particular focus was placed on the possibilities of enabling behavioural change via community engagement using contemporary information and communications technologies (ICT). The subject of that focus is generating a resilient, sustainable urbanism, primarily centred initially on helping to reduce a city's greenhouse gas emissions, but also drawing in other aspects of sustainability (mobility, food systems, economic development and so on.) Additionally, focus was placed on making better use of a city's existing and possible data, to better understand the impact of policy and to improve management and services.

2 Smart cities

Our intent is to explore and test the possibilities of contemporary and future ICT in transforming the city into a 'smart city'.

A smart city is one in which the seams and structures of the various urban systems are made clear, simple, responsive and even malleable via contemporary technology and design. Citizens are not only engaged and informed in the relationship between their activities, their neighbourhoods, and the wider urban ecosystems, but are actively encouraged to see the city itself as something they can collectively *tune*, such that it is efficient, interactive, engaging, adaptive and flexible, as opposed to the inflexible, mono-functional and monolithic structures of many 20th century cities.

This is not simply a philosophical aspiration but can directly address core strategic drivers, such as reducing costs or greenhouse gas (GHG) emissions, and increasing competitiveness.

Key to this is the idea of measurement; of infrastructure, buildings and activities reporting their state and behaviour to systems that learn and adapt in response. These systems could be technological, legislative or social. The maxim "if you can't measure it, you can't manage it" applies here, and so the idea that urban fabric and activity can be 'instrumented' and measured in detail, and acted upon in instantly, enables a new form of management, operation and engagement, perhaps equivalent to the difference between a traditional highstreet bookstore and Amazon.com. The latter is a constantly shifting, scalable system that is automatically generated 'on the fly' by constant learning from millions of interactions in near-realtime, within a framework that enables both top-down intervention and bottomup organisation.

Every single interaction within Amazon.com reconfigures the offering in real-time. The offering itself is largely constructed from the actions of its users, such that it near-effortlessly moulds itself around the apparent desires of its users. For policy-makers, often accusedof being out-of-touch, and only capable of taking the temperature of their citizens via ad-hoc, expensive opinion surveys or unrepresentative focus groups, this level of engagement seems impossible, yet the smart city vision entails a similar shift in thinking. ICT gives city governments a way of involving citizens more directly in the direction and operation of their city, and by doing so, creates a platform through which the city can learn from their actions.

Yet even though the city is also a form of distributed, even emergent realtime system in reality, it is rarely run as such. Most city governments retain the structure and operational modes of the 20th century city.

In contrast, many if not all contemporary business and cultural sectors are being transformed by the internet, and businesses themselves increasingly understand and position themselves as data-driven organisations. This often entails moving information management, and its associated ICT, from a back-room activity right to the front of organisations, in which they are reconceived as key strategic drivers. If the city is to be increasingly run on data, ICT can become a major tool of public policy in smart cities.

The smart city vision does involve hard infrastructure—such as introducing smart grids alongside various forms of renewable energy generation, and building new systems of mobility based on distributed networks—but is perhaps primarily articulated through 'soft infrastructure' i.e. social networks and communities, legal and cultural systems, various forms of ICT. This fast-moving layer is perhaps more approachable and appealing for cities, offering a way to quickly 'retro-fit' existing buildings and infrastructure with smart elements at relatively low-cost, whilst planning carefully for the longer-term shift to the 'heavier' forms of smart infrastructure.

Equally, the output of such thinking, through the emerging medium of urban informatics, can often be engaging, informative, even beautiful, realised in the form of increasingly refined audiovisual displays and interfaces, installations, websites and systems, all driven via these real-time learning layers overlaid onto the existing city. This has the effect of 'making the invisible visible' thus raising awareness about urban infrastructure, activity and ecosystem.

3 Why the smart city?

The benefits of pursuing a smart city strategy are manyfold. The necessity of doing so is becoming increasingly obvious, to both cities and citizens.

Harvard Business School academics Rosabeth Moss Kanter and Stanley S. Litow have described a 'smarter city manifesto' in order to address the many problems facing city governments in particular1. With a slant towards North American cities, the authors outline issues such as the silo-based structures governments ended up with at the end of the 20th century, combined with the inability of governments to stretch their services over the large sprawling distances and conditions of the contemporary city, a weakened civic leadership, and a focus on delivery rather than addressing the cause of problems (described as a lack of 'strategic impact orientation').

This can leave city governments in a position where they are unable to scale, where they are inefficient in delivery, where they are unable to create holistic, interconnected services due to a fragmented approach to strategic data, branding, operations and management.

Kanter and Litow compare this with the not-for-profit or social innovation sector, who have been able to plug the gap at the local level, but who also suffer from an inability to scale, an inability to connect.

We might also compare this with emergence of new media and social media-based services that have transformed apparently unrelated sectors, such as Facebook or iTunes for example, which not only have levels of engagement that city governments might only dream of—33% of the Australian population is on Facebook alone; 25% of all music sales in the US are through iTunes alone; both these services are only six and seven years old respectively—but also indicate a new kind of system, one that is user-centred, responsive, realtime, flexible, local and global, pervasive, location-based, platform-based, and so on. Compared to these new kinds of systems, how do existing city systems stack up?

This perhaps implies that the expectations of citizens will become increasingly key. Perhaps the city's systems will seem 'broken' in comparison, unless they too evolve?

However, it also implies that this evolution of technology is something that city governments can also take advantage of. These internet-based systems are predicated on a kind of connectivity quite different to the traditional corporate IT department and is almost becoming a de facto standard that defines how systems in general should be.

So this presents both a challenge and an opportunity to cities, in that citizens may increasingly expect urban systems to behave how the other systems in the rest of their life behave, but also that a city's ICT services could also take advantage of these contemporary approaches.

3.1 A new urban user experience

What might this mean in practice? The smart city is already around us all the time, to some extent2. Urban infrastructure now includes smartphones, wireless internet, netbooks and tablets, media façades, sensor networks, smart meters, RFID tags and so on, upon which sits a rich layer of sophisticated user experiences, comprising social media like Twitter and Foursquare, 'apps' and maps and augmented reality, as well as so-called 'e-government' services.

However, the smart city also describes a step-change in both intensity and extent of connection, in that almost all aspects of infrastructure—from transit networks to energy, waste and water; from housing to street trees—can wirelessly broadcast their state and activity in real-time through the use of robust, cheap and discreet sensors. This concept is known as 'the internet of things', in which almost every inanimate object can become aware to some degree. As with contemporary engine control systems, smart urban infrastructure can tirelessly watch its own operation, predicting faults before they occur, optimising delivery of resources or services to match demand.

Equally, sensors can be placed on existing infrastructure, as in installations that monitor water quality or air quality or mobile phone data revealing patterns of movement of people in the city.

Multiply this by the increasing interest in both individual citizens and communities logging their own descriptive data about their lives and activities3, and by a vast and varied range of technologies of both input and output, and the smart city emerges as a vision in which almost every urban activity is enabled by pervasive, wireless technology.

The advantage for citizens is the sense that their city has a series of smart interfaces, enabling a richer, more efficient, more personalised experience. The advantage for cities is in the more effective delivery of services, more efficient use of infrastructure and unprecedented strategic information on the use of the city and their services.

This combination demonstrates the real potential of the smart city: the more effective delivery of popular services with vastly improved user experiences for citizens, which in turn delivers in-depth data on their operation.

Better user experience generates increased uptake. Increased uptake generates better data. Better data generates better user experience. And so on.

4 Smart City as a system

Contemporary thinking about the integrated sustainable city—of the city as a system—can only be turned into reality with a smart, integrated approach to both delivery and strategy.

In an interconnected urban system, trees and green walls can naturally cool streets and buildings with their green waste forming an energy input into a fleet of street cleaning vehicles that uses recycled greywater from apartments whose organic waste is used on greenhouses on their roof which delivers food in return to the apartments below or the café at street level, and so on. Nutrient cycles are closed, water cycles are closed, energy is transferred from one system to another, communities are engaged. Benefits are environmental, social and economic.

Importantly, data forms part of the 'connective tissue' linking these systems together—just as natural ecosystems rely on feedback loops— enabling these systems to be managed, balanced and efficient, as well as those feedback loops enabling the behavioural change required to make it happen. The strategic value derived from embedding data in such processes enables the system, and the city, to learn from its own activity, transforming almost all aspects of operation, from planning to delivery and beyond.

This connected vision might be described as 'ecological age' thinking, but is also heavily predicated on smart city thinking, which is intrinsically oriented around users, which intrinsically enables interoperability and lateral connectivity, which intrinsically binds disparate structures together rather than allowing them to float free of each other.

So the idea of the smart city has become important not simply due to the emergence of the internet over the last two decades but also due to political, organisational, social, cultural and spatial challenges now facing city governments.

While smart city thinking can address virtually every walk of life, as indicated by the internet's extraordinary reach, climate change has substantially focused the thinking around smart cities in terms of reducing GHG emissions and making cities more pleasant to live in.

5 Smart behavioural change

As discussed, the area of smart cities encompasses a number of different technology-led or -enabled advances, running from the hard infrastructure of smart grids through to a soft infrastructure of community engagement.

Arup's Smart City work is pitched largely between this hard and soft infrastructure, rather that focusing on one or the other. 'Smart Cities thinking' also addresses the new products, services, protocols, and governance layers enabled by these contemporary ICT, and so the area also addresses organisational and cultural aspects, including the relationship between behavioural change and such approaches.

Building on the need to address emissions and the potential of a smart infrastructure for engagement and management, a core premise is that people make bad decisions due to poor information and that with better information, behaviour change will follow, which can cut emissions and increase quality of life.

This premise is supported by behavioural psychology research that indicates two key drivers of behavioural change are 'active learning' and 'social proof' i.e. trying something out, and seeing others doing it too. Contemporary ICT, such as social media, can enable this self-learning and self-reflection, as well as reinforce these broader social patterns; making 'social proof' visible, essentially.

A precedent also exists in terms of water use in Australia, where significant behavioural change has been achieved through a combination of regulation (restrictions) and information (more focused and contextualised information on usage, sometimes indicating an individual's performance in a wider social context or against targets set for the city). Household water use diminished by 7% from 2000-01 to 2004-05, despite an increase in population during this period.

While many cities have been reluctant to directly address the possibility of sustainability-related behaviour change amongst citizens, perhaps understandably given their history and culture, some cities are beginning to realise that it could significantly contribute to both a more sustainable city and a higher quality of life. London is expecting that 30% of its reduction in carbon emissions will be driven by behavioural change. In Helsinki, the Low2No project explicitly states that 50% of a citizen's carbon footprint concerns lifestyle choices and has launched an informatics-enabled behavioural change workstream accordingly.

Other sectors, such as media, marketing, product/service design, social innovation and non-profits, aim to enable behavioural change as a core mission. Although they might have different motives and drivers, cities can also use these tools to effect more sustainable urban systems.

Accordingly, expressed city should express an aspiration to build upon these kinds of active engagement via ICT, such that both 'social proof' and the so-called 'network effect' enable a wider, deeper, more meaningful engagement between citizens and their city.

6 European Smart Cities

European Cities are generally well-placed to lead in terms of developing themselves into 'smart cities' for a number of reasons. These include the strength of the city in terms of knowledge industries and a particularlystrong higher education sector, a background in technical innovation including industrial design, an emerging new media sector, and a worldrenowned focus on urban design and the quality of the urban environment.

Equally, few cities are yet to demonstrate coherent, holistic thinking about the possibilities of smart cities. Recent years have witnessed advances around 'open data' and 'open government' or 'government 2.0' in several cities, and while have been innovations in particular areas—around cultural centres, transit or community engagement, for example—few cities have consolidated and communicated a genuinely allencompassing smart cities vision and strategy.

As a result, it can be argued that no major city has as yet taken advantage of the possibilities afforded by both contemporary understanding of 'the city as a system' and the synergies, efficiencies and creative possibilities enabled by smart cities thinking.

European cities could play an important catalyst role in terms of capturing and developing the thinking that emerges from the FI PPP,

The outcome may not simply be in directly enabling sustainability, efficiency and livability. As cities increasingly compete with each other, and reinforce their positions as the primary drivers of economic activity, city brands become ever more important. Cities which are perceived to be leaders in both urban sustainability and smart city thinking are only likely to benefit in terms of international competitiveness.

Equally, there will be economic activity associated with creation and operation of smart city services. The challenge now is to create a strategic framework by which these various activities might be aligned and encouraged.

7 Smart city strategies

Emerging from Arup's involvement with other smart city projects, it is possible to discern three interlinked component parts of a smart city vision, each of which is necessary to complete the holistic view of the smart city. (It should be noted that any smart city strategy is itself necessarily integrated into other strategies i.e. mobility, sustainability, economic development and so on.)

The overarching framework or layer is that of urban information architecture. This describes the most obviously organisational set of activities, from the procurement, design and

operational models of ICT services and infrastructure through to the shape, profile and staffing of the city government itself. The implication here is that the smart city is so different in essence to the 20th century city that the governance models and organisational frameworks themselves must evolve.

In simple terms, cities will have a housing strategy, a transport strategy, a sustainability strategy and so on, yet the IT strategy, if it exists, will tend to be focused on streamlining administration, cutting basic operational costs and perhaps internal knowledge management. Yet when it is so integral to the functioning of the 21st century city, why would this not assume a similar level of significance as those public-facing strategies? Particularly if it enables more effective ways of delivering those strategies. An urban information architecture would describe how this might occur.

This involves a strategic re-framing of how ICT is thought of in the organisation. At one level it needs to re-badge ICT itself. It is usually viewed as “IT” and taken to mean those back-room administrative operations, somewhat subservient to other more strategic functions.

Yet this doesn’t reflect the contemporary cultural status associated with internet-based communications technology.

In other words, can we really describe a teenager updating her Facebook status from her mobile as she walks down the street as ‘IT’? Technically, it might be, but it is also obviously deeply social and cultural, highly-valued and intimate, increasingly a core part of how people perceive themselves and what they are.

Perhaps ‘IT’ is too important for the IT department?

By this, it should not be inferred that a city’s current IT department is without value; quite the opposite. Rather, it means realising the smart city vision will entail repositioning ICT at the strategic heart of the organisation, with the new culture, status and approach intimated to above.

Cities will be at differing stages along this evolution, and this progress can often be discerned from indicators such as the presence, status, and budget of their Chief Information Officer (CIO). Yet there is far more to it than one role. So an urban information architecture may be required to help the city in defining projects, making decisions about outsourcing, procurement and technical design, operational frameworks and management, organisational structure, data protocols and policies.

It transforms a smart city vision into strategy.

Within a smart city, urban informatics plays the role of making data tangible, by creating design-led interventions, often drawing from real-time data on urban activity. It provides the new interfaces through which citizens can engage with their city. It encompasses web and mobile services, urban-scale displays, installations within architecture and infrastructure, and extends from analytical dashboards to public art.

Examples might include feedback loops on energy consumption or environmental quality, real-time transport information, visualisations of traffic, network activity or food miles and so on (case studies are dotted throughout this report). Not all of these examples need be commissioned, managed or owned by city governments—indeed, a contemporary approach might be for a public body to publish and manage civic data, upon which others could build.

This layer is the most obvious to citizens, and so it is through informatics that activities enabling behavioural change might be effected and coordinated. Urban informatics is the public interface onto the smart city.

The third layer, instrumenting resource systems, is a genuine enabler of the other components. It involves the design—for either new-build or retrofit— of sensor networks, and associated technologies, that report on the activity and performance of infrastructure. This reporting is increasingly real-time, recognising that efficient operation requires on

immediate feedback loops, and is built upon a platform of software services and wireless sensor networks distributed across much of the city's infrastructure, including natural ecosystems as well as built fabric.

Interpreting the concept of sensors widely, they could include the data from integrated ticketing systems such as Myki6, as well as comments from the general public via council web services, or derived from 'bottom-up' community- initiated services. They provide a constant, ongoing feedback that drives both informatics and operations as well as building longitudinal data to inform strategic decision-making.

8 Feedback loops

The interplay between these three systems enables feedback loops on urban activity.

Urban activity is instrumented and monitored by sensors, which feeds data to an organisational layer or model, which is then fed back via informatics, such as that it can affect urban activity i.e. modify the operation of infrastructure (re-route trams to where demand exists, for example) or inform citizens about environmental qualities, and so on. This can create a virtuous cycle, if well-designed and well-run.

At a basic level, this is how smart meters appear to be dramatically modifying energy use in the home. The meter (sensor) monitors energy use (activity), which is then quickly analysed (modelled) and displayed (feedback) to the user, who drops their energy use. This drop in energy use can be between 5-25%, depending on the trial, and up to 44% when combined with real-time pricing. While the longitudinal patterns of activity around these simple feedback loops are yet to be gathered and assessed, this 'smart meter effect' begins to indicate their potential nonetheless.

9 Example project ideas

Workshops held by Arup have yielded many ideas to kick-start a smart city programme.

Many ideas have emerged during various workshop exercises held by Arup. Three that have repeatedly surfaced comprised an 'informational retrofit' of a city's transport infrastructure, a sensor-based series of services highlighting the performance and role of the city's green infrastructure, and a real-time city model that functions as a broker for all urban data.

Interestingly, while the three primary ideas all address GHG reduction, all approach it indirectly by creating appealing services in their own right, offering increased quality of life, strategic insight or new urban experiences, as a result of which GHG emissions are reduced.

This again illustrates the interconnected nature of smart city thinking, in which emissions are reduced by creating a better experience around public transit, or raising awareness of natural ecosystems, or by creating a real-time city model that can enable more efficient operation as well as 'what if' analysis for urban planning and strategy and public engagement via open data feeds.

All project ideas were refined by considering likely impact, potential enablers and barriers, gaps in data, lead city department, possible staging and initial costs and so on. In doing so, all three projects described different barriers, different lead city departments, and varying impacts.

All three ideas indicate particular aspects of "the city as a system" strategic approach and the potential of informatics to augment existing infrastructure.

10 Next steps

Subsequent to the workshops, Arup is framing a roadmap for a smart city vision

While the first two project ideas are strong enough to be move forward in some shape or form, as discrete ideas, and essentially within particular departments, they cannot fully capitalise on the smart city vision.

Only with the kind of strategic work implicit in project three, the real-time city model, can an 'urban information architecture' for a city be articulated. This would provide the mechanism by which the emerging vision of a 'European Smart City' becomes strategy, and then reality.

11 PROJECT IDEAS

11.1 100 GREEN OASES

Connected sensor networks monitor the performance of a city's green infrastructure ('oases') in realtime, indicating their value whilst enabling deeper engagement from volunteers and users.

11.2 SEAMLESS MOBILITY

A genuinely integrated mobility system, connecting the city's installed transit infrastructure together via information, generating strategic data, whilst upgrading the transit experience.

11.3 REAL-TIME CITY MODEL

A visual real-time model of the city that provides Council with the platform for integrating all urban data, running services, enabling analysis, as well as publishing to internal/external clients and open feeds.

11.4 TRANSPARENT BUILDINGS

The city's public properties display their real-time energy and water use on both the inside and outside of buildings (data drawn from building management systems) to act as exemplar and help change behaviour.