REUSE POTENTIAL ASSESSMENT FRAMEWORK FOR GAMIFICATION-BASED SMART CITY PILOTS

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***Abstract*—The paper proposes a unified framework for assessing the re-use potential for the Smart Engagement Pilot currently being realized in the city of Ghent (Belgium). The pilot aims to stimulate the digital engagement in users (citizens) by involving them in online and offline communities, and increasing the social capital through the use of ICT (Information and Communications Technology). To engage the citizens, the pilot makes use of Gamification based entities (intelligent wireless sensors) embedded in public hardware, through which innovative games are organized in places of interest (neighbourhood, parks, schools, etc.). Once finished, this pilot will be re-used in other European cities under the context of CIP SMART IP project. Since, the success of a pilot in one city doesn't guarantee its success in the other, an objective socio-economic-organizational reuse assessment becomes critical. To do this assessment, we propose a framework, which uses a Key Performance Indicator (KPI) based scorecard to determine the roadblocks and battlefields that could deter such a transition.**

Keywords - reuse assessment, gamification, smart cities, smart engagement, scorecard, reusability

I. Introduction

Academic researchers, sociologists, and citizens have long debated over the interrelated process of urbanization and its impact on the social order. With urbanization, communities were replaced by individualism and anonymity [1], and solitude and loneliness has become a permanent feature of industrialized cities [2]. Therefore, fostering the development of socially integrated communities is one of the key priorities for public administrations, researchers, and policy makers. So far, there has been an incremental evolution in the way citizens in communities socialize and engage with each other. In this paper, we research one such evolution where ICT tools and co-design techniques are integrated together to stimulate social cohesion and create socially integrated communities.

The idea of ICT-based gamification was first conceived in 2008 within the digital media industry. Within 2 years, it emerged in mainstream [3]. Gamification is defined in [3] as the use of game design elements in non-game contexts. It uses some characteristic elements of games (rules, competitive strife towards precise goals) in a structured way to achieve non-playing goals. Gamification is therefore not related to playfulness per se, as the goal is not entertainment and improvisation but defining a structured organization addressed to a specific goal (ICT projects, surveys, qualitative interviews for academic research, viral marketing, advertising, etc.).

The Smart Engagement Pilot proposed in SMART IP project [4] uses ICT-based gamification techniques to activate and engage local communities, thereby promoting a sense of social cohesion among the citizens dwelling in a city. In this paper, we focus on elaborating the key technical features of such a pilot along with the organizational and socio-economic requirements for their successful deployment, and the potential for its reuse in other European cities. Particularly, to be able to identify and assess the reuse potential of the pilot we introduce a Key Performance Indicator based re-use potential assessment framework. While a number of frameworks in the literature [5][6] address the issues pertaining to the reuse of software and ICT projects, there exists no such unified framework that focuses on the reuse of smart city pilots and applications. The framework along with its key performance indicators is first introduced and elaborated in Section 3.

The rest of this paper is structured as follows. In Section 2, we introduce the Smart Engagement Pilot and its key technical components along with involved Gamification processes. In Section 4, we adapt and apply the reuse framework to the SmartIP pilot and map the outcomes of our analysis to a scorecard. Finally, Section 5 presents validated results of the analysis and concludes the paper with a discussion of findings: drivers and barriers for re-use of gamification based pilots in future cities along with directions for future research.

II. Smart Engagement Pilot

The Pilot on Smart Engagement is part of a larger European project called SmartIP [4]. Its aim is to transform public services in 5 European cities – Ghent, Manchester, Bologna, Cologne and Oulu – by developing citizen-centric Internet-enabled services. Citizen's changing needs are carefully considered by the SmartIP project through the development of new tools, mobile applications and sensor-based IT systems. The analysis of urban communities and a constant cooperation among IT stakeholders characterizes the development processes. The final goal of actualizing the collective intelligence of citizens through new ICT tools, methodologies and know-how suits recent literature such as [20].

The Smart Engagement Pilot (that has SCOGA - Smart Communities Game framework) aims at establishing a meaningful and stimulating contact between the citizens and their neighborhood. The SCOGA framework has 2 overarching objectives:

- Socially: it wants to activate citizens around urban places of interest and motivate them to carry out assignments that are beneficial to the community. It also wants to emphasize neighborhoods as the place where citizens can meet each other, socialize and reinforce social cohesion [1].
- Technically: it encourages a better take-up and use of ICT and to help develop the information society. It also provides a framework ready to be reused, modified or extended [12].

The pilot design included three interfaces: mobile, website and street furniture. As using and interacting with the Pilot should actively engage the citizens, the role of street furniture was considered particularly important.

As shown in Figure 1 digital, sensor-based sparrows were designed: when people whistle at them, leds lights up, and community credits are earned. In addition to this, hollow trees were engineered: they allow to check in with RFID cards, obtain an overview of the network, earn credits, and they are meeting points where players can encounter each other [16]. More credits are earned when people engage in a collective check-in (by swiping multiple RFID cards in a given timeframe, a so called 'combo' check-in), thus stimulating new encounters, neighborhood cohesion and sense of community.

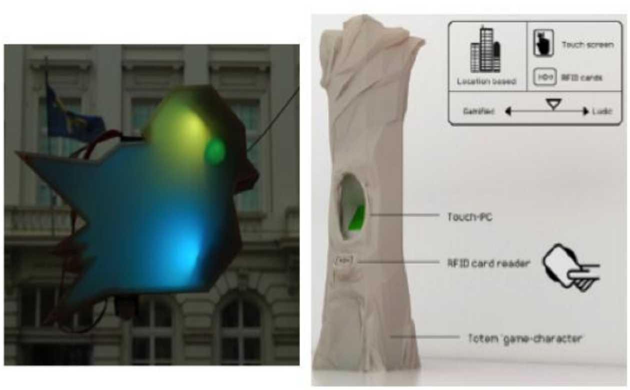


Figure 1: Smart sparrow and hollow tree [10]

Eight sparrows were placed on windowsills and balconies of resident's houses in the two districts, while two hollow trees were placed on central squares in these districts. While the sparrows were a ludic and poetic intervention in the city, aimed at making the city a more playful and cheerful environment, the hollow trees served as meeting points and as alternative interfaces for residents deprived of Internet access. Participants in the city game ZWERM could find an overview of the location and a real-time status of every sparrow on the ZWERM website, mobile app, and on the screens of the hollow trees in their neighborhoods. This website (and its mobile app) included social networking affordances, feedback mechanisms and a scoreboard (on neighborhood as well as on individual level). The official website and a custom created Facebook page were also the main channels to engage ZWERM participants in 'off-line' or 'away-from-keyboard' activities such as a geo-cache challenge, a garage sale or an out-door informal reception [22]. Each week, gift-vouchers were handed out the best scoring residents and a new 'campaign' was started (neighborhood scores were reset to zero). In this way, people stayed engaged in the game and new players could easily join up.

To be able to objectively evaluate the reusability of the Smart Engagement Pilot in other partnering cities, the following section introduces the reuse framework and conducts the KPI scorecard based assessment with representatives of each partnering city.

III. Reuse Framework : Rationale & Indicators

A. *Framework Rationale*

Reuse processes are considered increasingly important for developing high-quality software and ICT projects. As explained in [5], re-use processes can play a crucial role in the success of private entrepreneurial initiatives as well public projects. Re-use is critical, as it allows working on existing artifacts instead of starting from scratch, thereby enabling the development and deployment of software and services with a greater ease. Consequently, time and human effort required to develop software product and pilots can also be effectively reduced. Given the financial crisis that across Europe, reuse of ICT-based pilots and products can effectively add to the cost-cutting measures proposed by the public and private bodies. In addition to this, iterative reuse can also have a relevant, verifiable impact on product productivity and quality, as re-using existing artifacts can iteratively improve the quality of the software or pilot.

Rothenberger [18] extended the rationale for reusing ICT based processes by distinguishing six critical reuse dimensions. The six dimensions also partly reflect in our framework are as follows:
- *Planning and improvement* to rationally prepare the reuse process;
- *Formalized process*. A formalized structure eases reuse management and helps beginners;
- *Management support*, especially in terms of allocation of resources (funds, infrastructures, people and skills);

- *Project similarity*. Resemblance between different projects can of course increase the opportunities for reuse;
- *Object technologies*. This parameter "captures the extent of object technology used on reuse projects".
- *Common architecture*. A common architectural starting point can ease the development of the process.

That said, not every reuse process is often successful. After studying the phenomenon and verifying that several reuse programs roll over and fail to show any return in the course of time, for this, Card & Comer in [6] pinpointed two main causes: first, some organizations risk to consider reuse merely as technology-acquisition process, forgetting that the process of buying technology doesn't guarantee the success of the operation per se. Second, companies often fail to weigh the business implications of reuse, and don't develop business strategies that look beyond the acquisition of technologies already developed.

Card and Comer's analysis highlights how important it is to verify the feasibility of reuse processes before delving into technological acquisitions and development plans. As a first step in this direction, our reuse framework provides a means to capture holistic techno-business requirements for public/private stakeholders interested in reusing the pilot and its components. Within the SmartIP project, next to the technical requirements for the deployment of the Smart Engagement Pilot, the operational and business reusability was also a concern for many partners in the consortium. One of the goals of the project was to identify Pilot's crucial processes and analyze them in order to extract best practices that could be strategically replicated in other Smart cities [4]. Therefore to be able to develop market-driven and user-oriented reuse processes, a unified framework for assessing the re-use potential for the SmartIP pilots was designed. This framework performs such a re-use potential test and uses a scorecard to determine the micro and macro roadblocks before such a transition could materialize.

B. Framework Indicators

This section introduces the key components and performance indicators used in the framework (see Figure 2 and Table 1). The framework investigates the readiness of four partnering cities (Bologna, Manchester, Cologne and Oulu) to reuse technologies, methodologies, and pilot components currently developed and tested by the city of Ghent. First proposed in the form of business model matrix in [8], the framework consists of four building blocks encompassing various technical and non-technical attributes of the pilot:

Demographics (D1-D5): Indicators are geared towards a comprehensive evaluation of city's ICT environment, mobile penetration, along with ICT awareness of its citizens.

Technology design (T1-T7): Comprises of indicators geared towards the identification of technical requirements and processes within the pilot. Requirements vary from the city's awareness of sensor technologies to RFID cards and readers, from local expertise in management of beta testing of the software to open data procedures.

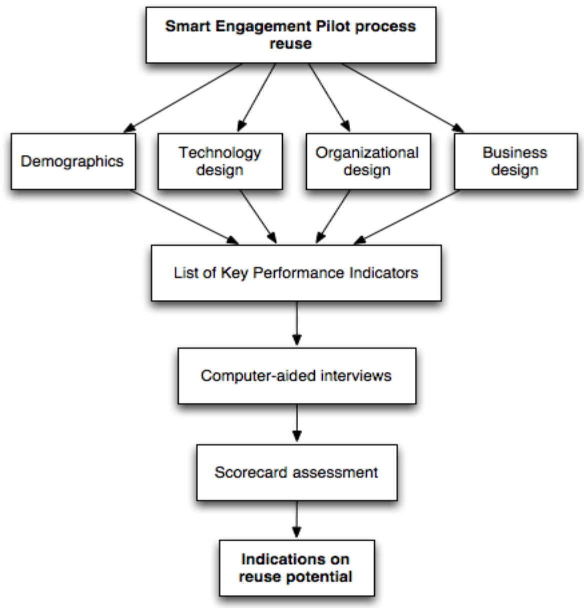


Figure 2: Proposed reuse framework for smart city pilots

Organizational design (O1-O3): The organizational indicators include collaboration with city communities and inclusion of special categories (e.g. disabled people) in the platform. Also, in order to realize a pilot, cities often require a series of approvals/permits from relevant public departments: therefore, ease and timing of this process required careful evaluation. Indicator (O3) also included the evaluation of communication mechanisms adopted by the cities to engage its users (citizens). Since the project stimulates citizens to become co-producers of the pilot, a well-designed communication mechanism can effectively introduce the pilot to the inhabitants showcasing its strengths and value-add to the society.

Business design (B1-B5): Different contextual factors that influence the business organization of pilots were considered. In particular, ownership of the interface hardware (B2) and aggregation platform (B1) is studied and financing strategies are evaluated. Cities were also asked (i) to estimate their willingness to invest and (ii) to provide more insight into their investment strategies for similar engagement pilots.

Given below are the four building blocks including 20 Key Performance Indicators representing the Demographics, Technology Design, Organizational Design, and Business Design aspects of the Pilot (see Table 1).

Identifier		Key Performance indicators	Responses
Demographics	D1	Awareness of ICT and new media technologies among citizens	Medium/ high (6/10)
	D2	Awareness of cities in terms of Living Labs	High (7/10)
	D3	Awareness of city partners in terms of RFID cards	Medium/low (4/10)
	D4	In-house innovation center	Medium/high (6/10)
	D5	Mobile application design & development	Medium/low (4/10)
Technology design	T1	Experience in using CMS systems	High (7/10)
	T2	Knowledge of Open Data Standards	Yes
	T3	Person responsible for the management of GIS data quality	Yes
	T4	Safety of location-related private data	Yes
	T5	Awareness of sensor technologies	Yes
	T6	Use of sensor technologies	Medium/high[1]
	T7	Ownership and maintenance of the sensors	No
Org. design	O1	Time to acquire permissions	5-8 weeks[2]
	O2	Ease of acquiring permissions	High (7/9)
	O3	Communication strategies	Yes
Business design	B1	Ownership of aggregation platform	No
	B2	Ownership of the interface hardware	No
	B3	Guarantees of risk-free pilot	No
	B4	Willingness to invest	High
	B5	Alternative investment strategies (PPPs, etc.)	Medium/high[3]

Table 1: Key Performance Indicators & Responses for Ghent

After establishing and prioritizing the list of KPIs, a first round of validation interview was conducted with the representative from the city of Ghent. Such an exercise was meant to confirm the scope and fit of the framework with the objectives of the pilot. During the interview, responses were recorded for all the 20 indicators and are shown in the Responses column of Table 1.

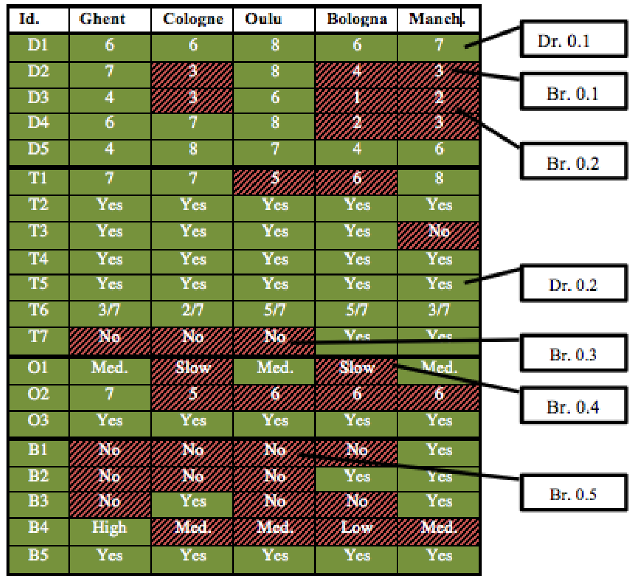
IV. REUSE POTENTIAL ASSESSMENT

Once the base values (responses from Ghent) for each indicator are established, a series of computer aided-interviews (CAI) were organized with other partnering cities (Bologna, Manchester, Cologne, and Oulu) to collect their inputs for each indicator (See Figure 2). To further improve the relevance of the input data, city representatives from

[1] Ghent makes use of sensor technologies especially for mobility management, social engagement and within environmental projects.

[2] Ghent stated they could obtain permissions in 2 months, while some other partners need up to 3 months (or more).

[3] Like other partners, Ghent considers different investment strategies like PPPs so as to attract private investments and finance public projects.



Id.	Ghent	Cologne	Oulu	Bologna	Manch.
D1	6	6	8	6	7
D2	7	3	8	4	3
D3	4	3	6	1	2
D4	6	7	8	2	3
D5	4	8	7	4	6
T1	7	7	5	6	8
T2	Yes	Yes	Yes	Yes	Yes
T3	Yes	Yes	Yes	Yes	No
T4	Yes	Yes	Yes	Yes	Yes
T5	Yes	Yes	Yes	Yes	Yes
T6	3/7	2/7	5/7	5/7	3/7
T7	No	No	No	Yes	Yes
O1	Med.	Slow	Med.	Slow	Med.
O2	7	5	6	6	6
O3	Yes	Yes	Yes	Yes	Yes
B1	No	No	No	No	Yes
B2	No	No	No	Yes	Yes
B3	No	Yes	No	No	Yes
B4	High	Med.	Med.	Low	Med.
B5	Yes	Yes	Yes	Yes	Yes

Figure 3: Scorecard assessment [Dr: drivers – Br: barriers]

strategic departments such as e-strategy, e-government and ICT departments were chosen. Once inputs are collected (via Qualtrics [17]), they are translated into a scorecard in order cross-compare the differences and underline the readiness of each city partner intending to reuse the Smart Engagement Pilot. Results are aggregated in the form of a single, all-inclusive scorecard as presented in Figure 3. While the strengths of each city are recorded in green, weakness or problem areas are colored in red. The scorecard also brings forward the key drivers (Dr.0.x) and barriers (Br.0.y) for a successful re-deployment of the Smart Engagement Pilot across the participating cities. Table 2 extracts the key drivers and barriers from the scorecard and presents possible counter responses and recommendations to address the problem areas. Below we first explain our findings from the scorecard, following which, we transition towards discussing the drivers and barriers for successful reuse.

A. *Scorecard Findings*

In terms of **demographics,** almost all the cities have a very highly ICT aware audience (D1) for the Smart Engagement Pilot. The rating above 6 for all the cities signifies a high degree of ICT awareness among the citizens. However, significant efforts are required in order to improve collaboration (D2) with Living Labs and related innovation centers. Only the city of Oulu shows in depth knowledge of working with living labs (more than Ghent). That said, some cities like Cologne have shown their enthusiasm to take steps in order to improve such innovation-focused collaboration. In terms of know-how in RFID technologies (D3), with the exception of Oulu, other cities do not have a higher degree of technical know-how when compared to Ghent. In the Smart Engagement Pilot, the use of smartphone interface plays a critical role in engaging the citizens to the SCOGA Pilot; as per D5, all cities

	Id.	Indicators	Findings / Recommendations
Drivers	D1	ICT readiness of citizens	Dr. 0.1: High degree of ICT awareness. Citizens could easily accept and engage in the smart community games based on digital and sensor technologies.
	T1, T6	Knowledge of technical requirements	Dr. 0.2: As cities are well aware of technical requirements, they seem ready to develop smart community games based on digital and sensor technologies.
	O3	Communication strategies	Dr. 0.4: Communication strategy will play a critical role in engaging the citizens to the pilot. Several partners are considering the idea to prepare a pilot-specific communications plan to ensure its maximum diffusion.
	B5	Willingness to invest through	Dr. 0.5: Instead of direct public investments, cities are open to consider alternative investment options such as public-private investment and sponsorships.
Barriers	D2	More collaboration with Living Labs	Br. 0.1: Living Labs, user-centered ecosystems operating in the cities are best placed instruments for cities to innovate. In their absence, development and deployment of technologically advanced pilots could be hampered.
	D3	Knowledge of RFID technologies	Br. 0.2: As the pilot users have to use RFID cards during the games to check-in and earn credits, improved understanding of RFIDs could guarantee success during the reuse of the pilot.
	T7	Ownership and maintenance of sensors	Br. 0.3: Maintenance of the sensors during the pilot and their ownership need further investigation. Several cities pointed out the fact that without knowing which department is responsible for the project, it is difficult to identify the ownership structure and the organization responsible for the maintenance of the sensors.
	O1, O2	Faster procedures for approvals	Br. 0.4: In order to carry out a pilot, partnering cities require approvals from relevant authorities and departments, but the chances that they are able to secure these permissions are often limited because of the bureaucratic complexity of local public administration.
	B1, B2	Ownership of aggregation platform & Interface hardware	Br. 0.5: Cities have found it difficult to identify a clear ownership structure for the aggregation platform. In addition to this, alternative options to MAX like COSM are not well known by the partners. The Interface hardware still needs to be identified.

Table 2: Final drivers and barriers

demonstrated their awareness of developing/using mobile application, some are more experienced than others.

As per the **technology design,** all the partners are aware of Drupal-like CMS systems (rating above 5 in T1 for all cities). Manchester has gained expertise in this domain over time due to involvement in several EU projects and in-house pilot development. Other partners are also ready to adopt this technology and manage the content from a central interface. All cities interviewed showed their awareness of current Open Data Standards (T2), Sensor (T5), and Geographical Information System (GIS) data management techniques (T3). When asked about the safety of location-related private data (T4), every city acknowledged the privacy risks of conducting such a pilot. Manchester and Oulu are particularly well versed with the data protection issues, and any implementation of such a system would be rapid. Sensors have been intensively used (T6) by the cities over the last years. Some partners have used sensors for mobility management (radar traps, restricted traffic zones) and for pollution control (CO_2 emissions, humidity, etc.). Bologna and Oulu have the most experience using the sensor technology in five application domains. Bologna and Manchester have already identified the ownership structure (T7), whereas more research on stakeholder and ownership structure for the city of Ghent, Cologne and Oulu is recommended. About the maintenance of the sensors, this issue seems to be a challenge for Ghent and Bologna.

The **Organizational design** in the scorecard evaluates the organizational readiness of cities to reuse the pilot. In our evaluations, all cities unanimously agreed and recognized the risk of delays (in securing permissions from relevant city department) that can slow down the reuse process (O1). Cologne and Bologna may require as long as 3 months to obtain relevant approvals from their departments. As shown in O2, the city of Ghent is best placed to acquire the permissions and hence outperforms the other partners. Two other partners claim that their city could have low chances of obtaining the necessary assistance from the IT department in case of reusing the pilot. Another critical organization issues is the communication strategy using which each city could interact and engage with its citizens. As shown in O3, all the cities have state-of-the-art communication strategy in place to better evangelize the piloting idea to their citizens.

Moving to the **Business design,** almost all cities have found it difficult to identify a clear ownership structure for the pilot components (B1). In addition to this, alternative options to MAX (sensor data aggregation platform from Alcatel Lucent) like COSM are not well known by the SmartIP partners with an exception of Manchester. As shown in B2, Ghent, Cologne and Oulu can't identify the ownership of the interface hardware, pointing out the fact that without knowing which department is responsible for the project, it is difficult to identify the ownership structure. As far as risk-free piloting is concerned, only Cologne and Manchester could guarantee such a risk-free pilot (accident prevention and public domain protection). Although a real interest in the reuse of the Smart Engagement Pilot exists, investments are limited due to the current economic situation (B4). When compared, only Ghent showed a high willingness to invest w.r.t to its peer cities. As shown in B5, in lieu of direct public investment, several partners are considering alternative funding options such as PPPs (public-private partnerships).

B. Recommendations

Since the success of one pilot in a city doesn`t guarantee its success in the other, a clear understanding of possible externalities, requirements and intricacies faced by each pilot is necessary. Table 2 extracts the final list of drivers and barriers to successful re-use of the Smart Engagement Pilot. Strategic drivers and barriers from Table 2 are synthesized in order to create a list of recommendations (Figure 4) that should be taken into account when transferring/reusing the Smart Engagement Pilot in other cities.

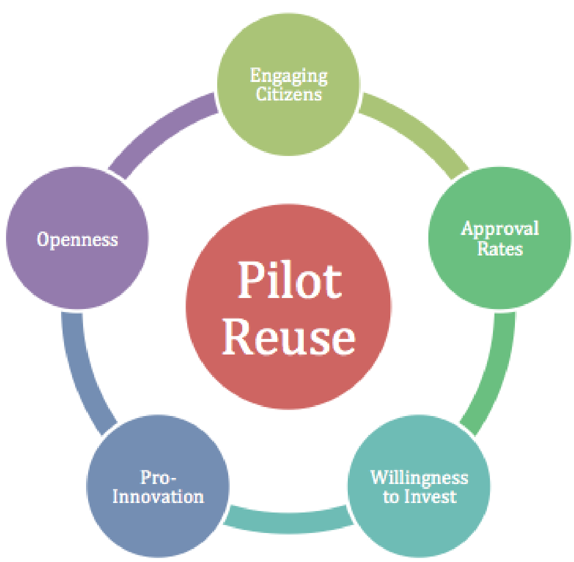


Figure 4: Recommendations

Engaging Citizens: Success of the Smart Engagement Pilot hinges on the city's ability to engage its citizens. The pilot deployed in Ghent showed how citizens could be successfully engaged in different steps of piloting. By engaging citizens early in the design phase, cities can very well exploit their location-specific knowledge and in turn develop more user-friendly pilots for its citizens.

Approval Rates: Through our scorecard assessment we identified the difficulties faced by the cities to obtain appropriate permissions and approvals. The complexity of the local public administration reduces the possibility of securing permissions within a short period of time. Structurally separated public departments further create the delays in acquiring permissions and hence may slow the entire reuse process. More attention to the internal communication could definitely speed the process and ensure a successful reuse of pilots.

Willingness-to-invest: Due to current economic conditions in Europe, willingness-to-invest amongst cities is moderately low. Today the economic crisis poses a threat to local budgets, and hence cities are increasingly stimulated to cooperate with private and/or not-for-profit stakeholders. Partners are more open to considering the opportunities offered by co-financing projects such as PPPs (Public-private partnerships), Sponsorships etc. More attention is required in order to explore the public-private partnership and to develop guidelines for such investments.

Pro-Innovation: SmartIP project infuses innovation in cities by actively engaging its citizens and end user, thus enabling the creation of a virtuous co-production dynamics. A city willing to reuse the pilot can engage with Innovation Centers and Living Labs for engaging its citizens early in the pilot development phase. During our assessment, it was clear that some are still new at adopting Living Labs as means of user engagement during the design of new ICT-based public services.

Openness: Since the beginning of the work, the SmartIP consortium underscored the importance of openness in the pilots: services should be open in order to develop a viable and reusable model of Smart City. A step forward has already been taken, and SmartIP cities are still exploring the opportunities offered by an open development methodology based on Open Data and co-production. In this sense, the open data public database deployed in Ghent is a clear indicator of this new paradigm.

V. CONCLUSIONS AND FUTURE WORK

This paper evaluated the Smart Engagement Pilot currently being developed and deployment in the CIP Project SmartIP. An in-depth qualitative assessment via scorecards and peer interviews demonstrated the re-use potential of the pilot across four other partnering cities (Bologna, Manchester, Cologne and Oulu) in Europe. To capture both the technical and non-technical issues pertaining to the success of pilot reuse, key performance indicators from four major domains - demographics, organization, technology and business are considered.

The Figure 3 presents the scorecard where we cross-compare the KPIs from each city. The difference in readiness/willingness of each city w.r.t to the parent city (in our case Ghent) is recorded. Drivers for re-use of the engagement pilot include high degree of ICT awareness among the cities and its citizens. Highly developed communication strategy along with high willingness to explore alternative investment opportunities among the cities will further drive the reuse of such engagement pilots in the future. However, there exists barriers such as lack of collaboration with innovation centres and living labs can deter the development and diffusion of such technologically advanced pilots. Also, lack of knowledge of ownership structure of pilot components, involved platforms and inability to expedite the permission procedures could delay, even cripple the reuse process. Unless these barriers are addressed adequately such disjunctions might prevent the Smart Engagement Pilot from being deployed in other cities. As a first step towards countering these barriers a first set of recommendations are drafted in the Section 4. Recommendations vary from ensuring openness in technical architecture to exploring alternative funding schemes for cities.

Next steps for future research and development includes refinement of the key performance indicators to better reflect the nuances of other application domains such as Smart Environment, Smart Mobility etc. This implies further methodological development when it comes to combining separate KPI analyses for multiple pilots into an integrative analysis. The need for such methodologies to assess reusability of pilots is expected to grow in the coming years. The re-use of technologies will not only be resource efficient, it will also be error/failure free due to iterative re-use and debugging, hence contributing to the quality control. By applying the reuse framework to the Smart Engagement Pilot in Ghent, this research paves the way for future discussion on re-use potential assessment of pilots and at the same time inspire cities to increase civic engagement through ICT and gamification.

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