System Engineering for Smart Cities - Hybrid-Agile Approach in Smart Cities Procurement

Michal LOM, Ondrej PRIBYL, Tomas ZELINKA
Faculty of Transportation Sciences, Czech Technical University in Prague
Konviktska 293/20, 110 00 Prague 1, Czech Republic

ABSTRACT

A smart city is a growing phenomenon of the last years with a lot of researches as well as implementation activities. A smart city is an interdisciplinary field that requires a high level of cooperation among experts from different fields and a contribution of the latest technologies in order to achieve the best results in six key areas. The six key areas cover economy, environment, mobility, people, living and governance. Following a system development methodology is in general a necessity for a successful implementation of a system or a project. Smart city projects introduce additionally new challenges. There is a need for cooperation across many fields, from technical or economic through legislation to humanitarian, together with sharing of resources. The traditional Systems Engineering methodologies fail with respect to such challenges. This paper provides an overview of the existing Systems Engineering methodologies and their limitations. A new Hybrid-Agile approach is proposed and its advantages with respect to smart city projects are discussed. However, the approach expects changes in our thinking. Customers (typically municipality or governmental organizations) have to become active and engaged in smart city projects. It is demonstrated that a city cannot be smart without smart government.

Keywords: Smart City; Smart Government; Systems Engineering; SCRUM; Procurement Process; Agile

1. INTRODUCTION

Systems Engineering (SE) as a discipline was coined in Bell Telephone Laboratories in the 1940s and was mainly used in huge military projects [1]. SE evolved into a general approach how to describe projects with emphasis on a planning and a project work over time, which often includes technical innovations [2]. SE is an interdisciplinary approach focusing on how to design and manage complex engineering systems over their life cycle. SE can be used to any system development, so whether we are developing a manufacturing process, building a house, making a procurement process, or for example implementing a sophisticated information system [3]. SE focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and following proceeding with design synthesis and system validation. Considering both business and technical needs of all customers with the goal of providing a quality product that meets user needs [4]. According to Arthur D. Hall [5], the Systems Engineering process makes use of the five system life phases. There is necessary a deep study of the system or project planning in the first phase. The second phase is the exploratory planning, which includes the definition of the problem, the selection of objectives, synthesis system, systems analysis, the selection of the best system, and communicating the results. The third phase is the development planning, which repeats the second phase in more detail. The fourth phase is tracked during the development, which includes the development of system parts and the testing of this system. The final phase is a current engineering, which is what takes place while the system is operational and being refined.

The Standish Group has done a research over many years to collect statistics on the success rates and success criteria for information technology (IT) projects, so called The CHAOS Report [6]. As shown in the Figure 1, only 16 % of projects surveyed met the criteria for success in 2014 – completed on time, on budget, and with all the features originally specified. It means on every 100 projects, 53 projects were late or over budget and another 31 were failed [7]. This demonstrates complexity and challenges of IT project development. The CHAOS Report has also presented the major reasons for IT projects failures, mainly lack of proper management or lack of development methodologies.

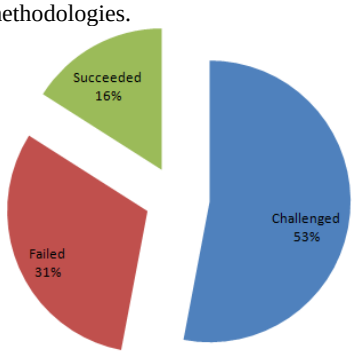

Figure 1 – The Standish Group: 2014 CHAOS Report Project Success Rate [7]

An important overview of the systems engineering approaches and basic principles is provided in the Guide to the Systems Engineering Body of Knowledge (SEBoK) [8]. Of course, many different methodologies and approaches have been developed over the years to address the Systems Engineering. The Systems Engineering Management Plan (SEMP) focuses on a technical plan of a project and systems engineering processes to be used for the project. Its main purpose is to provide detailed information on the processes, deliverables, roles and quality gateways to be used.

A nice overview of the different development methodologies were provided for example by Whitten [9]:

- Category I:
  - Structured Design
  - Waterfall Development
  - Parallel Development
- Category II: Rapid Application Development
  - Phased Development
  - Prototyping-based Methodology
  - Throwaway Prototyping-based Methodology
- Category III: Agile Development
  - An Extreme Programming-based Methodology
  - SCRUM

There is certainly not only the best methodology. The selection process depends on many different and project specific aspects,

such as a complexity of the system to be developed, time constraints, need for visibility of a schedule, experiences of the development team or even the level of customer's involvement. In this paper we want to present two different approaches covering the width of system development methodologies. The first approach is based on the traditional approaches from Category I – Systems Engineering Management Plan (SEMP). The second approach belongs to the category of Agile development.

2. SYSTEMS ENGINEERING MANAGEMENT PLAN (SEMP)

In the previous section the need for a standardized Systems Engineering approach was discussed and different approaches were briefly presented. At this section we focus on one particular approach used especially at systems consisting of software and hardware together. Typical examples of such systems are intelligent transport systems that have closely related to the smart city initiative. A detailed handbook explaining the principles, steps, deliverables, responsibilities and providing additional resources is provided by Federal Highway Administration – Californian division (USA) [10]. The usage of systems engineering management for ITS systems was provided for example by [11] and is a mandatory document for the Ministry of Transport in the Czech Republic.

The Systems Engineering Management Plan presents the V model. A version adopted from [12], which aimed on pragmatic application of the general SEMP Framework is depicted in the Figure 2.

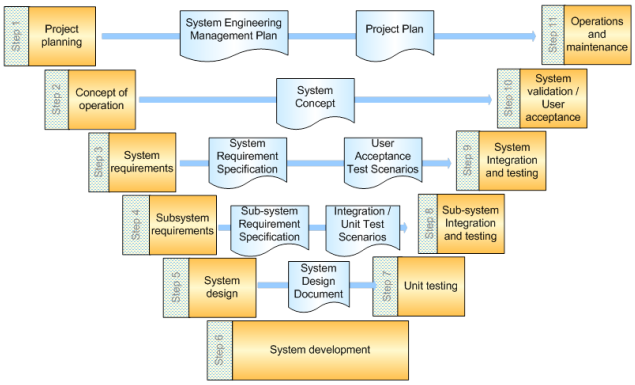

Figure 2 – The Systems Engineering Management Plan Framework [10]

The SEMP defines not only the particular steps, but more importantly also the deliverables of the particular steps as well as the quality requirements and checklists.

This SEMP has several advantages, among others clarity, the fact that it is understood by different stakeholders and in the way in which the customer is involved: first through requirements management which form basically a contract between the customer and the developer and at the end of the process through user acceptance testing proving meeting of the customer expectations.

However, the smart city initiative introduces new aspects, which are not addressed by the standard SEMP [13], which include:

- **Cooperation among experts from different fields** – Smart cities cannot be solved through traditional focusing on particular engineering disciplines, such as transportation, energy, ICT and others. There is strong need to address problems jointly through an interdisciplinary team. Sharing of resources - in smart cities, the different processes within a city must access the same resources in order to use them effectively. This covers information, energy, infrastructure and many others.
- **Focus on soft measures** – also contrary to traditional approaches, a city can be smart only when the citizen's feel happy in it. This is something that cannot be always expressed through a clear objective function where an optimum can be found. Terms such as happiness, quality of life, habitual behavior and feelings are very important.
- **The control and management systems are not strictly hierarchical** – in the traditional control or management systems, there are a clear hierarchy and clear rules. For example in transportation, there is a local traffic controller responsible for the signal timings, an area controller responsible for orchestrating different local controllers, main city control center responsible for traffic information and general strategies and typically a national traffic control center mainly responsible for collecting traffic data and providing traveler information. Such distinction is no more possible in smart cities and internet of things. Each element can be understood as an agent (in the multi-agent system theory – [14]), which exchanges information with other agents, but can make an own decision and follow own objective functions based on trustfulness of the other agents, environment and current as well as the past states. Such agents do not communicate only with agents from the same field (e.g. transportation), but also with others. This can mean that for example a street lighting is not only affected by the time of a day or environmental sensors, but for example also by the traffic density or the presence of a pedestrian on the side walk.

Such new aspects make it very difficult to use the traditional SEMP. In such SEMP, the tasks and problems are firstly divided into separate subsystems/sub-problems and interfaces are defined. Each subsystem is then solved with a dedicated group of experts. However, this approach is contrary to the key specifics of smart cities such as cooperation, sharing, or the amount of different heterogeneous agents' communication across different fields. We need to change this traditional perception if we want to build smart cities effectively. This is also the main motivation for this paper. A modified approach to Systems Engineering must be defined in order to achieve.

3. AGILE METHODOLOGIES

SCRUM is the next approach discussed in this paper, the approach from the class of Agile methodologies. The Agile methodologies were originally designed for developing a software based on iterative and incremental development [15]. In 2001, Manifesto for Agile Software Development was published and 12 basic principles of Agile were also presented. These principles are shown below and are defined for software projects [16]:

1) A customer satisfaction by early and continuous delivery of useful software
2) Welcome changing requirements, even late in a development
3) Working software is delivered frequently (weeks rather than months)
4) Close, daily cooperation between business people and developers

5) Projects are built around motivated individuals, who should be trusted
6) Face-to-face conversation is the best form of communication (co-location)
7) Working software is the principal measure of progress
8) Sustainable development, able to maintain a constant pace
9) Continuous attention to technical excellence and good design
10) Simplicity - the art of maximizing the amount of work not done - is essential
11) Self-organizing teams
12) Regular adaptation to changing circumstance

According to these methodologies, verifying the accuracy of the system only by means of quick development, presenting to customers and incorporating directly the customer feedback. Agile approach is not only limited to programming, but also found its application in business intelligence and marketing planning [16]. It helps teams respond to unpredictability through incremental, iterative work cadences, known as sprints. Agile methodologies are an alternative to waterfall, or traditional sequential development.

The shortcomings of Agile approaches are that customers like their contracts fixed in time and budget. In the case of Agile development, it is not possible to state exactly how much it will cost in advance, because it depends on the requirements expressed during the entire duration of the project and the discussions with customers. This could be a problem in terms of public contracts, because every voter wants to know how much will cost contract execution. The next shortcoming is that a poor customer participation directly affects product quality. It means that customers must be directly involved in the whole development process and closely cooperate with the development team. Another well-known problem of Agile methodologies is originally designed for small software projects, but there are alternatives for large projects now [17].

Scrum is a particular application of Agile methodologies in practice. It defines a flexible strategy for product development, where the development team works as a unit to achieve a common goal. A key principle of the Scrum is that customers can change their minds about what they want and need (often called "set of requirements"), and that unexpected tasks cannot be solved simply traditional forecasting and planning during the project. Scrum uses an empirical approach in which the problem cannot be fully understood or defined, and therefore focuses on maximum team's ability to deliver quickly and respond to new requirements [18].

There are 3 key team roles in the whole Scrum process:

1) A **development team** is responsible for the delivery of potentially shippable increments (PSIS) product at the end of each sprint (sprint goal). The team is typically composed of 3 to 9 individuals, who are doing the current work (analysis, design, development, test, technical communication, document, etc.) [19].
2) A **Product Owner** represents stakeholders and the voice of the customer. He is responsible for ensuring that the team will add value to the business. The Product Owner shall understand the customer needs and expectation and clearly state those to the development team, evaluates particular working tasks and assigns them a priority, and adds them to the product backlog. The Product Owner is on the business side of the development, and can never interact with the team members during the development apart from scheduled meetings (sprint meetings) [19].
3) A **Scrum Master** is responsible for the removal of barriers of the team on product delivery goals. The Scrum Master is not a traditional team leader or project manager, but acts as an intermediary between the team and any negative effects. The Scrum Master ensures that the Scrum process is used as planned and team members shall comply with agreed processes. Meetings are organized often and encourage the team to improvements [20].

A **sprint** (or an iteration) is the basic unit of development in Scrum. The sprint is a time boxed effort; that is restricted to a specific duration [21]. Each sprint starts with a sprint planning event that aims to define a sprint backlog, identify the work for the sprint, and make an estimated commitment for the sprint goal. Each sprint ends with a sprint review and a sprint retrospective [22]. Each day during a sprint, the team holds a daily Scrum. The overview of the Scrum methodology is shown in the Figure 3.

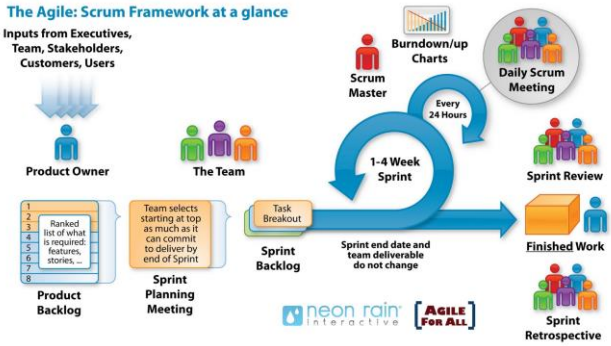

Figure 3 – The Scrum Framework [23]

4. SMART CITY NEEDS

A smart city is a phenomenon of the last years, which is very inflected especially since 2008 when the world was hit by the financial crisis. The main reasons for the emergence of Smart City Initiative are to create a sustainable model for cities and preserve quality of life of their citizens [24]. The population of our planet will increase up to 10 billion in 2050 according to the United Nations [25]. There is still not existing one common definition what the smart city is. For instance, the official definition of the smart city according to the IEEE is: *„A Smart city brings together technology, government and society to enable the following characteristics: a smart economy, smart mobility, a smart environment, smart people, smart living, and smart governance. [26]"* The main purpose of the Smart City Initiative is to provide a framework how to ensure the sustainability of cities, quality of life and safety of their citizens, and maximum energy efficiency, all of those in the six key areas: economy, environment, mobility, people, living, and governance, with the contribution of the latest technologies.

The smart city is, similarly to Systems Engineering area, an interdisciplinary discipline and requires a high degree of a cooperation between experts from many different fields. The topic of the smart city cannot be seen only as a technical discipline, but it is necessary to involve economic, humanitarian and legal aspects. Different systems within the smart city must cooperate very closely together and share information and other resources in order to achieve their objectives. The approach divide and conquer is not sufficient any more within the Smart City Initiative. This approach does not ensure the required cooperation among experts and general public, interdisciplinary nor sharing of resources.

For example, let us discuss a public street lighting. We cannot look at the public street lighting only in terms of energy consumption. We have to look at it in terms of other disciplines too. When looking into the more advanced street lighting control, we must take into consideration environmental data, and the more advanced control approaches even react to movement of particular vehicles or even pedestrians [27]. It is also not possible simply to change the source of light as would a simplistic business plan suggests. LED is clearly more efficient than sodium light bulbs, but it is not nature for human eyes. This is not acceptable for example in city centers. Meeting the legal limits have to be taken also into account. An architect or even sociologist should be members of our interdisciplinary smart street lighting project.

There are existing methodologies for a procurement process and management of state or municipal contracts co-financed by the European Union [28]. Each state also has its national laws and directives how to proceed in the context of the government procurement process. In the Czech Republic, the public procurement law no. 40/2004 Sb. prescribes how a contract award has to be specified, what a contractor has to comply and what are the criteria for winning the contract. When we take into account current state of the procurement process, we get diagram as shown in the Figure 4.

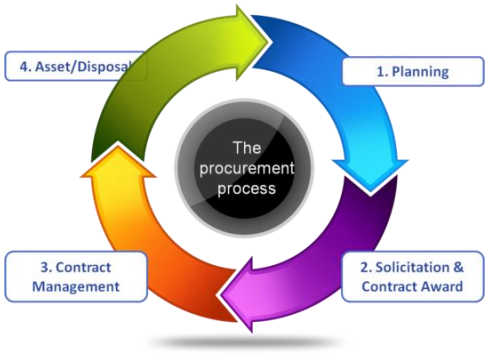

Figure 4 - The current procurement process [29]

The big shortcoming of the current procurement process is that the cooperation among different disciplines is not encouraged. Nowadays, it is common that a general contractor wins an entire contract. There are such circumstances that for the win of a public contract is the most important criterion price. This leads to the efforts of many companies to win the contract with the price that is below the cost. This is very inefficient and often leads to situations where companies are looking for the cheapest and often not so quality solutions. Unfortunately, communication during the development process is currently not coordinated. This leads to situations where steps can no longer be definitely affected. This paper describes the new approach how to manage the procurement process and the implementation of the contract applying Agile methodologies.

5. HYBRID-AGILE METHODOLOGY AS AN ALTERNATIVE FOR SMART CITIES

In this paper, a short overview of different development methodologies needed for any system development process was presented. However, none of the existing methodologies are appropriate for the challenges linked to smart cities. Therefore, this section introduces a new approach called the *Hybrid-Agile Methodology* (HAM).

When approaching the smart cities procurement process in terms of a public contract, a new hybrid methodology combining the Agile principles with the SEMP principles is needed. It is clear, that meeting the challenges of smart cities require a major shift in our thinking and in approaching problems must be performed. This new hybrid approach is based on the 12 basic principles of Agile with certain adaptations, which are part of our proposal. First, we have to specify various roles throughout the process. The roles are based on the Agile methodology, but their definition can differ.

A Product Owner (PO) is the most crucial role. S/he should understand the customer needs and expectations, understand the technical terms and be able to make certain decision on regular basis at the same time. It is difficult to place this role to a customer as the customer can hardly have the required technical knowledge. The Product Owner located by the solution provider cannot have the decision making power and would have to validate the decisions by the customer. Therefore, there are two Product Owners in the *Hybrid-Agile Methodology*: the first by the customer (PO-C) and the second by the solution provider (PO-P). They have to work together and cooperate very closely with each other. This is the first and very important difference between the Agile and the *Hybrid-Agile Methodology*. It is important that the Product Owners are fully integrated with the entire process and also have a key role in communication between both sides. Their joint negotiations always result in requirements that are followed by the team.
The development team is performing in a similar way to the standard Agile methods.
The Scrum Master is also supporting the development team in the traditional way.
The basic principles and changes to the standard Agile methodologies are provided below:

1) **The customer (municipality) shall be fully involved** during all project steps in, i.e. not only to prepare a tender and select proper solution provider, but also during the implementation by providing feedback to the developers and making decisions. The Product Owners on both sides are fully responsible to gather the requirements to specify them and to present them to the team during regular meetings. This is not an activity performed once at the beginning, but the ongoing activity. When questions are presented, the Product Owner on the customer side (PO-C) must be able to make decisions.
2) **The requirements** (often in the form of a request for proposal or tender materials) **play still an essential role in the development process.** This is one of the major differences in comparison to the standard Agile methods. Since the municipality/government organization must be able to manage the project in a transparent way, the scope expressed must be known through requirements from the beginning. However, this hybrid approach minimizes the major problem with requirements – they are rarely written in a form that allows direct implementation and ensures that the customer gets what is expected. We depend not only on the System Requirements Specification (SRS) document, but we combine it with the knowledge and decision making of the PO-Customer. With such combination, we can prepare a project plan and manage the project while at the same time minimize the discrepancies in expectations between the customer and the solution provider.

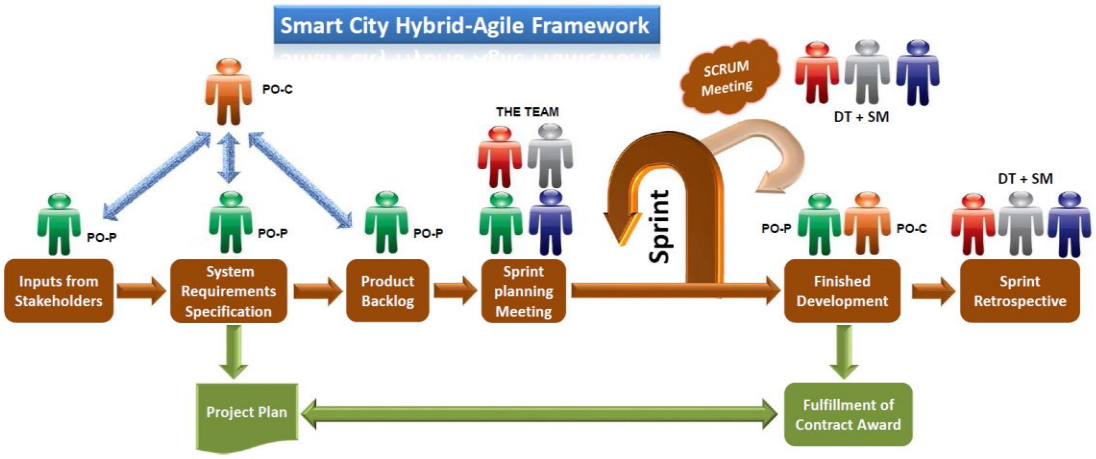

Figure 5 - Hybrid-Agile Methodologies Framework

3) **The entire contract is divided into short cycles** – Scrum sprints (recommended one to four weeks) can respond quickly to any changes. The Product Owner collects requirements and is entered into the Product Backlog, where they are further processed by the development team. At the beginning of each short cycle (sprint) is a sprint planning meeting, where is specified when it must be done. The major advantage for customers is that the progress is monitored regularly – at the end of each sprint. The aim of these sprints is to provide a detailed review as well as planning of next steps during a following cycle.
4) **Not being afraid to change specifications and requirements**, if it turns out that it is more efficient and cheaper, even if it is in the implementation phase. This point is one of the more important and also the most difficult since it requires a complete change in the mindset from the procurers and the developers as well as other stakeholders. Based on the fact that in the process of planning and early execution of the contract, it is not know exactly what the customer wants and it is not possible to predict what may during the implementation to appear (new technologies, change of an assignment for streamlining the entire implementation). This principle says that both the customer and the developer not worrying about come up with completely new requirements and specification during the implementation if this should help to streamline, simplify and cheapen the entire process. However, this does not necessarily means a problem in tracking public projects. Since the PO-C is closely linked to the development process and must understand all the reasons for change, s/he must be able and ready to justify them to general public.
5) **Close daily cooperation between representatives of cities or countries and developers.** There is necessary especially daily communication between both Products Owners who should communicate and gather the requirements and put them to the Product backlog. A Face-to-face conversation is the best form of communication (co-location). This is a fairly simple rule that says that the face-to-face communication is preferred form of the communication before for instance emails. The reason is that the verbal communication is better understood by both sides what the other party requests them. Since the communication is in generally the key success factor in the system development, a lot of focus must be dedicated to the communication in general and to this rule in particular.
6) **The fulfilment of the contract award is the measure of success**. The destination success is a final completion, which meet the individual steps that are given by requirements through the Product Owner. Therefore, as the measure of success can be taken to carry out tasks that are always entered in the individual sprints. Of course, the Agile methodologies are based on changes during the process. Therefore, it cannot be taken as a failure if certain task is changed during the development. However, the changes should contribute to better performance of the system.
7) **Sustainable development able to maintain a constant pace** is necessary for the duration of creating a contract award and the subsequent implementation sets a pace that will be sustainable throughout the project. If it does not manage to the process, requests should find out why prosecute are meet. The primary task of the *Hybrid-Agile Methodology* is obviously the fastest performing a given task, but the rate should never prevail over the quality and fulfilment of the task.
8) **Simplicity - the art of maximizing the amount of work not done - is essential**. This is the key principle of the Agile methodology. Do only what is necessary. This principle says that the Product Owner and the development team should quickly and accurately analyze whether the task needs to be done in order to achieve performance completion. It is also necessary to assess whether such a step will help us in some other saves. This is extremely complicated and it is directly dependent on the experience of the whole team.

If we analyze the HAM principles described above, we find out that the application of the *Hybrid-Agile Methodology* to smart cities procurement process has the potential to solve major shortcomings of two dedicated methods discussed above. The detailed overview of the proposed HAM is shown in the Figure 5.

The first disadvantage was the inability to determine a fixed final price and delivery date in advance. Through combination of the Agile approaches with strong focus on documenting requirements, this is not the case anymore. Additionally the project progress is monitored regularly and the customer is informed about any new developments or challenges through regular sprints. The major advantage of applying the *Hybrid-*

Agile Methodologies is in achieving the cooperation and the communication among the developer, the customer and other experts throughout the implementation. This is the key requirement in order to achieve the best possible results in the shortest time and meet the objectives of smart cities such as sharing of resources. Since we have the role of *Product Owner – Customer* and *Product Owner – Provider* with strong focus on the face-to-face communication, the cooperation is supported in the best possible way.

The danger of appearing extra project costs during the project lifetime due to misunderstandings between the customer and the provider are minimized. The general scope and directions are set from the beginning through the requirements. However, they are clarified via the Product Owner.

6. CONCLUSION

This paper discusses the necessity to use Systems Engineering for projects in the field of smart cities. The different methodologies are introduced and two are discussed in more details. However, both of them not fully suitable for the challenges of smart city projects. The main requirements are the emphasis on the cooperation and the communication between different disciplines, feedback and active approach of the customer as well as creating highly engaged interdisciplinary teams. In order to overcome the existing limitations, the new *Hybrid-Agile Methodology* was proposed in this paper.

This HAM is based on the 12 basic principles of the Agile development and basically uses the best characteristics of the Scrum methodology and the Systems Engineering Management Plan. The basic modifications and principles are discussed in the previous section. However, an application of this new methodology requires a major shift in our thinking and puts new requirements especially on the customer of such projects, typically municipality or governmental organizations.

The Agile principles require an active involvement of municipal contracting authorities in the smart city projects. It is not sufficient to prepare tender materials and wait till after several months the system is ready. The system must be built incrementally and the customer must be involved actively in all stages through the entire project duration.

As [30] stated, “a city cannot be smart without smart citizens”. We additionally claim **that a city cannot be smart without smart government**. This paper provides guidance how a smart municipality employee can improve the development process with smart cities.

7. REFERENCES

[1] K. J. Schlager, Systems engineering-key to modern development. *IRE Transactions on Engineering Management* [online]. 1956, **EM-3**(3), 64-66 [cit. 2016-01-17]. DOI: 10.1109/IRET-EM.1956.5007383.

[2] R. S. Pressman, *Software engineering: a practitioner's approach*. Eighth edition. New York, NY: McGraw-Hill Education, 2015, 941 pages. ISBN 0078022126.

[3] H. Kerzner, *Project management: a systems approach to planning, scheduling, and controlling*. 10th ed. Hoboken, New Jersey: John Wiley & Sons, 2009, 1094 s. ISBN 978-0-470-27870-3.

[4] A. P. Sage, W. B. Rouse, *Handbook of systems engineering and management*. 2nd ed. Hoboken, N.J.: John Wiley & Sons, 2009, xxiii, 1476 p. Wiley series in systems engineering and management. ISBN 0470083530.

[5] A. D. Hall, *A Methodology for Systems Engineering*. Princeton (N.J.): D. Van Nostrand Company, 1966, 478 p.

[6] The Standish Group, *The Chaos Report 1994*. Online: https://www.standishgroup.com/sample_research_files/chaos_report_1994.pdf [2015-11-12]

[7] James Johnson, *CHAOS Report 2014*. The Standish Group, 2015

[8] BKCASE Editorial Board. 2015. *The Guide to the Systems Engineering Body of Knowledge (SEBoK)*, v. 1.5. R.D. Adcock (EIC). Hoboken, NJ: The Trustees of the Stevens Institute of Technology. Accessed 01/2016. www.sebokwiki.org.

[9] J. L. Whitten, L. D. Bentley. *Systems analysis and design methods*. 7th ed. Boston: McGraw-Hill/Irwin, 2007, xv, 747 p. ISBN 9780073052335.

[10] Caltrans and USDOT. 2005. *Systems Engineering Guidebook for Intelligent Transportation Systems (ITS)*. Sacramento, CA, USA: California Department of Transportation (Caltrans) Division of Reserach & Innovation/USDOT, SEG for ITS 1.1.

[11] P. Přibyl, O. Přibyl (ed.). *Projektování dopravně-telematických aplikací: metodický pokyn*. Vyd. 1. Praha: Ředitelství silnic a dálnic ČR, 2010, 130 p. ISBN 978-80-01-04385-1.

[12] O. Pribyl, *SEMP Framework*, Report for ATVAM Project, Kingdom of Saudi Arabia. JENOPTIK/11/002/02.07.10/ en/B, 2010

[13] C. Breining et al., Orchestrating infrastructure for sustainable Smart Cities – White paper, IEC, 02/26/2015. Accessible online: http://www.iec.ch/whitepaper/pdf/ iecWP-smartcities-LR-en.pdf , Pribyl and Svitek, 2015

[14] M. J. Wooldridge. *An introduction to multiagent systems*. 2nd ed. Chichester, U.K.: John Wiley & Sons, 2009, xxii, 461 p. ISBN 0470519460.

[15] Kent Beck; et al. (2001). "Manifesto for Agile Software Development". Agile Alliance. Retrieved 14 June 2010.

[16] Kent Beck; et al. (2001). "Principles behind the Agile Manifesto". Agile Alliance.

[17] Ken Schwaber. *Agile project management with Scrum*. Redmond, Wash.: Microsoft Press, 2004, xix, 163 p. ISBN 073561993x.

[18] Jim Highsmith. *Agile project management: creating innovative products*. Pearson Education, 2009.

[19] Jeff Sutherland; Ken Schwaber. The Scrum Guide. *The Definitive Guide to Scrum: The Rules of the Game*, 2011.

[20] K. S. Rubin. *Essential Scrum: A practical guide to the most popular Agile process*. Addison-Wesley, 2012.

[21] Jim Highsmith, Cockburn Alistair. "Agile software development: The business of innovation." *Computer* 34.9 (2001): 120-127.

[22] Sutherland, Jeff, et al. "Distributed scrum: Agile project management with outsourced development teams." *System Sciences, 2007. HICSS 2007. 40th Annual Hawaii International Conference on*. IEEE, 2007.

[23] Agile For All. *Intro To Agile*. Accessible online: http://www.agileforall.com/intro-to-agile/ [2015-10-28]

[24] K. Mori, and A. Christodoulou, “Review of Sustainability Indices and Indicators: Towards a New City Sustainability Index (CSI),” Environmental Impact Assessment Review 32: 1 (2012) 94–106.

[25] United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision

[26] IEEE, *About Smart Cities*. Accessible online: http://smartcities.ieee.org/about.html [2015-10-28]

[27] ICE Gateway, Lighting for replacement. Accessible online: http://www.ice-gateway.com/ [2015-10-30]

[28] European Commission, Internal Market and Services, 2013. Accessible online: http://ec.europa.eu/internal_market/publicprocurement/docs/modernising_rules/executive-summary_en.pdf

[29] United Nations University. Procurement process, Dresden. Accessible online: https://flores.unu.edu/procurement/

[30] Learning and Diversity in the Cities of the Future, Ilona Buchem. Logos Verlag Berlin GmbH, 23. 12. 2014