acatech TAKES A POSITION – No. 10

> SMART CITIES

GERMAN HIGH TECHNOLOGY FOR THE CITIES OF THE FUTURE

TASKS AND OPPORTUNITIES

acatech
NATIONAL ACADEMY OF
SCIENCE AND ENGINEERING

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Editor:
acatech – National Academy of Science and Engineering

Munich office
Residenz München
Hofgartenstraße 2
80539 München, Germany

T +49(0)89/5203090
F +49(0)89/5203099

Berlin Office
Unter den Linden 14
10117 Berlin, Germany

T +49(0)30/206309610
F +49(0)30/206309611

E-Mail: info@acatech.de
Internet: www.acatech.de

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Coordination: Dr. Andreas Möller
Editing: Julian Molina Romero M.A., Victor Molina Romero M.A. M.A., Dr. Katja Thierjung
Layout concept: acatech
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COURSE OF THE PROJECT AND PARTICIPANTS

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> MANAGEMENT

– Prof. Dr.-Ing. Ina Schieferdecker, Fraunhofer FOKUS

> PARTICIPANTS

– Dr. Peter Biesenbach, Robert Bosch GmbH
– Dr. Andreas Breuer, RWE AG
– Dr. Gunnar Brink, Fraunhofer Gesellschaft
– Prof. Dr. Mandfred Broy, Technische Universität München
– Matthias Brucke, OFFIS Institut für Informatik
– Ralph Büchele, Roland Berger Strategy Consultants GmbH
– Clemens Deilmann, Leibniz-Institut für ökologische Raumentwicklung
– Prof. Dr. Benjamin Doerr, Max Planck Institut für Informatik
– Marcus Fehling, Siemens AG
– Tine Fuchs, Deutscher Industrie- und Handelskammertag e.V.
– Dr.-Ing. Raimund Glitz, VDI Technologiezentrum
– Prof. Dr. Otthein Herzog, Jacobs University Bremen and Universität Bremen
– Prof. Dr. Lutz Heuser, AGT Group
– Dr. Herbert Kemming, Institut für Landes- und Stadtentwicklungsforschung
– Tobias Krug, Bundesverband der Deutschen Industrie e.V.
– Peter Liebhart, Technologien für Zivile Sicherheit GmbH (TZS)
– Prof. Dr. Kurt Mehlhorn, Max-Planck-Institut für Informatik
– Prof. Dr. Wolfgang Nebel, OFFIS Institut für Informatik
– Oliver Rau, IBM Deutschland Research & Development
– Alexander Rieck, Fraunhofer Gesellschaft
– Dr. Joachim Roser, BASF Construction Chemicals GmbH
– Prof. Dr. Robert Schlögl, Fritz-Haber-Institut der Max-Planck-Gesellschaft
– Prof. Dr. Gernot Spiegelberg, Siemens AG
– Helmuth von Grolman, Deutsches Dialog Institut
– Michael Wedler, B.A.U.M. Consult GmbH

> COMMENTERS

- Prof. Dr. Rudolf Giffinger, Technische Universität Wien
- Josef Lorenz, Nokia Siemens Network

> EDITING

- Julian Molina Romero, M.A., acatech office
- Victor Molina Romero, M.A. M.A., acatech office
- Dr. Katja Thierjung, acatech office

ABSTRACT

Global urbanisation is one of the key challenges of the 21st century. The number of people living in cities is increasing rapidly: Since 2007 more people have been living in urban areas than in rural areas, consuming 75% of the global energy production. The United Nations estimate that by 2030, nearly 60% of the world population would live in an urban environment. In 1900, this number was only 13%. The increasing degree of urbanisation does not only affect industrialised nations (80% by 2030), but in particular the developing countries (55% by 2030). In a globalized world, this development confronts politics, science, and the economy with the following challenges:

1. Cities in developing countries and emerging economies find it more difficult to cope with the global urbanisation trend: There is scarcity of residential space, a lack in infrastructure, and the risk of insufficient water and power supply.

2. Uncontrolled growth of cities puts the ecosystem and the resources of the urban population at risk.

3. Urbanisation also provides opportunities to citizens: Major cities and conurbations could offer goods and services efficiently at comparatively low per-capita costs and hence could provide good basic conditions for growth and productivity, thereby contributing to improving the overall living conditions.

The city as a central node of human life depends on smart technologies for efficient and integrated infrastructures. Smart technologies offer innovative solutions for current and future challenges for cities and municipalities in various areas. The fields where cities can improve range from citizens' service, accommodation, and mobility to education, energy, and health support, to public safety. This is about new primary solutions (typically interdisciplinary integrated solutions) as well as secondary solutions (such as information and communications technologies) for more efficient infrastructure.

The present publication approaches the "Smart City" topic from the perspective of technology policy. The topic is embedded in other acatech activities, like the Smart Cities workshop conducted in Bangalore on 12 November 2010 as part of the German Indian Partnership for IT-Systems (GRIP-IT) project. The objective of this acatech publication is to provide an approach for strategic forecasting and planning of political action. Recommendations will mainly focus on the tasks of the sovereign state that cannot be assumed by the market.

For Germany as a business location, the topic of smart cities is relevant for two reasons: Germany is both a leading market and a leading provider of smart city technologies and know-how. Considering the European and global demand of smart technologies, we are facing the task of establishing Germany as a leading provider of innovative overall solutions. Policy can contribute to promoting smart city solutions in Germany by providing adequate framework conditions. Local pilot projects and reference cities provide a good opportunity to increase the knowledge in the area of system integration for smart cities. The German economy can profit from such measures and position itself for the future, not only as a leading provider but also as a leading market.

Central recommendations are:

1. **The establishment of propitious general conditions and linkage of decision-making processes are prerequisites for establishing smart technologies in the local market:** In order to develop technical solutions, we should not assume clear-cut divisions between society, economy, and politics. Rather, an understanding of urban management (in the sense of governance instead

of government) should be achieved in which smart technological innovations are the results of problem-oriented and interactive processes between all parties involved. An integrated joint decision-making process between public and private industrial investors and public administration is crucial here. „Conventional" deregulation in terms of reducing bureaucracy is just as important as promotion of better interaction between the economic and political actors.

This way acceptance of such innovations in urban areas will increase as more industrial companies are involved, while also improving the value creation chains. The generation of economic clusters will result in important synergies and spill-overs and make the technological innovations (products, processes, services) particularly marketable.

2. **Germany's position as a leading provider depends on internationally recognised norms and technology standards:** Smart city interoperability is an important precondition for planning reliability for exports. Germany can only become a leading provider for smart cities or urban management if the export strategy is accompanied by a consequent standardisation strategy unaffected by particular interests. It is therefore indispensable for Germany to contribute essentially to European and international standardisation. International cooperation is necessary for the implementation and spreading of the results of the German standardizations.

3. **Pilot projects and reference cities are vital for both local demand and export of smart technologies:** for efficient planning of new cities in non-European countries it is important to first collect concrete experiences with smart city projects in Germany, but also with selected projects abroad. Then, larger projects and test platforms like the Living Lab in Bangalore/India as envisioned within the scope of the acatech project GRIP-IT can provide expert knowledge and references for the export of smart city solutions. Establishing interconnectedness between the various existing pilot projects for smart cities, or city districts and urban areas respectively, is an important approach in this context.

4. **Research funding and competition provide incentives for building smart cities:** Targeted promotion of smart city technologies should first and foremost support system integration methods in order to address the interdisciplinary dimension of smart cities. As a basis, the education and research requirements must be determined first. Competitive incentives for targeted project support among the cities are only one option to guarantee effective use of the funds.

1 INTRODUCTION

The city of the future is facing enormous challenges: scarce energy, lack of water supply, environmental pollution, demographic changes and logistic bottlenecks. Many urban infrastructures are overloaded by now. Politics, science, and administration are facing the task of providing adequate solutions based on democratic decision-making processes.

Modern cities rely on smart technologies. Smart technologies can offer innovative solutions for current and future challenges of cities and municipalities in different areas of life and work. From a technological perspective, a smart city is intelligent, integrated, and networked. All three attributes have the corresponding technologies available to support decisions, to control information flows, and to assess complex situations. The term of a smart city therefore represents a more complex attitude that considers several areas of urban development and management:

- Knowledge-intensive and competitive economic activities
- Resource-protecting and environmentally compatible forms of mobility
- Healthy environmental conditions while keeping the strain on the environment as low as possible
- Education-oriented and open city population
- Socially balanced and attractive quality of living
- Transparent and participative governance

Based on this understanding, it becomes clear that technologically smart solutions (intelligent, integrated, and interconnected) are in demand and useful in different areas of city development. This means that, in order to benefit sustainable development, smart technology solutions should be

- aligned with urban issues and interests
- driven in a targeted manner based on existing expertise and not adopted from the outside without further reflection, and
- effectively developing existing assets (competencies, know-how, competitive focus activities) in cooperation with social, economic and political forces (based on generally accepted guiding principles).

Generally, the (on-going) development of a smart city can be considered as a continuous process in which new solutions are developed in cooperation with society, economy, administration, and politics and implemented as offers to the citizens and companies of a city. This is both about new primary solutions – typically interdisciplinary integration solutions, often with ICT-support – and secondary solutions to increase efficiency of present infrastructure by ICT down to comprehensive "ambient intelligence" in comprehensive sensor and machine-to-machine networks. This way, relatively static infrastructures can become more dynamic, opening up new possibilities.

The concept of a "city" cannot be defined by administrative borders: Rather, the concrete problems and challenges must be the starting point. Smart city concepts should focus on the structural plans of the city in their objectives and include the surrounding region as far as the problems require this. The respective problems and challenges vary depending on site conditions and socio-cultural contexts; therefore, there are many different forms of smart cities around the world. In German conurbations, allocation of city resources according to sustainability and climate protection principles are identified objectives. Smart technologies can enable this by increasingly automated, integrated, and optimised use of resources and infrastructures.

The quality of work and life, and thus city attractiveness, can be increased by flexible offers while also improving the cost structure. Examples for this are approaches for "ambient intelligence" that were mainly promoted throughout Europe for the construction and health industry in the scope of ambient assisted living (AAL)".

In the following, this acatech publication will deal with the themes surrounding smart cities from the point of view of technology policy. Initially, part 2 will discuss the framework conditions of smart cities. Against this backdrop, part 3 points out the relevant fields of action. In the last part, the topic group will suggest concrete recommendations for action. The objective is to offer an approach for strategic forecasting and planning of political action.

Both the demand for and export of smart solutions are of special interest for Germany. Germany as a high technology country and export nation is predestined to establish itself as a leading provider in this growing field of innovation and to exploit its value generation potential. Here, it is important to understand the necessities, options, and offers for system integration as an essential competitive advantage.

Smart city solutions can only be implemented across industries. Such a systemic approach could in particular be offered by German consortia. The leading market should not be ignored in the leading provider discussion. Technology implementation will not take place without adequate national framework conditions. Not only the integration technologies as such, but also the decision-making and implementation processes are very important for as complex a system as a city. Therefore, the German market as well is important for smart cities as a source of experience and point of reference for exports. Pilot cities, quarters, and regions must be developed as test fields and proof of concept.

2 FRAMEWORK CONDITIONS

Urbanisation becomes more and more important around the world. The number of people living in cities is growing rapidly: Since 2007, more people have been living in conurbations than in rural regions, and they consume 75% of the power generated around the world.

The United Nations estimate that almost 60% of all people will be living in cities by 2030. In 1900, this figure only reached 13%. The degree of urbanisation rises not only in the industrial nations (80% by 2030), but mainly in the developing countries (55% by 2030) (UNDESA 2010). In particular the Chinese and Indian metropolitan centers have to expect rapid increase in population and thus area growth. This leads to new conurbations, like the Chinese Pearl River Delta, a huge urbanisation zone covering 150 kilometres from Hong Kong to Shenzhen to Guangzhou. In the next four decades, 500 million people will move into cities both in China (Siemens 2010) and India (Financial Times 2009). To cover the huge accommodation demand, India alone will have to build 500 new cities (Financial Times 2009). Population increase and urbanisation pose high demands to systems like transport, health care, energy supply, education, and public security, as well as on the provision of accommodation and design of open areas.

In the course of globalisation, this development creates great political, scientific, and economic challenges. Cities in developing and emerging countries have increasing problems dealing with the global urbanisation trend. Uncontrolled city growth also endangers the ecosystem and thus the basis of living for the city population. The current UN city report notes that about one third of the global city population – about one billion people – are living in slums and other precarious city areas (State Of The World's Cities 2010/11).

However, even wealthy major cities in America, Europe, and Asia are badly prepared for future challenges. The outdated infrastructure is often overwhelmed: In London, one third of the potable water leaks from the sometimes150-years-old water lines; in German cities, this value reaches even 40%. Traffic chaos, gas explosions and bursting water pipes, overcrowded schools, insufficient health care and crime are commonplace in many large Western cities. According to a study of Deutsche Bank Research, 40,000 billion dollars would have to be invested in city infrastructures around the world until 2030 to prevent safety risks.

Yet urbanisation also provides new opportunities for citizens. Large cities and conurbations are able to provide goods and services efficiently at comparatively low per-capita costs, thus offering good framework conditions for growth and productivity and contributing to the improvement of living conditions. This is not only about lowering costs, but also about a sustainable increase of the quality of work and life in the urban area: Cities compete for companies, investments, and, ultimately, also for citizens. Only an innovative competitive city – a smart city – is able to attract and retain qualified young talents and offer new companies a flexible public administration. Sustainable competition-oriented city development therefore requires the use of smart infrastructures.

Smart city projects comprise all aspects of urban life. Planning new cities, so-called green-fields, or hyper-growth cities, first and foremost requires ecological sustainability through renewable energies, efficient architectures, and smart traffic infrastructure. The climate conditions also need to be considered. The planned city of Masdar in the United Arab Emirates is the latest example for a state-of-the-art "eco-city", characterised by shade-giving construction; it will be emission-free and nearly waste-free due to its strict recycling regime. While establishing smart technologies (mainly for primary solutions) in growing cities may be spectacular and relatively easy to implement, the need to retrofit and improve existing systems and market potentials is current-

ly much higher. For one thing, there are many shrinking (large) cities even now; for another, growing quarters are marginal phenomena in the overall situation of urbanised areas and population groups.

Therefore, the innovation is more complex when it comes to legacy infrastructures in the so-called stagnating cities and regions. Retrofitting of established city infrastructure seems difficult in terms of costs and time. The latest technology advances, however, make it possible to smartly re-design historically grown infrastructures. Information and communication technologies (ICT) can be used as secondary solutions to make the service processes more efficient while also clearly increasing quality of living. This is about digitization and interconnection of systems to make data available in the first place. They are then analysed and integrated to react to respective demands. The largely static city infrastructures can be observed, assessed, and optimised with sensors, sensor networks, and mobile communication. It is important to refer to the different fields of action, since every city is characterised by its very specific combination of socio-economic, ecological, and geographic conditions. If cities are characterised by different city profiles and trends, there are also different needs for action that cannot solely be determined by the characterization of 'growth' or 'shrinking'. Smartness therefore should also mean aligning smart, integrated, and interconnected solutions to the need for action of every individual city.

For Germany as a business location, the topic of smart cities is relevant for two reasons: first, because Germany is a leading market, and second, a leading provider for smart city technologies and know-how as well. While the Federal Republic will hardly become a leading market in the short term, there is still a long-term demand for smart infrastructures to meet the urgent challenges like transport, energy efficiency, and climate protection. Reduction of energy and water loss in the power and water supply grids is another great challenge in the light of increasing feed-in of fluctuating renewable energies, a condition that applies to all of Europe. A Booz survey estimates the necessary investments in transport, energy, water and environment in Germany to be at 400 billion Euros by 2030 (Booz Allen Hamilton Analyse 2007). A large share of these costs is caused by the expansion and new construction of traffic infrastructure, accounting for about 150 bn. Euro.

3 FIELDS OF ACTION

The framework conditions predetermine the various fields of action where concrete solutions can be applied. With regard to planning smart cities, the following distinction has been emphasized: Cities with hyper-growth can be planned and implemented as a smart city from the beginning. These green fields are mainly found in developing and emerging countries; this is where hyper-growth cities will continue to appear in the future as well. In contrast, stagnating cities and regions form the basis for smart city projects in Germany, Europe, and other industrial nations. Generally, the individual needs of the respective city as well as existing infrastructure conditions must be taken into consideration when building smart cities.

However, it is possible to identify common fields of action for smart cities. On the one hand, they result from universal topic areas like mobility or energy. On the other hand, they are determined by demand.

Regarding the topic areas, the following focus points, which are relevant both for Germany as a leading market and as a leading provider, can be identified:

- *Demographics:* A smart city depends on considering population development. How many people move to or leave the city? Which ethnic groups are living in the city? What age groups are represented? How is it possible to involve both the citizens and businesses in open-governance process, such as idea generation, decision-making, and implementation?
- *Mobility:* Future mobility depends on pro-active regulation. In the mobility area, all infrastructures (e.g. means of transport, streets, or buildings) can be smartly interconnected using (micro-electronic) sensors which diagnose the status of certain objects and trends of object groups. The "Internet of things" interconnects the objects in a way that facilitates exchange of information among and about them. One example are new traffic concepts for inner-city traffic which interconnect existing routes and means of transport (e.g. for car and railway traffic), forming a multi-modal system for new transport solutions. This results in more cost-efficient, secure, and environmentally compatible options for passenger services and freight traffic. If electrical cars reach essential market shares in cities, knowledge of their charging needs and storage capacity will be indispensable for load management within the local power supply system. However, functioning roads and railways will continue to be vital and need to correspond to the traffic conditions and needs of businesses and citizens in the city. Only when these basic requirements are met, network solutions can remove further obstacles.
- *Energy:* Integration and interconnectedness of conventional and alternative, regional and cross-regional energy sources change the energy supply system. The increased use of renewable and fluctuating energy requires stronger coordination between generation, distribution, storage, and consumption via ICT. A smart grid is able to use information on consumption (smart meters), grid and storage conditions in real time to adjust them to the generation and load conditions by market and control signals. Similar possibilities apply to water, gas, and heat consumption.
- *Environment:* The causes of climate change are concentrated in urban areas. Therefore, climate protection measures are most effective in cities. With energy-efficient and climate-adapted solutions, the world's metropolises can pave the way to a CO_2-neutral society. Among other things, this requires smart grids and provision of high energy and power storage capacities. Only flexible management of the power supply networks and a differentiated provision of the most diverse storage technologies make it possible to fully utilise the potential of the volatile renewable energy sources – in particular wind and solar energy. The increase of energy efficiency of buildings is an es-

sential element of cities: energy modernisation of residential and industrial sites and increased use of solar and environmental heat leads to a savings potential exceeding the current use of renewable energy sources. Regarding traffic, the negative consequences of the increasing number of cars in the cities must also be considered. Smart interconnectedness of the traffic and transport options in smart cities would enable more active regulation of citizens' mobility conduct. However, an orientation only towards active climate protection measures is no longer sufficient. The expected increase of the world's average temperature makes it necessary for cities to prepare for climate change and more frequent occurrence of extreme weather, and to adopt corresponding countermeasures.

- *Security:* Citizens' security, information network security, and security of infrastructure and public life are great challenges to the city of the future. Sensor grids and location-based services provide an opportunity to securely monitor and control the different flows in a city (e.g. traffic or energy). New approaches to governing visitor flows and to the cooperation of security-providing institutions increase the effectiveness of safety measures. Combined with cross-scenario cross-sectional topics like "rescue forces of the future" or "universal detection systems", they constitute an approach towards future security systems. The German export industry has the opportunity to develop competencies and know-how in international competition in order to launch security products and technologies.
- *Communication:* Information and communications technologies (ICT) will more and more play a defining and formative role in value-generation processes. Our systems are digitised and interconnected, so that data is collected, analysed, integrated, and combined into value-added information to react to the needs to cities and their districts. Intelligent networks optimise products, systems and services and enable regional communication and interaction platforms down to district level. Thus, the cross-sectional ICT technology accelerates all future developments. Fundamental further developments towards a next generation Internet ensure a high-performance basic infrastructure for all applications and services that already now form the basis for entire industry branches. In the future, smart, self-repairing networks and information systems will recognise outages and security-critical attacks and automatically adopt counter-measures.
- *Health:* Due to demographic developments and accordingly a rising demand for high-quality health-care services, the health-care sector will rise in importance. There will be a transition towards more prevention in all care processes in order to prevent both disease as well as unnecessary treatments. Integrated, customised care concepts will replace today's strongly fragmented health care system. Innovative technologies, such as process-supporting ICT and molecular medicine, will increase care efficiency. New technical and organisational structures will facilitate seamless, integrated, and individualized care in prevention, diagnosis, therapy, and nursing.
- *Administration:* The keyword "eGovernment" stands for simplified and direct information, communication and transaction processes between governmental institutions, citizens, and companies based on the usage of ICT. This is particularly important for the EU with its 495 million citizens in 27 member states. Technical progress, in particular in the area of the Internet, enables new communications and interaction channels. Administrative processes are simplified and automated through these new possibilities while simultaneously freeing up capacity for emergencies. At the same time, transparency in administration increases as individual processing steps or paths of information become clearer for citizens and businesses. Corruption becomes more difficult. However, in order to prepare the city for its role as a service provider for future administrative requirements, it is necessary to develop an eGovernment of the next

generation which provides active and cross-area administrative solutions.
- *Education:* All urban educational facilities can be combined into education platforms by smart networking. Other actors of civil society can be integrated into this process as well. The resulting transparency of educational offers facilitates a stronger integration of educational institutions outside of schools. However, networking among educational facilities is still insufficient; there still is much room for improvement and potential for integration.
- *Market place city:* A smart city should be an attractive place for trade, commerce, and service provision. A prerequisite for this is the connection between the work sphere, residential conditions, and leisure time facilities. A look at the new high-tech eco-cities like Dongtan, New Songdo, and Lingang New City reveals a close connection of the work sphere and the residential and leisure-time worlds. There are many spacious and green areas inside and outside of the buildings. In Germany, the project "Duisburger Freiheit" exemplifies this concept.

Only the integration of all the fields of action outlined above into an overall concept is what ultimately constitutes a smart city. The information systems and solutions of the individual fields communicate with each other and must be combined, integrated, and shaped into one information and communication network.

The wide fields of action make it necessary to set priorities and focus points for the need for action in order to achieve a coherent export strategy. This strategy has two separate dimensions: First, the technical demands are to be discussed with citizens, business, administration, and politics and the fields for action must be defined. Second, the need for regulation must be determined, because cities are complex systems with multifaceted decision-making structures and implementation processes.

Regarding the technical demands, certain technology prerequisites are needed for clever designs of the different fields of a city using smart technologies. In the following, the essential key technologies are mapped to the respective demand:

- *Broadband as an area-crossing basic technology:* High-quality broadband communication is a basis for smart cities. While a city can become smarter even without broadband technologies, this will be limited to certain areas. Therefore, it is important that households and utility infrastructures are connected to suitable high-performance networks. According to the BMWi ePerformance Report 2009, Germany is above-average in the area of "broadband connections" in a European comparison, but also shows a backlog where broadband connections in private households are concerned. In order to quickly connect the "white spots" to the high-performance data networks as well, the Federal government passed the Broadband Initiative 2009. It intended to provide broadband connectivity to all previously unsupplied areas by the end of 2010, with data transmission rates of at least 2 MBit/s. By 2014, three quarters of all households, and as soon as possible thereafter, all households, are to have access to Internet at transmission rates of at least 50 MBit/s. However, it must be noted that Germany is lagging behind countries, in particular when compared to Japan, where 36% of all households are equipped with Internet at transmission rates of at least 100 MBit/s. There is still a need for action in this field in Germany.
- *Smart distribution grids as a basis for smart cities:* Smart cities require innovative concepts for active energy distribution networks. In spite of an increasing use of volatile energy sources, in particular from renewable energy providers, reliable power distribution and supply must be guaranteed. Other challenges include overall control systems for central, -regional and local providers as well as recognition and active grid control. Yet protective strategies and technologies will become more and more

important, too . All in all, a number of technical innovations in distribution networks is necessary, for example in the area of high-performance electronics.

– *State-of-the-art sensor networks:* Sensor networks also contribute decisively to the intelligence in distribution networks, making them very important for smart cities. A sensor network interconnects many different sensors and devices with computer networks via machine-to-machine (M2M) communication. The interconnection can use wireless, mobile, or fixed networks or low-voltage power line communication. Sensor networks are used in diverse applications in the areas of energy, logistics, traffic technology, and administration. The basic problem of sensor networks and M2M is the lack of compatibility and interoperability between applications.
– *City Data Cloud:* Cloud computing stands for a pool of abstracted, highly scalable, and administrated IT infrastructures. Since urban management requires enormous IT infrastructures, it is predestined for cloud use. Mail, traffic management, tourism, energy supply, public services, and waste removal can be integrated here. Japan is currently implementing a national cloud that shall comprise the country's entire IT infrastructure. The United States are also working on City Data Clouds, while Europe has backlog demands in spite of the regulation on Public Sector Information. There is also demand concerning integration of public and entrepreneurial information in a city.
– *System integration:* Due to the close interaction among the various systems, integration of the multiple areas of a smart city is a crucial point. System integration ultimately aims at an ICT-based integration of all urban infrastructures into integrated and consistent solutions that enable tailor-made, customised responses to the problems and challenges of each city Germany traditionally has strong expertise and an excellent reputation for "glue development" for system integration. This basis should be used for a cross-industry initiative to offer innovative and customised system integration solutions. The objective is to become the international market leader.

The demand for regulation must not be neglected in this context. It is exactly this outstanding position of system integration which shows that all efforts towards making a city smarter depend on the framework conditions. In particular stagnating cities need corresponding administrative reforms in order to facilitate an integration of the different areas. This is not about centralisation, but rather about decentralized yet consistent and integrated management systems that integrate the various aspects of urban life. Here we would like to name some of the essential aspects and concrete regulatory requirements:

– *Standardisation:* Since divergent national and regional standards impair the global market for smart cities, uniform standards in this area are very important, in particular for Germany as an export nation. There is a need for statutory provisions and technical standards for any type of consistent ICT interfaces of the different urban infrastructures. International harmonisation can be achieved by the various standardisation organisations: Here, Europe is competing with the U.S. and the Asian countries, in particular China. For selected important technological areas of smart cities, there already exist various internationally recognised IEC (International Electrotechnical Commission) standards. For example, almost 90% of the European electrical engineering standards are already harmonised with international norms. The actors in the field should take recourse to these already existing standards. Cooperation with other eEnergy projects is recommended, possibly also within the scope of the "Future Energy Grid" project driven by acatech; the success of which also strongly depends on the respective standardisation. However, a great number of smart city applications will generate different types of data that will have to be transferred via telecommunication networks, such as system, measure-

ment, topology, equipment, condition, or consumption data. Process integration and interoperability of the respective components and systems therefore requires wide standardisation of the data and information structures, the interfaces and their transfer mechanisms, storage, and, if applicable, archiving features. The question of user acceptance with regard to data privacy and data security must not be neglected either.

- *Data privacy problem:* Smart cities rely on collecting enormous amounts of data. Therefore, the political decision-makers must deal with the question of data security and data privacy. Data security requires control of the type and depth of encryption; data privacy refers to ownership and access rights to data.
- *Regulation and deregulation:* In connection with new smart technologies and their implementation, lawmakers face the tension between liberalisation and regulation. On the one hand, there are many liberalisation options for the (primarily public) markets to promote innovations and investments, also regarding smart city technologies. Considerable investments are needed in all areas; in particular in a regulated environment (e.g. energy), they cannot be realized without a risk-adequate, capital market-oriented yield. Another vivid example is the construction industry, where smart city innovations are thwarted by restrictive provisions in regional planning, state planning and the Federal land utilisation ordinance (Baunutzungsverordnung; BauNVO). On the other hand, smart cities in particular require politics to cooperate across sectorial and departmental boundaries in order to promote smart technologies. For example, current traffic problems need to be solved by using smart technologies that would be easier to implement in closed systems than it is in a free market. In particular the use of new information, communication, and channelling technologies in traffic (traffic telematics) requires increased coordination and cooperation between the carriers and their systems. A strategy for integration under dynamic competitive conditions must be found.
- *Local/regional distribution of tasks:* : The strict division of tasks between federal, state, and municipal authorities is a great obstacle for implementing smart city solutions. Integrated solutions concern all areas of life in a city and require coordinated procedures. In particular in Germany, the vertical distribution of power poses a challenge. It is mandatory to establish decision-making processes that bring together all public actors involved as well as private investors from the corresponding industries.
- *Development of governance structures for smart cities:* Governance structures are an important demand area for smart cities. Due to the integration of smart city infrastructures and services, generic, individually parameterizable concepts must be developed for urban management and city governance.

The diverse fields of action for smart cities can be determined by topic and by concrete demand situations. Due to the diversity of tasks it is necessary to set priorities with regard to policy implementation options.

4 RECOMMENDATIONS FOR ACTION

In view of the potentials of Smart Cities, the right decisions need to be taken within the fields of actions described above. Due to the diversity of tasks priorities must be set with regard to policy implementation the politics action options. The recommendations for action will focus on the state's sovereign tasks that cannot be assumed by the market.

The recommendations are targeted towards the leading market/leading provider discussion. The objective is to exploit the export options of smart city technologies without neglecting the domestic market. In order to position Germany on the global market as a leading provider, the domestic market must be established (in the best case as a leading market) as an experimental environment where appropriate technologies for the various applications can be developed, standardised, integrated, and tested. Innovations can be developed here for stagnating and ageing cities, where the emphasis would be specifically on optimisation of present infrastructures and technologies via secondary solutions.

In order to support this process, government action should promote technology development and accelerate standardisation processes. This means creating organisational framework conditions for targeted promotion of smart solutions in Germany. Based on the insights and experiences gained, Germany can prepare for an export of research results to other cities around the world. German pilot projects and reference cities provide good opportunities to deepen know-how in the area of system integration for smart cities.

For Germany as a business location, the export of smart city technologies, systems, and solutions for green fields and hyper-growth cities offers great potential for the future. These cities will grow extremely fast and new cities will be founded due to the demographic developments and strongly increasing rural exodus. It has been shown that the development of smart technologies for growing cities (in particular regarding primary solutions) may be spectacular and their implementation relatively easy, but the need to retrofit and improve existing legacy systems is equally urgent and the market potential for existing cities is at least as high. Most of the cities are already built. Smart developments for present infrastructures (by use of secondary solutions) therefore represent a challenge. At this point, it is thus important to point to the different fields of action, since every city is characterised by a very specific combination of social-economic, ecologic and geographic conditions. If cities distinguish themselves by divergent city profiles and trends, the needs for action vary accordingly. Smartness therefore should also mean aligning intelligent, integrated, and interconnected solutions as precisely as possible with every individual city's need for action of.

Central Recommendations for Politicians:

1. **Creation of organisational framework conditions and interconnectedness of decision-making processes are prerequisites for establishing smart technologies on the domestic market:** In order to develop technological solutions, one should not assume a real differentiation between society, economy, and politics. Rather, the understanding of urban management (in the sense of governance instead of government) should be adjusted in a way that recognizes that smart technological innovation is the result of problem-oriented and interactive processes between all parties and stakeholders involved. Such technological advances are achieved primarily by activating creative potential and transforming it into city-specific assets. Focussed programme support instruments (defined at European, national, and regional levels) should support and drive such developments forward in a target-oriented manner. Continuous and individually adjusted concepts, as well as new business models for investors are the focus here. A joint decision-making process that involves public and private investors from industries and public administrations is vital. "Traditional" deregulation in the sense of a reduction of bureaucracy is just as important as the promotion of

better cooperation between economic and political actors. Technologically innovative solutions should, whenever possible, be created through cooperation of different parties on municipal and regional levels. On the one hand, such an involvement of multiple stake holders ensures a higher acceptance of such innovations in the city or region while, on the other hand, simultaneously improving the value generation chains when more businesses are involved. If the city or region succeeds in establishing economic clusters, specific business environments and corresponding social networks will lead to important synergies and spill-overs that make the resulting technological innovations (products and processes) particularly competitive on the international market.

2. **Germany being a leading provider is dependent upon internationally recognised norms and technology standards:** Smart city interoperability is an important prerequisite for export planning reliability. Germany can only become a leading provider for architecture and urban planning of smart cities if the export strategy is supported by an aggressive standardisation strategy unaffected by particular interests. It is therefore indispensable for Germany to contribute substantially to European and international standardisation processes. International cooperation is necessary for implementation and dissemination of the German standardization results.

3. **Pilot projects and reference cities are indispensable both for local demand and export of smart technologies:** It is important for planning new cities in countries outside of Europe that concrete experience with smart city projects is collected first in Germany, but also at selected foreign sites. Larger projects and test platforms like the Living Lab in Bangalore/India envisioned in the scope of the acatech project GRIP-IT can provide know-how and references for the export of smart city technologies and solutions. These reference cities can be futuristically planned as living labs on a green field following the Masdar City example or serve as promoter or facilitator" for a migration reference city. Efficient networking between the different existing pilot projects for smart cities, their quarters or regions is an important approach in this context. Framework programmes for technology development already promote various pilot projects. One example is the new capital airport Berlin-Brandenburg International (BBI), where innovative information and communication technologies are combined to achieve increased safety levels. However, such projects are implemented without any overarching strategy up to now.

4. **Research promotion and competition provide incentives for building smart cities:** Targeted promotion of smart city technologies mainly has to support system integration methods in order to grasp the interdisciplinary dimension of smart cities. As a basis, the employee qualification and research demand must be established first. Competitive incentives for targeted project support among the cities are only one option to guarantee an effective use of the funds.

All in all, any smart city strategy must distinguish itself by selecting an integrated approach towards the focus topics. Cross-industry and cross-departmental considerations are an essential requirement for the "glue" development of system integration. As in the "Toll Collect" project, Germany may take on the international role of an enabler for smart cities. Due to the enormous international market potential, an export hit "Smart City – Made in Germany" offers future potential and an important perspective for value generation in Germany.

This will also have positive effects on the development of smart cities in Germany. Not only references projects, but also technology acceptance and systematic access to education and further training will play an important role for smart cities in Germany. This way, smart German cities and urban regions can serve as a reference for the vision of smart cities as well as leverage the competition among cities.

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Global urbanisation is a central challenge of the 21st century. Since 2007, more people have been living in conurbations than in rural regions. In 2030, the ratio will be at 60 percent. It is all the more necessary for cities and agglomerations to use integrated technology. „Smart" technologies offer answers in different demand areas. Germany has developed the advanced technologies to provide the necessary innovative holistic solutions. The present statement of acatech – National Academy of Science and Engineering shows the framework conditions politics must establish to use this potential.

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