RUGGEDISED
Designing smart, resilient cities for all

Brno's review of practices: ICT and Security

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731198. The sole responsibility for the content of this document lies with the RUGGEDISED project and does not necessarily reflect the opinion of the European Union.

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Annotation

The world is facing some profound changes in several areas driven by economic, technological changes, demography, climate, and many others. These changes also bring many new challenges and opportunities. Therefore, new trends such as Smart Cities start to be introduced as a solution for future development and for the challenges, which are brought by the changing world.
There are many different definitions of the Smart City. For example, Gartner defines a smart city as an urbanized area where multiple sectors cooperate to achieve sustainable outcomes through the analysis of contextual, real-time information shared among sector-specific information and operational technology systems. Most of the current definitions have common parts, which including ICT enabling the smart city based on its applications. However, each city is different and the main purpose of the smart city or its definitions should come out of the benefits or improved quality of life for its citizens, which should always be on the first place. The benefits might be in domains such as economic activity, infrastructure efficiency, mobility, energy distribution and consumption, environment, safety, e-government, digital inclusion, healthcare, culture, citizen welfare and many other domains.
The Smart City is divided mostly into several areas: smart energy, smart transport, smart government, smart health, smart health, smart home and others. The Brno city council see three main pillars of the Smart City: (i) Smart Living, (ii) Smart Resources, and (iii) Smart Governance. Together there are also main priorities in the areas of:

- Energy and sustainability,
- Mobility, parking, quality of public transpiration system,
- Open data and information system based on the current needs,
- Efficient city management,
- City development and intelligent urbanization,
- Environmental protection and waste management,
- Services for residents, leisure time, and quality of living,
- Healthcare and social-care,
- Innovation, planning and new technologies,
- Economy and transparency,
- Safety, education and information.

As already said, the ICT infrastructure and technologies are the key part in the implementation of these defined and also many other areas into the Smart City infrastructure. This case study focuses on the role of the ICT in the context of Smart City. Therefore, we introduce the smart city term, its parts and how the ICT is included in its implementation. Moreover, we introduce the basic vision of ICT infrastructure for Smart City. Following by description of successful stories and solution from different parts of the Czech Republic, Europe, or World. These solutions are evaluated based on the replication potential in the environment of Brno city. Therefore, the street Spitalka is selected as a showcase location. Last but not least, we also touch the ICT security topic, where we introduce the main threats to the smart city, mitigations, and best practice.
The rest of this publication is divided into following sections: Executive summary, Study specification, ICT trends in Smart City, Best cases for Spitalka and Brno City, Security context in ICT and Smart

City, and Conclusion.

Executive summary

The study aims at the ICT and Security. The study covers hundreds of projects, ideas, initiatives and solutions from national, European and worldwide perspective. We identified the global reference model.

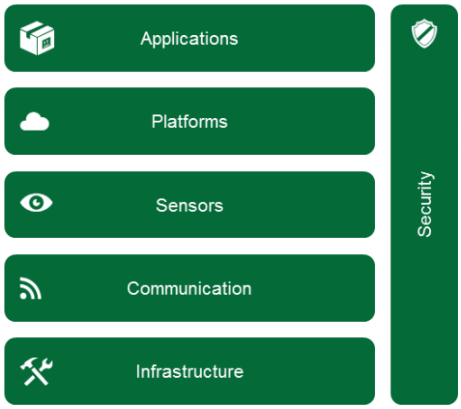

Figure 1: Reference model for Smart City (source Deloitte, 2017).

Based on the reference model, we exclude the high-detail application layer as it is not essential from the ICT point of view and it will be most probably covered in the different case-studies through the RUGGEDISED project. Two main domains were identified: **ICT infrastructure** and **cybersecurity**.

The deep investigation shows that most of the smart city solutions are just application-based solutions, focused on "show-case" ability more than replicability. Therefore, the potential of replication is very low in most of the cases. However, some exciting projects – blueprints, were found such as Prague portal, Hong Kong Blueprint, Smart Africa Blueprint, and many OpenData portals.

For the Spitalka street, three main topics were selected as a suitable solution:

- **ICT Infrastructure,** including the basic solution via fiber, but also wireless solution for the sensor network. Some basic schematics were introduced via smart city projects. However, the design for Spitalka street must be handled via external independent experts to provide sufficient quality of the proposal.
- **Open data portal,** many different portals were introduced from where might be taken inspiration. The open data portal is a simple, but strong way, how to introduce the Smart City to the communities. Processed data might bring many interesting conclusions for citizens, researchers and companies.
- **Security,** including not only technical point of view but also methodological and management point of view. The Spitalka street is a right place, where to learn important lessons from the cybersecurity for the future development of system covering the whole city. Moreover, the security games might be a very interesting way how to engage the community in the security development and bring many new approaches to the security from different corners via researchers and independent security experts.

2 Study specification

2.1 Short introduction to the ICT and Smart city context

There are many solutions, which touches the topic of information and communication technologies (ICT) including smart parking, smart grid, smart e-shop, smart housing, smart building and many others. However, these are just the final applications, which use the already finished infrastructure and offer different services (the reference model is displayed in Figure 2).

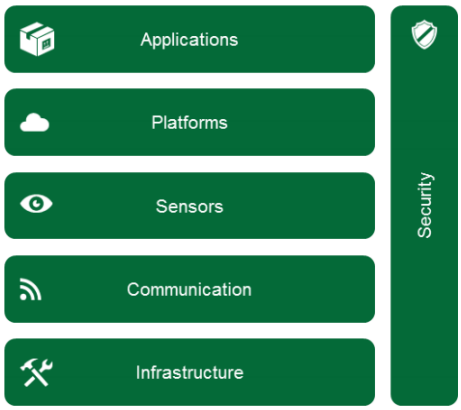

Figure 2: Reference model for Smart City (source Deloitte, 2017).

2.1.1 Applications

The application layer is the layer, which is visible to the end-customers or citizens. These are often the only one part about which is spoken about but from ICT point of view the least interesting or least important. If the above layers of the reference model are well-designed, there is no-limit in creating or connecting any application to the infrastructure. Thus, the city should more focus on deploying high-quality low-level blocks than high-quality application blocks. Unfortunately, the reality is entirely different and many cities select to provide applications before building sufficient low-level blocks. There are many reasons for it, i.e., to introduce to citizens the Smart City idea and provide preliminary services. However, this often leads to security problems, non-functional applications and it has the reverse effect in Smart City idea rejection.

2.1.2 Platforms

The data platforms offer mostly services to store a high load of data collected via sensors. Considering cloud or static servers, city needs to always think about security. The cloud services are mostly more expensive, but the comfortable solution with complex security requirements. On the other hand, static servers do not provide such modularity, visibility or space as a cloud service. However, the city needs to decide which approach is appropriate in their situation and provide sufficient solution also for future. The most critical issues are the security, data ownership, data and platform control, sufficient data storage space, and others. The consequences from wrong decision or underestimation of most crucial parts of platform might lead in future to much more expensive issues, i.e., in case of security incidents such as data robbery.

2.1.3 Sensors

These are the end-devices, which collect the information across the city. Moreover, the sensors

(among other types of information collecting) provides a simple way for information processing and analysis. However, the infrastructure must be ready to process big data in real-time, use appropriate anonymization techniques, and others. Moreover, the city needs to have a strict and transparent policy for connecting new technologies or sensors to the infrastructure together with following the most common standards and protocols to provide sufficient possibilities to connect variation of different sensors.

2.1.4 Communication

The layer above passive infrastructure with communication equipment that makes it possible for actors in a Smart City to transmit information in various formats and according to different standards, thus enabling various types of capacity and transmission services such as Wavelength and Ethernet services, which are often performed by a communications operator. It is necessary to keep in mind that infrastructure should be open for different kind of communication technologies, which provide the maximum from information transmission over the network. Moreover, the interoperability is a key factor, which must be taken into account.

2.1.5 Infrastructure

The infrastructure includes the core of the whole Smart City and enables via fiber, copper or coax technologies the delivery of data, which is the basis of the ability to connect a vast number of sensors and deliver huge quantities of data and information within a city. However, the fiber should always be considered for new infrastructures as it offers the best parameters without technical limitations and it is only technology adequate for the future concept of Smart City. Unfortunately, the one downside of the fiber is the price and also reason to consider the fiber for the core lines of infrastructure. Besides fiber technology, a wireless network must be considered out of the core infrastructure to deliver the communication service across the city area to the small sensors, where optic fiber does provide a cost-efficient solution. However, the city should not rely on wireless technology and it should be used only in cases of end-sensors. In the end, the sufficient planning is very important as it can save future costs, where wrong choices of actors might be very costly to rectify at a later date.

2.1.6 Security

The security block is another very important part of the reference model. The Smart City is a part of the cyberspace thus also part of the cyber warfare. The growing security incident due to every day more connected world shows the importance of cybersecurity. Incidents such as hacking issues, company frauds or data robbery happen every day.
Moreover, we are also witnessing much more complex attacks led by a group of hackers or leaded government hackers to shut-down important parts of infrastructure or even start the black-out issues. Thus, the security is a very serious factor and responsible authorities for deploying ICT infrastructure or leading the Smart City project must take this factor in the account. Also, relatively innocent data such as data on waste collection can expose the living habits of individuals and vulnerabilities in public infrastructure in a manner that violates privacy. However, the more people and organizations have access to the infrastructure together with complex cloud/physical storage and multi-technological environment creates a very complex environment, where the security is hard to achieve. Thus the cities need to take an active role in security work at all layers of the reference

model, where the city can either take overall responsibility or a supervisory role. The most important is that the city has sufficient sources of experts, which may respond to the security issues and incidents, which will help to mitigate and reduce impacts of malicious acts.

2.2 Security concerns in Smart City ICT context

There are five main phases of cyber security (based on NIST Cybersecurity Framework, 2018): (i) Development, Cyber Assessment, Identity and Policy enforcement, (ii) Protection, Defend and Monitoring, (iii) Threat detection and forensics, (iv) Respond, and (v) Recover.

2.2.1 Development, Cyber Assessment, Identify and Policy enforcement

The development of the smart city infrastructure is never ending process. Therefore, the security audits should be included on the regular year basis or event-driven basis, i.e., in case of exchanging an important part of the infrastructure. The security audits should be mostly made by external experts. However, most of the following methods might be handled via internal experts or with help from the academic environment.

2.2.1.1 Assessment inputs

An important part of the assessment method as it defines basic terms, inputs, crucial parts and many other necessities, which are used in the assessment processes.

2.2.1.1.1 Use-case (environment) definition

We need to clarify, what will be the use-case, which kind of implementation will be used. The communication model needs to be clear (all the steps, techniques, methods must be included, inputs and outputs), the scenarios of the communication and situations must be defined. Cryptographic and security parts must be described.

2.2.1.1.2 Asset identification and definition

The first step in the security assessment must be the asset definition. We need first to know: the important (critical) parts to be protected (i.e., what kind of data - all of them? configuration messages? monitoring messages?), what security services are important (do we need nonrepudiation? Do we need confidentiality?). However, these do not need to be the only type of data, service or devices, but also general assets like citizens safety.

2.2.1.2 Theoretical Assessment methods

Theoretical methods are mostly working just with documentation without practical consideration. This is a basic assessment method to discover general security issues, implementation or design weaknesses with clear remediation before any practical tests will be conducted. This tests mostly helps as an initiative lookup to the security issues (initial phase of design), but also in cases such as new standard, a new area of use, and others (initial phase before deployment).

2.2.1.2.1 Design Analysis (Theoretical “qualitative” security assessment)

Weaknesses and potential issues must be pointed out based on the previous definitions (security threats and attack paths). Therefore, design analysis (high -> low design analysis based on the information given) should be conducted to identify potential gaps in the system design and provide information for improvements (remediation). The white-box analysis should be conducted (all documentation should be provided to give the entire picture of the system, all information related/nonrelated should be given).

2.2.1.2.2 Threat/Risk model and analysis (Theoretical “quantitative” security assessment)

Where design analysis should give a clear overview of potential weak design (weak crypto algorithms, insufficient key lengths, or others). The risk analysis should give a clear overview of potential risks and attacks (best if they are also quantified – quantitative analysis). There might be included different methods such as HAZOP analysis, what if analysis, integration review, STRIDE method, misuse cases, brainstorming, threat library or relevant best practice – if possible there should be a combination of such methods. These analyses should result in list of threats with clear computed value, the quantitative risk analysis (risk level is computed mostly from probability and impact, but also other variables may enter the equation – case from case, i.e., there might also be computed attack potential from the elapse time, expertise/knowledge needed, access needed, equipment needed etc. together with damage (impact) potential).

2.2.1.3 Practical "virtual" security assessment methods

Corresponding to its name, this approach uses virtual defined environment and models to save costs or to serve as a more practical security evaluation than the theoretical approach in the later design phase. There are several initiatives, which uses virtualized city or laboratory environment, which helps to city establish the security on the virtual level.

2.2.1.3.1 Model-based tests (Practical "virtual" security assessment)

The theoretical based approach, which tries to come closest possible to the real-case with defined model, threats and attack vectors (trees). It includes software and hardware model-based testing – it is not included in the penetration tests as it is not a physical approach.

2.2.1.4 Practical "physical" security assessment methods

Already practical "physical" tests, which should be a final stage of security assessment for devices, systems, networks and others.

2.2.1.4.1 Functional security assessment (Practical physical "passive" security assessment)

The first step in the practical security assessment focused on the functionalities, correctness of the implementation, differences to the specification, and others. This part should run the program (application, system and device) and try to discover errors, mistakes and issues in the given implementation to uncover the potential risks and weaknesses of the system on the practical level. This is the practical version of theoretical design analysis (even if they complement each other they should be conducted separately as they both use different approaches). Moreover, the code review might also be included, or robustness testing, and general static and dynamic SW analysis might be included.

2.2.1.4.2 Penetration testing – vulnerability analysis (Practical physical "active" security assessment)

Mostly known for application, but also devices, organizations and others used penetration testing to find potential weaknesses. Many cities are supporting these action and starting to support so-called security games to enforce their systems. In general, it includes following parts (considering software, hardware – device/network/infrastructure and human resources):

2.2.1.4.2.1 Vulnerability (network) scanning (Practical physical active "settings/network" security assessment)

The comprehensive analysis via port/vector/protocol scanning, outside entrance/third-party analysis,

probing, wireless analysis. This tests are mostly infrastructure based and not sure how relevant these test would be for our case. However, if methodology should be provided, this should be included (even if for this particular case is not exactly relevant, because we will use simulation/virtualized environment). Last but not least, this point might (theoretically) include malware, ransomware, DDoS protection and another testing as it is impacting the whole system and it is a question of special entrance into the system, device or application.

2.2.1.4.2.2 Software security assessment (Practical physical active "SW" security assessment)

The attack on a software level, which includes methods such as fuzzing (from the point of fuzzer – an active attacker), reverse engineering, exploitation, and other similar methods, which focus on the mistakes made by programmers and developers on the SW level.

2.2.1.4.2.3 Device level - HW tests (Practical physical active "HW" security assessment)

The hardware (device) based tests, which include memory extraction, component manipulation, abuse of test ports – but also methods for chips such as microscopic inspection, probing, beam modification, side-channel tests, fault testing, and other very complex methods.

2.2.1.4.2.4 Social engineering methods (Practical physical active "human" security assessment)

Also, very important part of the penetration/vulnerability testing as the main security incidents and issues are driven from insiders or by not sufficiently educated employers.

2.2.2 Protection, Defend and Monitoring

The general protection of the system must be handled in real-time by a 3rd party (as a service to protect the critical infrastructure) or by own security department with highly experienced experts. There are many different approaches to the security monitoring, but the two general methods are passive and active. Passive method mirrors the traffic and analyzes it based on the given behavioral model. The active method works with the flow and actively scan the system or enters the traffic to find the security incidents. Both solutions have its advantages and disadvantages and it is always a question of purpose. Moreover, the methods might be just traffic monitoring or the whole real-time security assessment, which offer both – traffic monitoring and real-time assessment method as in the previous point. However, the security assessment monitoring will never fully take over the security audits.

2.2.3 Threat detection and forensics

Point connected to the previous one. Based on the assets and also on the level of monitoring, detection and quality of the used tools there will be discovered during the time security incidents via tools or via security incidents. The action must be taken immediately afterward.

2.2.4 Respond

The organization same as the smart cities must have clear and straightforward threat response management and crisis plan. All these should reduce the impact of a security incident and occurred threats.

2.2.5 Recover

Each city should have not only the response plan but also the recovery plan, which allows restoring activities and internal processes. Again policy driven point, where each organization should re-think the consequences of the security incident, update internal policy, refresh the protection methods and start again with the full assessment. There must be clear lessen-learn policy to mitigate future threats of a similar approach. This also ensures to learn against zero-days attacks and respond to them.

2.3 The scope of the case-study

This study focuses on the ICT and Security in Smart City. Based on the last report of Allied Telesis from 2018, the most crucial part for Smart City is the existence and development of extensive, robust, and scalable Information and Communication Technologies (ICT) infrastructure, which enables not only the interpretation and collection of large amount of data, but also participatory governance and management part (Allied Telesis, 2018). Also, many other researchers identified that lack of infrastructure is a significant barrier in achieving smart city objectives (Chourabi et al., 2012, Dillon et al., 2002, Alghamdi et al., 2011, Giffinger et al. 2007, and Vasseur et al., 2010). The second biggest challenge for Smart City from the ICT point of view is the security and privacy, which is also discussed among many different papers (Wan et al., 2013, Sanchez et al., 2003, and Laplante et al., 2013).

From the point of the **infrastructure** the critical issues are (Narmeen et al., 2015):

- Heterogeneous environment and Interoperability,
- Efficiency, Availability and Scalability,
- Big data Management,
- Cost.

From the point of the **security** the critical issues are (Zhang et al., 2017):

- Privacy leakage in data sensing,
- Privacy and Availability in Data Storage and Processing,
- Trustworthy and Dependable Control.

This study will focus on the best practice cases from the Czech national projects, but also European and worldwide projects. The main aim is to find blueprints for Brno city, which might be replicated and used for development of Smart Brno. The main focus will be on the Infrastructure and Security implementations.

The main question, which should be answered:

- What are the main components of the ICT and Security for Smart City?
- How to build reliable, secure, scalable infrastructure for Smart City?
- How to implement security parts in the Smart City, what are the main components?
- What are the best practices on the national, European and worldwide level, are there any usable blue-prints for ICT Infrastructure or Security?

The answers to these questions should help to better understand the issue of ICT and Security in Smart City. Moreover, the light-houses and best-practices should show the possible approaches and also give some direction for the future development. In the best case, there will be selected several cases, which are suitable to deploy as a show-case in the Brno for Spitalka street.

3 ICT trends in Smart City

3.1 Czech Republic

3.1.1 Ministry of Regional Development

The main direction of the Smart City is in the Czech Republic also driven via Ministry of Regional Development, which published several methodological materials and introduced a concept of the Smart City divided into four parts (management, community, infrastructure, the final shape of the intelligent city) with sixteen components. The probably most important document would be "Metodika Konceptu inteligentních měst" (Barta, 2015), which also touch the information and communication technologies (ICT) and divide it to four levels: (i) Identification, (ii) communication, (iii) information, and (iv) application. However, most of the important scope of this document seems to be application based view (discussion about different applications – defined as ICT systems) and data view (discussion about the form and connection of data). *In our opinion, these views are important after the secure, functional and reliable ICT infrastructure is deployed.* Nowadays, there is not challenge in data gathering, the open-data is just a matter of methodology, and communication technology mostly matter of use-case. However, the ICT infrastructure should be always much more important than the application itself as it is an activator for applications, data, information and many others.

3.1.2 Prague (https://www.smartprague.eu/)

The capital of Czech Republic, Prague, has its initiative for Smart Prague and more than 50 projects are divided into the following pillars: (i) People and city environment, (ii) No-waste city, (iii) Attractive tourism, (iv) Data space, (v) Future mobility, (vi) Smart building and energy, and (vii) Smart Prague stamp. Another layer might be considered as a strategic project, secondary projects, ideas of Prague citizens, enterprises and partners' projects of a smart city, and smart projects of city parts.

3.1.2.1 People and city environment

Many projects including, which are not straight relevant to the ICT or security, but they are connected to the Prague Data platform and request already functional infrastructures such as Metropolitan emergency system (eHealth), Smart Prague Wi-Fi, Application MyPrague, AI driven projects, Indoor quality meters, Smart lightning and others.

3.1.2.2 No-waste city

Methodological or no-ICT driven solutions such as compress bins, but also solutions connected to the already ready-to-use infrastructure such as intelligent waste management, which seems to be still in development including 60-80 bin places with a vision to save costs, increase traffic/driving comfort, and data harvesting. This is an example of a project, where the small-driven project will be evaluated for bigger use in future together with its profits. *However, this does not bring anything new for the ICT or cyber-security.*

3.1.2.3 Attractive tourism

Currently includes just alfa-version of an interactive tourist guide. The project is driven again mainly by Operátor ICT, a.s. which should not only help the tourists, but also collect data and use them for future management and planning. *This application is again connected to the Golemio and ICT infrastructure of the city.*

3.1.2.4 Data space

From the point of ICT, the most interesting part including mainly following projects:

- **The Prague Data Platform (https://golemio.cz/)**, a public contract from Operátor ICT, a.s. with the main purpose to connect all the data-driven applications, data harvesting, data sharing and others. The main functionality is the collection, evaluation, management and visualization of the information. The main profit is claimed as the efficient management of key-field in city infrastructure, higher comfort for citizens and guests, saving costs in different fields of city management, and data used for processes optimization.
- Moreover, Prague opens all information and documentation about the Golemio platform and soon will be available also the GitHub solution. *Together, this information gives enough background for starting own data platform or learn from a different city. It is also an example of an open-data approach to the smart city solution and well-handled smart city project.* The platform includes applications such as public transport, parking, cyclo-traffic, sustainable city, compress bins, smart banks, public light sensor network, waste management, chatbot, air quality and more.
- **Virtualization of Prague and 3D data model**, very interesting project together with CVUT and mainly company Operátor ICT, a.s. was created 3D model of the city or laboratory with 3D city model for research, pilots and other evaluations/analysis. The application should provide space analysis, help in urbanization, support the predictive models, and provide space-time modeling opportunities for different kind of projects. *The documentation of the project seems to be still not open yet, but the idea of 3D data model or such a laboratory seems to be a very interesting idea, how to support the research and future development of the city.*

3.1.2.5 Future mobility

Section, which is led by parking and informative projects such as Information system of travel time, Infrastructure of e-cars, multi-channel public transport system, car-sharing application, intelligent traffic management, anti-collision system, emergency preference for an ambulance, or automatic system for exit/entry in urban parking spaces. *All these projects are slightly connected with ICT, but the main part is again the ready-to-use or ready-to-connect infrastructure, which helps to integrate great ideas as mentioned above.* The infrastructure should not be only ready, but also interoperable, which means it needs to support different technologies, protocols, company solutions, and much more.

3.1.2.6 Smart building and energy

This part includes four main strategic projects, two support projects and eight partners community projects. The strategic projects of Prague are the energy system for buildings, digital energy measurements, complex energy management in buildings and energy saving with EPC method. The strategic projects are still not fully tested or deployed, but the main direction of the city strategy is in power saving and power management for group or single buildings. *From the point of the ICT, these solutions are just another approach to the sensor network, SCADA communication and general infrastructure-based solutions.* Also, other projects such as smart lightning, or power saving methods are just another example of how to use the communication infrastructure, but no blueprint gave for the general ICT solution.

3.1.2.7 Smart Prague stamp

The Smart Prague Stamp is not a full group of project or direction of the smart city initiative in Prague, but it is a way how to claim that certain projects meet ideas of Smart Prague. This means that they fall into one of the areas defined by the Smart Prague vision, they use smart technologies and are beneficial to the Prague citizens. *This is again not fully ICT solution and it is more connected with the Smart city vision, but once again a solution, which needs an application, database, and infrastructure – such as Golemio.*

3.1.3 Brno (https://www.brno.cz/smartcity)

Brno city was not a part of the investigation as the main contractor is part of the Brno city council and it is more than sufficiently experienced with the Brno environment and projects. *Therefore, the Brno was excluded from this analysis.*

3.1.4 Czech Smart City Cluster (http://czechsmartcitycluster.com)

The main purpose of the Czech Smart City Cluster (CSCC) is creating the unique partnership between enterprises, government, academic environment and citizens. The main working groups are divided into following categories: intelligent buildings, healthcare, big data, waste, payment system for transport, industry 4.0, security and cybernetics, strategy and measurements, administration and legislative, traffic, energy. *More than solutions it is a community sharing, which is not much important from the point of the ICT, but the partnership might give a significant acceleration in technological deployment (however, Brno city is already part of the cluster. Therefore, there is no need for deep investigation).*

3.1.5 Smart city from Ceska Sporitelna (https://www.chytremesto.cz/)

Smart city concept from private company Ceska Sporitelna, which currently include five solutions spread around the Czech Republic (Smart waste bins, united information city portal, smart and economical public light system, fast recharge station for electro-cars, contactless check-in system for public transport). The application-based solutions are already deployed in some cities and prepared to be blueprinted. *However, the most important united information city portal case is not yet deployed. The system seems to be complex, but the deeper investigation is needed (no documentation is given). Moreover, this solution is not tested in a real environment thus is not appropriate for blueprinting.*

3.1.6 Smart City Innovation Institute (http://www.smartcityinstitut.cz/)

Initiative or NGO “Smart City Innovation Institute” s methodological group, which tries to make a business model from the education, methodology, analyses and partnership connection. Necessary to mention it, but *it does not bring any new information, technologies, solutions or blueprints from the ICT area.*

3.1.7 Other cities and solutions in the Czech Republic

Also, other cities in the Czech Republic are adopting the modern technologies as well as the whole concept of smart city evolution, including cities (but not limiting to): Pardubice, Hrusovany nad Jevisovkou, Jihlava, Zdar nad Sazavou, Nove mesto na Morave, Pisek, Ceske Budejovice, Jindrichuv Hradec, Prachatice, Tabor. However, these cities mostly start with the smart solutions or the blueprints are just application based show-cases. These solutions are mostly also already

implemented in different ways in Brno thus there is not the big potential for replication.

3.2 European context (The European Smart City Lighthouse Projects)

The most interesting solution in Europe should be considered lighthouses – the twelve projects that start with the EU foundations and accelerates the evolution of European cities, for this purpose, the following projects were considered: GrowSmarter, STARDUST, MAtchUP, RUGGEDISED, REPLICATE, SmartEnCity, SMARTER TOGETHER, IRIS, Sharing Cities, Triangulum, REMOURBAN. Moreover, there are also similar projects such as Embers, City Keys or Espresso, which are following the similar approach. These are the most important solution in the European context and will be considered as the main target of evaluation in this section.

3.2.1 GrowSmarter (http://www.grow-smarter.eu/)

The GrowSmarter projects are based on the idea to create a ready market or these smart solutions to support growth and the transition to a smart, sustainable Europe. The very general task contains 12 smart solutions with more than 20 industrial partners and three lighthouse cities – Stockholm, Cologne and Barcelona. The project deals with three main areas: low energy districts, integrated infrastructure, and sustainable urban mobility. Most of the projects are deployed as a show-case or in development.

3.2.1.1 Low energy districts

- **Smart building shell refurbishment**, including topics such as climate shell refurbishment, energy quality assurance re-build of an industrial site, smart shell and equipment refurbishment (200 unit apartment building, tertiary buildings or residential buildings), smart efficient climate shell refurbishment in Valla Torg or Energy efficient swimming pools. *These are again only applications without any close connection to the ICT issues.*
- **Smart building logistics**, including just one topic – construction consolidation center – which is *not important from the point of ICT view.*
- **Smart energy-savings tenants**, again one area with several topics such as home energy management, the active house, an open home net, upgrade energy savings center, home energy management system, virtual energy advisor, or dynamic pricing models. *These are solutions, which use the ready infrastructure – applications – and again are least important for the ICT topic.*
- **Smart local electricity management**, including few topics – residential estate management, smart energy and self-sufficient block, or building energy management system – and *also this last topic is not touching the ICT issue at all.*

3.2.1.2 Integrated Infrastructure

- **Smart street lightning**, application-driven area with smart LED street lighting, Streetlights as wifi, and Smart meter information analysis. Even so, the Streetlight as WiFi or Smart meter information analysis are interesting topics, the documentation is vague and there is no sufficient information to provide clear blue-printing. *It seems that these solutions were only ideas, which will be deployed during the H2020 project.*
- **Waste heat recovery**, covering areas such as open district heating using waste heat, district heating rings and smart local thermal districts. *However, these topics do not touch the ICT or security issues and are less important from this point of view as they are only applications.*

- **The smart waste collection**, just one area, covered – automated waste collection – which again is *only a "simple" application from ICT point of view.*
- **Big data management**, one very interesting topic from the ICT point of view. This area includes topics such as the urban cockpit, urban traffic, urban environment, and big consolidated open data platform. *Again interesting topics with very vague documentation, but these are topics which should be followed during their development as they could bring much important information about the data processing and platform block.*

3.2.1.3 Sustainable Urban Mobility

- **Sustainable delivery**, a series of communal service boxes installed in or close to the entrance hall of the residential building. When receiving goods, a service box will be allocated to the receiver along with a special code that will open the service box for the right person. This solution has a potential to improve quality of life together with reducing environmental and noise impact. Moreover, this part also contains a solution of micro-distribution of freight, the last mile delivery of goods, which is a new approach to reduce congestion, lower emissions and diminishing delivery times in dense urban areas. *These solutions are not purely ICT, but they need integration into the ICT infrastructure of the city. Once the infrastructure is ready, then these or similar solutions might be deployed.*
- **Smart traffic management**, this solution is tested in the Barcelona and Stockholm, where different solutions are considered. Barcelona uses a macro fundamental diagram (MFD), which assesses the relationship between space-mean flow, density and speed of an entire network, with many separate links. On the other hand, Stockholm uses traffic lights with software, which communicates the current status of the light and when it is about to switch to another color. This should be achieved through the data connection between the traffic light, the car's onboard software and GPS, and a central computer handling the calculations. *Again a solution, which is not straight connected to the ICT, but it includes the ready-for-use infrastructure with a communication network, computation servers and application ready-to-connect framework for different kind of applications.*
- **Alternative fuel driven vehicles**, first look to this section reveal pure energy solutions mostly based on the charging stations and electric cars infrastructure. However, most of these counts with an interactive map, user-driven applications and again ICT infrastructure already ready to use on the city-side. *Again solution, which proves the importance of the ICT infrastructure in the city, which should be ready before any of the solutions is deployed in the praxis.*
- **Smart mobility solution**, this section contains green parking index – a solution which rewards developers, which provide in their projects alternative forms of transport to their residents. This solution is purely a management solution without needs of ICT. Another solution is a mobility hub, which provides information to the commuters and residents a location, where you can easily find various kinds of transport, such as trams, trains, buses, taxis, e-carsharing, e-bike sharing and parking lots with online management of parking spaces. However, this solution from its nature needs a functional infrastructure to provide information to the residents (and to the integrators the platform for their applications or services). This section also contains a sensor-based smart taxi stand system, which provides online information to the residents and tourists about the taxi services in the city. Also, the taxi drivers get information about the demand for their service. The solution is based on the

Low Power Wide Area (LPWA) wireless network, which also shows the importance of ready-to-use infrastructure, which includes among others new modern wireless solutions such as LPWA. The last solution in this part is a car-sharing, a sustainable urban mobility solution, which is also integrated into the ICT infrastructure of the city. *From first look purely energy solutions and service-based solutions, but on the second look again solutions, which needs strong ICT infrastructure of the city.*

3.2.2 STARDUST (https://stardustproject.eu/)

Stardust claims to bring together advanced European cities, this forming into a "constellation" of "innovation islands" – exemplary models of smart, highly efficient, intelligent and citizen-oriented cities. Three main cities were chosen as a lighthouse: Pamplona, Tampere and Trento:

3.2.2.1 Pamplona city

Pamplona city seems not to have finished a smart city solution. However, they claim to have many methodological materials such as Sustainable Development Plan of the City, the Sustainable Energy Action Plan (SEAP) under the Covenant of Mayors, the e-Vehicle Action Plan of Pamplona, and the Navarra Energy Plan 2030. Moreover, they claim to have also energy-efficient solutions in the form of ICT, renewable energy resources and other unconventional techniques, District heating networks and
electric vehicles (i.e., e-taxis, e-cars, e-bikes and e-buses and some charging points and chargers in communal garages). These solutions are still in the planning and not functional, blueprint-replication ready solutions, but they might be used as an example of one of the directions in European Smart City.

3.2.2.2 Tampere

Another lighthouse from the Stardust project is Tampere city with again mostly methodological materials ready and initiative driven motivation such as The Open and Agile Smart Cities (OASC) initiative, and the Innovative Cities Programme (INKA). Most of the works and solutions are in draft or planned (not implemented) such as smart energy-efficient systems like heat recovery, building energy modeling and other advanced ICT schemes, combined heating and cooling energy systems, electric vehicles and charging stations or advanced ICT solutions (such as Green Light Optimised Speed Advisory). *Again draft driven lighthouse, which serves only as an example of the smart city direction, but not likes blueprint-replication ready. Moreover, most of the terms are highly generalized and overused through all the smart city project and not much information for the real-solution harvesting.*

3.2.2.3 Trento

Last city from the STARDUST project, but again beginner in the sense of the smart city. The project claims to include, introduce and install the following solutions: retrofitting techniques and energy-efficient systems, new renewable energy resources and novel combined heating and cooling systems, Urban Mobility plan and set of ICT tools. *Once again, very general directions, which does not tell much about real implementation, real solution or replicability.*

3.2.3 MAtchUP (http://www.matchup-project.eu/)

The MAtchUP project includes several areas such as:

- **Energy solutions** - smart controls, electrical storage, urban renewables, smart grids, public lighting, new building, retrofitting and building integrated RES, storage,
- **Mobility solutions** – charging station, electric vehicles, demand management, urban freight and intelligent transport system.
- **ICT solutions** – urban platform and internet of things.

The most interesting topic for this study is ICT solutions. The ICT solutions cover:

- Valencia (Smart home energy management system, Smart district energy management system, open data management, open APIs)
- and Dresden (New open data gateway, new open API developments, big data functionalities, VAMOS interface for the B2B platform, Urban Mobility Assistance, Citizens feedback mobility application, mobility planning application).

The IoT solutions cover:

- Valencia (IoT data integration with the VLCi smart city platform, IoT&BigData analysis – KPI dashboard),
- Dresden (IoT adaptors and Smart meter gateway for electromobility),
- and Antalya (IoT adaptors).

3.2.3.1 Valencia ICT solutions

The city of Valencia supports open data initiative and aims to develop an ecosystem of open data related applications. It is the leading city from MAtchUP project that develops ICT solutions for smart city. The city council created Valencia VLCi smart city platform integrating many open data catalogues and real time data APIs. Every smart solution, built by means of the VLCi platform, contributes with ISO37120 KPIs, which are reported by the city management using city dashboards. Smart city solutions in the city of Valencia are also developed under cooperation with company Telefonica and under Uraia smart city platform for exchange of information.

The system is built using CKAN API tool for making open data websites. This is a content management system for data, it is open source and developed under CKAN association. VLCi platform uses 350 sensors all over the city to gather information from the environment and uses Fiware open source based solution to gather the data and make them accessible to public.

It is also using Real time open data middleware RTOD built upon CKAN which is providing access to content from different sources of data in a single access point in real time. It also contains a georeferenced data API which is providing service for looking up points of interest near current location (free public parking spaces, bicycle stations, containers, public wifi points etc), but no technical details about this api are available.

Applications for city residents or visitors that emerged from this open initiative include:

- bike sharing apps: Bici, RideU, Valenbisi
- parking app: Apparcando
- tourist apps: VLC Tourist card, VLC Valencia, Museos y Monumentos Valencia
- city council apps: AppValencia

3.2.3.2 Dresden ICT solutions

City of Dresden mainly focuses on renewable energy clean solutions and to provide its residents

better standard of living in this area. They plan an integrated smart city platform, no technical details revealed yet. No technical details about IoT adaptors or Smart meter gateway as a part of MatchUP project are avaliable. Public initiative projects for smart city of Dresden are done under the OK LAB Dresden project. They provide a lot of public available applications but this effort still needs to be transferred to an integrated open data platform under city supervision.

3.2.3.3 Antalya ICT solutions

The city of Antalya is creating an urban transformation project of Kepez smart city – new town district rebuilt after earthquake. Kepez district is planned to be a complete modern smart city used for testing new approaches and comfortable living.

ICT smart city application is developed by Turkish IT company SAMPAŞ as their project AKOS. It is not open source and technical details are not available. Kepez smart city project is supported by EU Commission in scope of the Horizon 2020 program.

This project should be followed to see the practical results as it may offer high replicable solutions for Brno - mainly the Valencia smart city platform, which is developed using open source software such as FIWARE which is currently very popular solution for open data smart city platforms, Uraia platform, CKAN and RTOD Apis which enables rapid development of private applications based on real time open data shared by city platform.

Technical information about Dresden and Antalya ICT projects is not public with except of Turkish SAMPAS IT company providing smart city vendor dependent and not open source solution.

3.2.4 RUGGEDISED (http://www.ruggedised.eu)

RUGGEDISED project was not a part of the investigation as the main contractor is part of the consortium and it is more than sufficiently experienced with the use-cases or the project. Therefore, the RUGGEDISED was excluded from this analysis.

3.2.5 REPLICATE (https://replicate-project.eu)

The project, which is divided to the three parts: (i) Integrated energy – building retrofitting, district heating system, smart grid and demand-side platform, (ii) mobility – advanced charging infrastructure, transport management services for citizens, and (iii) ICT solutions – smart city platform and smart public lighting. This project includes light-cities Florence, Bristol, and San Sebastian with own already deployed solutions.

The Replicate EU Project also encourages the replication of already deployed solutions to its leader cities by a ‘City-to-City-Learning’ Programme led by the University of Oxford. This experience and solutions sharing programme is for stakeholders and cities that will joined this initiative, possibilities of joining this programme are not available.

3.2.5.1 San Sebastian ICT solutions

Neighborhood energy management system

- San Sebastian has plans for developing a platform to monitor the energy consumption of its residents to achieve better energy consumption efficiency. Technical details are not available

Urban data platform

- the city of San Sebastian developed an urban city integrated internet platform which is planned to be launched soon (launch date not available). It will provide open data access and aims to develop better citizen participation on smart city projects.

Travel demand management system

- development of urban mobility platform.

High speed mobile network

- San Sebastian is deploying a better and faster mobile network for its citizens. No technical details available.

Intelligent public lightning system

- Deployment of new smart lightning system in their testing area Poligono 27. Consists mainly of replacement 90 sodium lights by LED equivalents and reduction of energy consumption.

3.2.5.2 Florence ICT solutions

Urban city-wide dashboard platform for city management

- Florence is developing a responsive smart city platform to enable its citizens to interact with smart city systems and access the open data repository. Platform is currently under testing phase, plan is to get to production by the end of 2018, no technical data available

IOT and Capillary network development

- Florence plans to deploy sensor based systems to its current city infrastructure to harvest and publish more data, the objective is to develop three new IoT services with its capillary network that will be able to interface with city-wide dashboard. Currently deployed prototypes of smart benches and smart waste solutions.

3.2.5.3 Bristol ICT solutions

Sensor deployment on intelligent public lighting

- Collaboration between the city of Bristol, KWMC and the University of Bristol around the integration on sensors on lampposts enabling citizen sensing. Research has been done together with Data Unity about open standards. System is using the Humble Lamppost initiative standard for Lamppost design.

Integrated ICT Smart city platform concept

- Platform is developed to be operated under the FIWARE IoT platform system, which is an open source smart city data management initiative. Development of integration of FIWARE with NetOs Zeetta Network system. Plan is to build an open data smart platform together with mobility and citizen participation platform.

Technical information is available only for Bristol city ICT solutions – interesting technical solutions include development over the FIWARE (open source data platform smart city initiative) platform and using Humble Lamppost initiative (standard for intelligent sensing smart city lamppost design) design. As for other cities, the technical information about the deployment is missing and the project does not include any technical documentation about them. Thus the other involved cities might have some strong solutions for Smart City and interesting also for Brno, but the communication would need to be C2C (City to City).

3.2.6 SmartEnCity (https://smartencity.eu)

The SmartEnCity is another Light-city project from H2020 EU. It includes three cities:

- **Tartu** - Tartu ICT solutions include only one project - LED Lights with smart controllers system which is developed by company Cityntel OU and is based on a wireless mesh technology.

There are 312 smart light currently operating in Tartu and they are equipped with sensors:

- PIR movement sensors - capable of detecting people and vehicles and computing the overall human presence and traffic flow level
- Movement detector with cameras – detects people and vehicles using picture analytics and is capable of differentiating between vehicle
- Light reflection sensor – measures the rate of reflected light from road surface for analysing road conditions (dry, wet, snowy etc.);
- Noise sensor – capable of detecting noise level and source (human speech, traffic etc.)
- Environmental sensor – measures pollution (CO_2, NO_x), air temperature, humidity etc.

Benefits of this smart LED solution include smaller carbon footprint, increased comfort of living and better planning based on evidence (e.g. traffic). Budget of this project is 180,000 € (LED lamps) + 126,000 € (smart controllers).

Other smart city projects of Tartu city include retrofitting package (urban rebuilding of old rural areas), district cooling system that uses residual heat, reusing old EV batteries, public bike sharing system, gas buses in the whole city, smart home solution, LED lights with smart controllers, technical consultations and community meetings, lecture series "Planning an energy-efficient city", art solutions for pilot area buildings, study on attitudes towards technologies and the environment and social innovation experiments.

- **Victoria-Gasteiz** –Main ICT project of Victoria-Gasteiz is the urban management system platform. It is planned to be an integrated open data platform for implementing smart city open data concepts and enabling citizens involvement in the smart city initiative. The development of this platform is planned to be compliant with the Spanish UNE 178.104 standards. Other smart city projects of Victoria-Gasteiz includes projects with retrofitting, urban management, biomass district heating system and citizen engagement strategy for the retrofitting package.
- **Sonderborg** - includes projects with new biogas buses and biogas filling stations, citizen engagement program and Sonderborg retrofitting package. No ICT based solutions deployed.

Interesting project from the ICT point of view is mainly the Tartu LED smart lighting solution with published vendor and budget. This gives an excellent starting point for possible planning a testing deployment of smart city LED lights in Brno. No other ICT interesting solutions with technical information available.

3.2.7 SMARTER TOGETHER (https://www.smarter-together.eu/)

The Smarter Together include cities Lyon, Munich and Vienna. The main target of this project is to attract citizens and involve them in the Smart City project. Therefore, the project counts with many application driven projects, which offer additional services to the citizens such as energy visualization, citizens' platform and more. *However, the technical documentation is not available and the solutions are more application focused than infrastructure focused.*

3.2.8 IRIS (http://irissmartcities.eu/)

Iris is another H2020 project, where are involved three light-house cities – Gothenburg, Utrecht and Nice Cote d'Azur. The aim of the project is divided in to so call Tracks:

- **IRIS Transition Track #1**: Smart renewables and closed-loop energy positive districts, which includes Positive Energy Buildings, Near Zero Energy Retrofit District, and Symbiotic waste

heat networks.

- **IRIS Transition Track #2**: Smart Energy Management and Storage for Energy Grid Flexibility, which includes Flexible electricity grid networks, Smart multi-sourced low-temperature district heating with innovative storage solutions, and Utilizing second life batteries for smart large-scale storage schemes.
- **IRIS Transition Track #3**: Smart e-Mobility Sector, which includes Smart Solar V2G EVs charging, and Innovative Mobility Services for the Citizens.
- **IRIS Transition Track #4**: City Innovation Platform (CIP), which includes Services for Urban Monitoring, Services for City Management and Planning, Services for Mobility, and Services for Grid Flexibility.
- **IRIS Transition Track #5**: Citizen engagement and co-creation, which includes Co-creating the energy transition in your everyday environment, Participatory city modeling, Living labs (homes), and Apps and interfaces for energy efficient behavior.

Alike other smart city European projects, IRIS also demonstrates its outcomes in its three lighthouse cities which the other cities can follow. ICT projects from IRIS lighthouse cities include:

- Utrecht ICT and open data management platform – open data platform with over 200 publicly available datasets. Also built on FIWARE technology and on top of dataplatform.nl service. More technical details not available.
- Nice open data platform – open data platform of Nice city, no technical details available.

Again, one of the projects, which focuses mostly on the applications and services for the citizens. As already said, this approach is right when the infrastructure is ready to use. However, this study is focusing more on the case before the infrastructure is developed, implemented or deployed. Therefore, this project does not contain any blue-prints from the ICT/Security point of view except for two open data integrated platforms.

3.2.9 Sharing Cities (http://www.sharingcities.eu/)

The Sharing Cities project is H2020 project, which connects light-houses cities Lisbon, London and Milan with the aim to develop affordable, integrated, commercial-scale smart city solutions with high market potential. In praxis, this means to provide a sufficient number of applications for citizens to share and trade. *Therefore, this project is again application driven without any discussion over the infrastructure or security.*

3.2.10 Triangulum (https://www.triangulum-project.eu/)

Triangulum is again one of the test-bed driven smart city projects, which means that there are three light-houses (Manchester, Eindhoven and Stavanger), where some selected solution will be deployed, tested and blue-printed for the followers. Main areas covers also the most common Smart City direction such as joint ownership, smarter administration, energy saving technologies, CO2 reduction, data infrastructure with sensor network, people driven city, sustainable transformation of public space, quality of life incensement, energy cost reduction, increase mobility, air quality improvement, public transportation improvements, or even new jobs. All the areas are very general and follow no-given metrics or implementation plans for areas mentioned above.

Eindhoven ICT solutions:

- The city of Eindhoven plans to build two smart city testing areas for infrastructure testing and develop an integrated open data city portal
- District wide ICT portal will not only publish open data, but also is designed to provide citizens of Eindhoven a possibility to book and electric shared vehicles or use smart parking concept. No technical data available.
- Smart lighting testing site of pond in Eckart Vaartbroek is being developed for testing self dimming LED smart lights and other possible sensing components that can be built into smart Lampposts. No technical information available.

Manchester ICT solutions:

- The city of Manchester developed under the Triangulum initiative the Manchester-I (https://www.manchester-i.com/) open data portal and integrated platform to fulfill long-term vision of City-data management and Process system platform. This project mainly provides open data for third party application providers in the form of downloadable datasets or real time apis for data streaming. No technical data are available.

Stavanger ICT solutions:

- Smart city initiative works in Stavanger together with University of Stavanger to develop Cloud data hub, a group of open source technologies. No technical data available.

From the replication point of view, these project is interesting to follow, but right now no-examples or blue-prints are ready for use.

3.2.11 REMOURBAN (http://www.remourban.eu)

REMOURBAN or “REgeneration MOdel for accelerating the smart URBAN transformation” is the last project from the 12 lighthouses projects supported by European government. The project contains three lighthouses – Valladolid, Nottingham, and Tepebasi/Eskisehir. Most of the projects do not contain sufficient information. However, there are many solutions, which might be considered for this study. The project is divided into four categories: (i) Energy, (ii) Mobility, (iii) ICT, and (iv) Society.

3.2.11.1 Energy

The Energy actions are focused on low energy districts and include topics such as monitoring tools for energy, district scale retrofitting, renewable heating and cooling, electricity distributed generation, and advanced BEMS. The project claims to achieve at least 50% reduction of the building energy consumption through retrofitting interventions, but also by improving lighting and equipment efficiency. Moreover, the project also should deal with low carbon solutions for thermal energy supply and optimized electric facilities using decentralized electricity generation and smart grid management in order to achieve zero energy emission districts. *The goals are pretty interesting, but the solutions are not dealing with the topic of this study and the deeper investigation of it is beyond this study as it would not have any valid information for it.*

3.2.11.2 Mobility

The mobility focuses on addressing vehicles, transport infrastructures and the promotion plans for sustainable mobility. Again one of the section, which is not fully connected to the ICT, but it uses the ICT infrastructure to provide services or to obtain data. *However, no technical documentation about ICT/Security is given and therefore the importance of this study is minimal.*

3.2.11.3 ICT

Probably the most important part of this project for this study. Including solutions such as city information platform (combine and manage multiple data sources, provide inter-operability and data protocols between city domains), shared infrastructure planning (systematically exploit synergies between smart grid and broadband infrastructure), transforming the energy chain (very general task for integrating smart grid into smart city solution), road systems (mobile solution for optimizing the traffic flow based on route and travel information connected to the traffic light system), intelligent multi-modal transport solution (real-time multi-modal information to offer choice, personalize travel, and improve customer experience), peer-to-peer transport information (cloud-based solution for car sharing, e-taxi and others), and adverse events (connect key information sources with city monitoring system – sensors, people, etc.). *General and also specific tasks, mostly server-infrastructure-communication based approaches, which should provide and harvest information to the central point, which will open them for another process or give a different kind of visualization.*

3.2.11.4 Society

Many solutions, which are based on methodology, understanding the citizen's mentality, strategic and plan based solutions, funding models, *but also services and solutions again based on the ICT infrastructure such as stakeholder platform, social network regulation, city visualization, or smart energy map.*

3.2.12 mySMARTLife (https://www.mysmartlife.eu/)

One of the last founded H2020 smart city projects with light-house cities Nantes, Hamburg, and Helsinki. The project focuses on three topics: Inclusive Cities, Smart People, and Smart Economy. *Therefore, the topics are not valid for this study. Moreover, the project does not offer any valid solutions of documentations.*

3.2.13 Other European Projects

There are many interesting H2020 projects, but neither one is dealing with a clear and open (blue-printed) solution for security and ICT Infrastructure.

EMBERS (https://embers.city/)
There are projects such as EMBERS, which deals with specific areas – mostly application/market driven. EMPER project is highly focused on the mobility (mobility backend and mobility services for market). It just demonstrates that there is H2020 project connected closely to the Smart City, but the replicability from the point of ICT/Security is minimal.

City keys (http://www.citykeys-project.eu/)
Very interesting topic, which should be followed as it is focused on the issues and challenges of the smart city. The main aim is to define the needs, analyze existing results and develop recommendations for the use of performance indicators. The project ends in January 2017 and it has plenty of materials for the city council. Even so, it is not connected with ICT/Security, we come to it and decide to include the link as it might offer interesting ideas and materials to study.

Espresso (http://espresso-project.eu/)
The project is focused on developing an Information and Business Framework for cities, again only very far from the real infrastructure and ICT security topic, but as we jump on the topic, this might be an interesting project to follow.

European Innovation Partnership on Smart Cities and Communities (https://eu-smartcities.eu/)
The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) is a major market-changing undertaking supported by the European Commission bringing together cities, industries, SMEs, investors, researchers and other smart city actors. More than a specific project, the EIP-SCC includes all important European projects connected to the Smart City issues. Everything divided into the logical sub-groups with the possibility to search and dive into the topic. Most of the project in the database has basic information with a straight link to the original webpage. This portal was also included for the informative purpose as it might offer a lot more than just single-project review and for future in provides sufficient database of many different topics on Smart City.

EU Smart Cities information System (SCIS - **https://www.smartcities-infosystem.eu**)
The Smart Cities Information System is a very interesting platform aimed to sum up knowledge and information about European smart city projects. It provides a list of smart city projects divided into categories for easy lookup and shares experience and know-how with to ensure public open information sharing platform about smart city information.

Last but not least, the very interesting call for the security of cities might be the SU-INFRA02-2019[1], which deals exactly with the security and safety topic for cities, including public spaces. However, more focused on general security and safety than ICT and cybersecurity, but the topic should fall within the scope of the call.

[1] http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/su-infra02-2019.html

3.3 Worldwide context

Smart city technologies are currently developed all around the world but usually under vendor locked solutions. European union founded projects are unique because also some open source solutions are developed under them. Here is a list of important world smart cities with an overview of their ICT solutions and some other notable smart city related initiatives.

3.3.1 Top non-European smart cities

3.3.1.1 Singapore, Singapore

Singapore is labeled as second most smart city in the world by Easypark smart city index 2017 after Copenhagen. Singapore is one of the leading technological city in the world and provides ICT solutions for smart city:

- Open data platform – integrated open data platform with available datasets from 70 Singapore public agencies (https://data.gov.sg/). Platform is developed by company Govtech and offers wide range of publicly available data not only in the form of downloadable datasets, but also real time data streaming APIs and APIs in the CKAN format, which is popular amongst smart city app developers.
- Smart nation sensor platform (SNSP) – Singapore is actively creating an infrastructure of IoT sensor devices that will provide data for smart applications and therefore creating active ecosystem of developers and citizens using the technology. They plan to create wireless sensor network in orchard roads and selected rural areas, provide personal alert buttons for citizens and deploy smart and sensing Lampposts generating data about its surrounding environment. No technical data available.

3.3.1.2 Boston, USA

Boston is often cited as the most smart-city in the USA. As being one of the lighthouse smart cities in USA, Boston published an interesting guide for smart city application development for city councils – the Boston smart city playbook (https://monum.github.io/playbook/) that provides practical info about choosing the right strategy for your city to going smart. Except for classic open data platforms, Boston is testing deploying sensors and creating ICT infrastructure first:

- Smart streets project – implementation of many sensors on two main streets has goal to end serious traffic accidents by analyzing the movement of drivers, cyclists, and pedestrians. This project will use data generated by video cameras, LED smart lights, sensors under the road and will use a web based platform for data analysis and visualization. Getting and analyzing new data from the environment in the testing phase greatly increases predicting if the global deployment can be really valuable and effective. This project is done under cooperation with Verizon, no other technical data available.
- Self-driving cars – futuristic project of shared self-driving cars is already being tested under cooperation with Lyft.

3.3.1.3 Melbourne, Australia

Melbourne is very active in deploying and testing smart city technologies. Mostly notable provides not only open data, but is active in the developer community by organizing hackathons and encourages its citizens to participate in shaping the future of the city. Melbourne ICT smart projects include:

- CityLab – a space to prototype new ideas and test the city services with community. Melbourne provides its active citizens a possibility to bring new ideas and get those ideas to practice by a community center called the CityLab. This center is helping with organizing social events for active citizens such as hackathons or accessing the possibility to re-design council services. This center also creates Melbourne open data initiative program.
- Open data platform – Melbourne is providing access to many of its open data thru datasets and APis in real time via integrated data platform (https://data.melbourne.vic.gov.au/), no developer technical data available.
- City sensors – Melbourne is actively creating an infrastructure of a smart city by deploying many smart sensors across the city. These include parking sensors, video cameras, Smart light systems and more. Vendor and technical information not found.

3.3.2 Other worldwide notable smart city projects and initiatives

3.3.2.1 Hong Kong Smart City Blueprint (https://www.smartcity.gov.hk)

Very interesting project with a focus on open blueprint solutions, the main goals are:

- Make use of innovation and technology (I&T) to address urban challenges, enhance the effectiveness of city management and improve peoples' quality of living as well as Hong Kong's sustainability, efficiency and safety.
- Enhance Hong Kong's attractiveness to global business and talents.
- Inspire continuous city innovation and sustainable economic development.

Moreover, the areas of this project cover the following topics:

- **Smart mobility**, including topics such as intelligent transport system and traffic management, public transport interchanges PTs/Bus stops and parking, environmental friendliness in transport, and smart airport
- **Smart living**, including topics such as Wi-Fi connected city, digital payment, eID, support for elderly and persons with disabilities, and support for healthcare.
- **Smart Environment**, including topics such as climate action plan 2030+, green and intelligent buildings and energy efficiency, waste management, and pollution monitoring.
- **Smart people**, including topics such as nurturing young talent, and innovation and entrepreneurial culture.
- **Smart Government**, including topics such as open data, smart city infrastructure, and adoption of technology.
- **Smart Economy**, including topics such as strengthen the current pillars by leveraging I&T, and develop new economic pillars.

If we do not consider the application layer, the most important parts are the Smart Government topics, open data and smart city infrastructure. The Open-data platform already works on http://data.gov.hk with the health, transport and education sector. The project should open up more public and private sector data in digital forms to facilitate research and innovation. The infrastructure promises 5G mobile network as a catalyst for smart city development with offering ultra-high speed and high capacity, supporting D2D ultra reliable/low latency communications, and enabling massive M2M communication for better implementation of IoT. Moreover, the eID should be adopted by 2020 with enhanced e-services via artificial intelligence, chatbots and big data analytics. Further, there is also

an initiative to build new big data analytics platform by 2020, public cloud by 2019, revamp the government cloud infrastructure platform by 2020 and enhance the government's cybersecurity capability to address new security risks, facilitate collaboration among stakeholders to promote awareness and incident response capability in the community. Figure 3 displays the considered infrastructure blocks for Smart City. Where the report pwc, 2017 summarized all the blocks. *The project should be monitored as it has a high potential for future replication.*

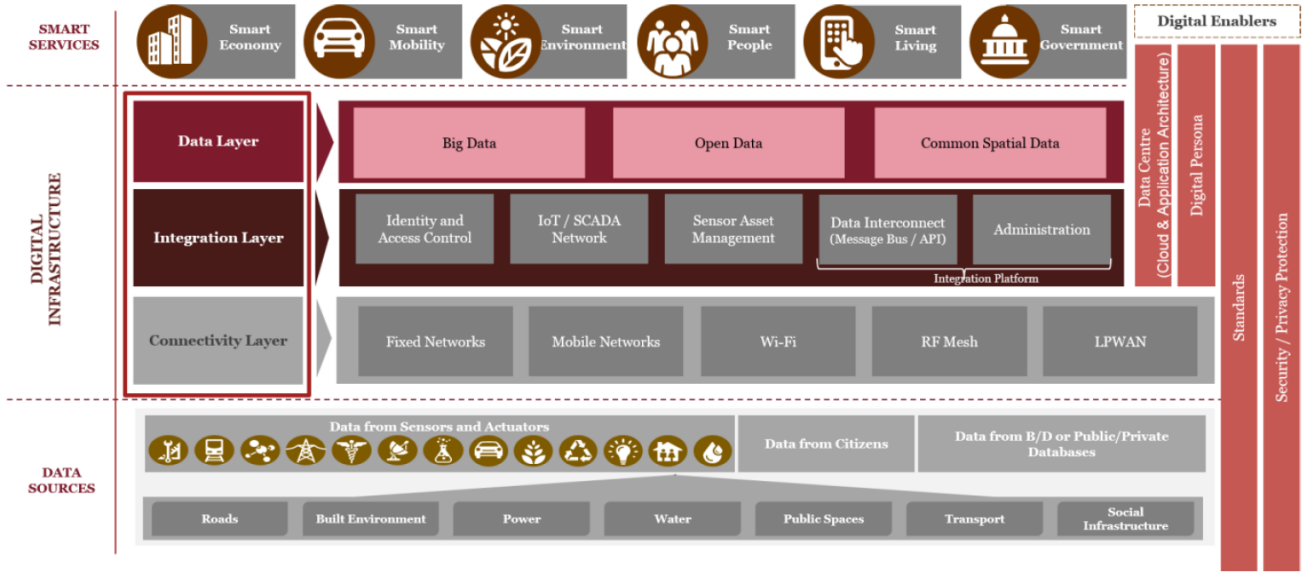

Figure 3: Generic Digital Framework for Smart City Development (source pwc, 2017).

3.3.2.2 Smart Sustainable Cities: A blueprint for Africa (http://smartafrica.org)

Another very interesting project with many different solutions and a high amount of information. The last study (SA, 2017) includes a full case-study report on the smart city topic including also the view of infrastructure. The horizontal stack is displayed in Figure 4 and as you can see it covers all areas already defined in previous sections. *However, the project at the moment provides only general information and the real Blueprint solution is not available, but the project should be monitored as it will contain for sure valuable data.*

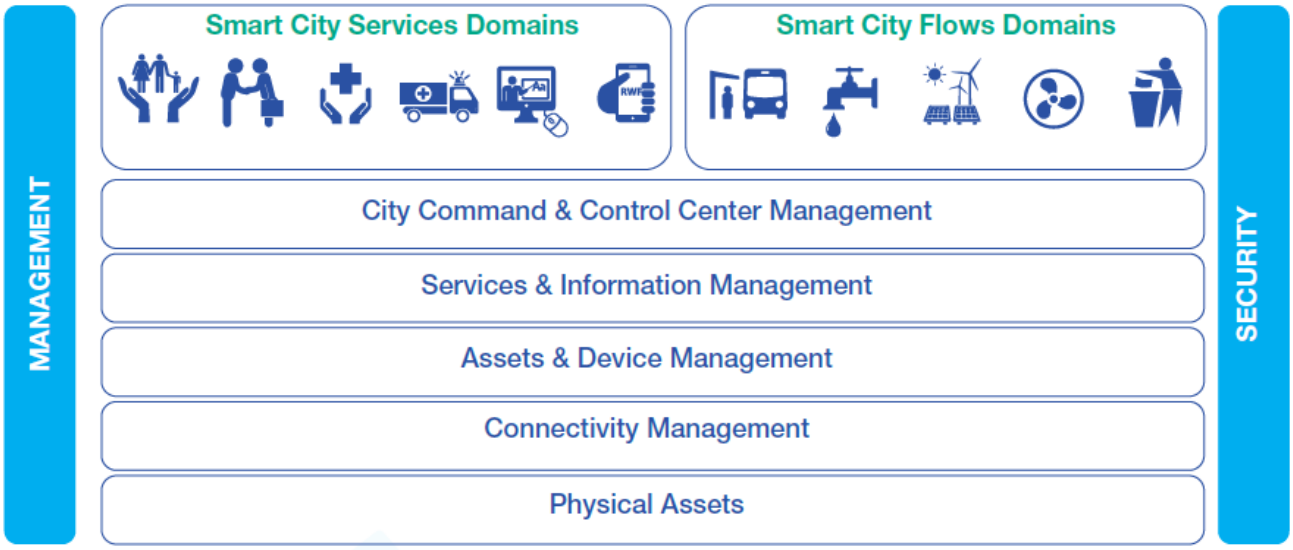

Figure 4: Horizontal stack for a smart, sustainable city (source SA, 2017).

3.3.2.3 Other initiatives and projects

The very interesting project is **NOMINETs list of smart city projects** (https://www.nominet.uk/list-smart-city-projects/). It contains many different European, but also worldwide projects focused on the Smart City issue. Again, more than a single project this platform provides a sufficient number of ideas to dive in. The most interesting topics from the ICT/Security point of view might be:

- **Smart Hamburg** (https://hamburgsmartcity.com/) and **Open Data Hamburg** (http://transparenz.hamburg.de/open-data/). The Smart Hamburg platform itself does not include much information yet, but the open platform shows that open data might be provided in an anonymized format to the citizens, enterprises and researchers.
- **Smart Santander** (http://www.smartsantander.eu/) offers general information not only about applications but also about the infrastructure and testbed.
- **London data store** (https://data.london.gov.uk/) *is another open data portal, which might be taken as a blueprint for Brno.* Offering data from many different areas such as jobs and economy, transport, environment, community safety, housing, communities, health, or GLA performance.
- **Chicago data portal** (https://data.cityofchicago.org/) very impressive data portal with much interesting information sorted to the categories, projects and more. Moreover, there is also a training a program on how to work with the portal and it seems that the Chicago is very interested in providing open data. *This is a good example of how to provide open data to the community.*

There are also connections to other cities such as Smart Vienna, Smart Berlin, Manoco 3.0 and many others. However, these cities lack proofs and open technical documentation.

Many private solutions such as Cisco or IBM infrastructure solution for Smart City provide paid a closed form of smart city infrastructure. The Cisco Company also creates already a successful blueprint solution (Cisco, 2015). However, the experts agree that open smart city infrastructure is the

future way how to build up the Smart City (Ismail, 2018). There are many different projects, which focus on the open smart city infrastructure such as Open Smart City Infrastructure and Service leaded by Juniper, Inocybe and Cengn (Cengn et al., 2018). However, these are also often company driven approaches, where each company deliver some service or devices. The open platform should be designed via independent experts, which will no prioritize one or another solution. Last but not least, most of the researchers and developers agree that the open approach is the way for Smart City, but there are still missing a sufficient number of demonstrators, which will show the right direction for the infrastructure (Lloyds, 2017).

4 Best cases for Spitalka street and Brno city

There are many interesting projects dealing with ICT and security. However, the replicability of these projects is minimal as they were more focused on the show-case strategy than the replicability. There are several very interesting ideas, which might apply to the Spitalka project. Moreover, several projects offer a sufficient number of information on smart city infrastructure or security. In this place we would like to remind the Boston smart city playbook (https://monum.github.io/playbook/) which is interesting counseling material when choosing any smart city solutions.

The Spitalka project might be a very interesting case, where might be tested, i.e., these solutions:

- **ICT Infrastructure**, the Spitalka street is a small location and build-up real high-speed infrastructure should not be much cost heavy. Interconnected environment including high-speed fiber together with a wireless connection over the whole area should be a sufficient show-case and experimental environment to gain valuable experiences. Moreover, the resilience and scalability might be tested via many different traffic generator tools, which will give feedback for future deployment over the whole city.

- Another proposed solution for creating testing infrastructure of smart city ICT applications is **installing 5-10 smart LED** lights with sensing capabilities of Humble Lamppost initiative design (https://eu-smartcities.eu/initiatives/78/description). This solution could be inspired by smart lighting project deployed in Tartu under SmartEnCity from vendor Cityntel OU (in a much lesser scale). By deploying smart lights with sensors and by making real time data from these sensors accessible in open data portal, Spitalka could become a testing place for developing smart city real time applications.

- **Open Data Portal using modern open source technologies,** the open data portal is a very sensitive topic. The AI algorithms, data mining algorithms, anonymizing algorithms must be tested before real deployment. Spitalka street might be the first phase of testing, where the open data might not have (in case of error) a high impact on the community. Many smart cities today use FIWARE open source data technology together with CKAN APIs standard. This solution should of course be second after creating an infrastructure of ICT sensor network.

- **Cybersecurity,** the security features might be very hard to test in already deployed systems. However, Spitalka street should be built from zero. This means to develop not only the technological aspects but also methodological aspects of how to implement security features. All the phases might be tested and the responsible authorities might learn once again important lessons. Moreover, security games might be a very interesting approach, which might be included only in the testbeds. The community of security experts might be very interested in testing the city pilot environment and providing to the authorities sufficient materials on how to improve the security of the system and infrastructure.

- **Open-source Web Service for Personal Data Detection,** the idea of open data access has plenty of advantages and usually leads to new products and services in the city that habitats can benefit from. Unfortunately, providers of the data are not always open to share the data

and update the data to keep them valuable and up-to-date. Open data initiative was relatively successful in the recent years in pushing data from the government and administration and releasing for the public. Unfortunately, recent researches have revealed that barriers still lies on the side of data releases and re-users. The barrier is also that the technologies are not shared across borders in EU. One of the main obstacle for collecting and also further sharing the data is the risk, they can contain personal information. This is of high importance, especially because of the General Data Protection Regulation (GDPR) (EU) 2016/679, which is connected with relatively significant fines that can go up to 20 million Euros or 4 percent of annual global turnover of a company. The data can be collected from various sources like sensors, CCTV, cameras, web pages, text being shared through web portals and social communities etc. Manual removal of personal information can be significantly time consuming and especially in the cases when also third parties are contributing there is no control about the released content. Especially when we consider big volumes of data in various data formats, for example texts can be a plain text, a word document, PDF or many other. One of the existing solutions is a FERARI project (Flexible Event pRocessing for big dAta aRchItectures), which was finished in December 2017 which was funded by EU FP7.

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