Smart City Service Creation and the Living Lab Approach: Benefits & Challenges

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1. Introduction

The aim of the EPIC project was to examine the needs, requirements and added value of a pan European 'smart city' delivery platform for leading ICT companies, specialist SMEs, Living Labs and established and future Smart Cities. Its objective was therefore to explore the particular implications of the cloud platform paradigm as the basis for a pan-European service delivery platform so as to enable a more holistic approach in making European cities smarter. In order to make sure that the platform is best suited for the deployment of new smart city services, one important task of the EPIC project was the creation of different smart city services that each posed different requirements and aspects of the Smart city concept. Secondly, in creating these services, the EPIC project was interested in benefiting from the Living Lab approach which is associated with open innovation and user involvement in early stages of product or service development. The Living Lab methodology developed for the EPIC project generated three services in three pilot cities: a Relocation Service in Brussels (Belgium), an Urban Planning Service in Issy-les-Moulineaux (France) and a Smart Environment Service in Manchester (United Kingdom).

In this paper, we will focus in particular on the aspect of smart city service development and design in the context of Living Lab research. Drawing on the experiences we encountered and the user tests results we gathered during the EPIC project, the aim of this white paper is threefold: (1) presenting other European cities with a hands-on experience of how the EPIC project carried out its Living Labs guiding user tests of smart city services, (2) presenting the most important test results and lessons learned on the level of design, smart city value, sustainability as well as Living Lab management, and (3) based on these concrete experiences, we highlight the actual benefits and relevance of a Living Lab approach for the ideation, creation and development of new smart city services. This paper is therefore of particular interest to those readers interested in running a pan-European Living Lab testing user-facing Web and mobile services in the context of city services. The white paper summarises in this way the key lessons from the three deliverables that were produced by the WP7 team: D7.1 '*Pilot Operations Plan*', D7.2 '*Report of 3 pilots*' and D7.3 '*Pilot Evaluation Report*'.

The structure of this paper is as follows. First, it introduces the objectives of the three EPIC pilots. Secondly, we elaborate more theoretically on the Living Lab approach and its guiding principles as a recent and promising way of conducting user research in Europe as well as an inspirational source for the EPIC project. In the third part, we describe the set-up of the Living Lab and the execution of the user tests in the context of the EPIC project, the results it generated as well as practical management lessons that we learned throughout the duration of the project.

2. EPIC smart city services: Objectives of the 3 pilots

The three smart city services were developed in order to underpin the different requirements they were likely to pose for the development of the EPIC platform, thereby highlighting different elements associated with the smart city concept. This is presented next for each pilot smart city service.

2.1 Relocation pilot

The relocation service (RS) application is a pilot study that aims to assist professionals (and their families) in their (temporary) relocation to the city of Brussels. In its envisioned form, the application focuses on helping expatriate users to:

- Get to know the different areas of the city and help to decide which areas are preferable to live in (guided by language settings).
- Find available housing, for sale or for rent within these preferred areas.
- Evaluate individual properties, for sale or for rent, based on a multimedia description of the property itself and of the neighbourhood it is in.
- Discover various point of interests (e.g. educational, public transport facilities) around these properties.
- Discover and engage with institutions, organisations and facilities targeted at the integration and support of incoming and existing citizens of the smart city. This includes making sure the user knows what administrative tasks need to be fulfilled to move to the city, where family members can be enrolled in education and more.

These objectives are met by offering a web-based component and a mobile application (iPhone). The web application provides a feature-rich interface that can be used by incoming citizens when preparing their move to Brussels. These functionalities are extended by an Internet-enabled mobile application that supports incoming citizens when actually 'on the move' in Brussels. For example, preferences and searches made in the web-based component are reflected in the mobile application as it guides its users to preferred properties and the points of interest around them in situ. The application also allows its users to add their 'favourites' and feedback to the properties and places visited during their actual property search in Brussels. This information is stored online, so it can be used in both the web as mobile components.[i]

2.2. Urban Planning

The Urban Planning (UP) service is a pilot study with the aim to manage, share and communicate information about urban planning and development projects of the city and improve networking within local actors (citizen, city, SMEs). Mainly addressed to citizens, the Urban Planning Application is a virtual space combining 3D modelling, rich media and symbolic information and complements the already existing "Urban Planning Centre" of the city, a public area for consultation and communication where interested stakeholders can meet and exchange information on urban development, projects and studies that are to be carried out in Issy-les-Moulineaux, France.

For the EPIC project, the service has been extended and adapted by Issy Media and the SME Navidis so as to enable efficient real-time networking between businesses and citizens, but also provides an interconnection between Issy-les-Moulineaux's SMEs. It has been enriched with important information on the local SMEs (who is who, who does what, what are the current offers, both in direction of other businesses and the citizens). This is likely to enhance local activity in the long run as, on the one hand, citizens have faster access to the local economic infrastructure, and on the other hand, the local businesses gain insight into the local economic tissue, the competitors, and the potential partners.

Three different kinds of users could be identified for which the Urban Planning solution was likely to offer new and innovative services:

The Citizen view: A typical end-user can virtually fly over and move around the digital 3D model of the city and access enriched information about points of interests as well as about some particular categories dealing with their daily lives (i.e. Leisure and Culture, Sustainable Development, Urban Planning projects, Public Services, Enterprises).

The City View: This new solution can be managed by the city's operators that can maintain up-to-date information published and then use this application as communication tool for local development and urban planning.

The Business View: The section "Enterprises" of the Urban Planning application offers an overview of the existing innovative businesses in the city by offering them a media center and a way to interact with each other.

In this view, the application has a triple-oriented approach: a business-to-citizens approach allowing businesses to inform the citizens about the services offered and job opportunities, a business-to-business approach enabling businesses to have a better insight into the city's economical tissue and a government-to-citizens approach enabling the administration to interact with inhabitants and economic actors.

2.3 Smart Environment

The Smart Environment pilot (SE) aims to support both domestic households and city stakeholders to consider their use of energy (electricity usage) either in their own homes or to present a view of the use of energy in publicly owned buildings. The aim of the SE is to provide citizens with increased awareness of energy usage, and particularly electricity consumption, with the longer-term aim of changing usage patterns and hence reducing consumption and CO2 emissions, although behavioural change of citizens is out of scope of the EPIC project.

By informing users of their own electricity usage and also that of public buildings allows the city (or other building operators) to expose their building energy use to a wider audience. It may be seen as a step towards smart city which is able to leverage a service infrastructure that is capable of delivering 'one stop government' through the integration of services, interoperability of systems and use of actionable intelligence in service delivery.

The SE pilot has two different but complementary components. The domestic energy dashboard provides a personal dashboard of electricity consumed in the homes of participants, and allows a comparison with the average of similar properties. The public buildings dashboard makes visible data on electricity and, where data is available; gas consumed in the operation of public buildings owned the city administration and other organisations.

These objectives are met via significant use of Internet of Things (IoT) and web interface, using a relational database structure capable of aggregating data from a diverse range of sensor types.

These three services were developed with a living lab approach in mind. We therefore now will introduce the Living Lab approach and its philosophy.

3. The philosophy of the Living Lab approach

Historically, innovation has been viewed as a linear process, driven and controlled by the industrial developers of products for the marketplace. In the information society, two trends can be detected that led to different conceptions of innovation.

First, innovation is increasingly seen today as a catalyst for growth and competitiveness and has been enthusiastically promoted at regional, national and international level and included in new policy formulation. The linear concept has evolved more towards a network model involving partners supporting innovation, often focused on cycles of innovation activity. The greatest change in how we should consider innovation is coming about in open innovation. It postulates that companies should be open to outside ideas since innovation can only thrive when a company utilises a network of partnerships beyond its traditional internal resources (Chesbourgh, 2008).[ii]

The second trend encompasses the growing importance of the role of the user in the design process in the context of product and service innovation. The idea is that the resulting quality and appropriateness of a product or service will suffer if users, in one way or another, are not involved in the processes that make up the design stage. While many new approaches emerged that involve users in one way or another in a stage of the development process (user centric design, crowd-sourcing, wisdom of crowds, lead user), until recently the level of partnerships has focused on science parks, business incubators and other types of activities that support fledging new companies. Yet, in recent years, there has been a shift towards recognising the importance of getting feedback from users in their everyday life-context. This insight has foot in different disciplines, but the one that was particularly inspiring for the Living Lab partners of EPIC is the social shaping/social construction of technology paradigm (Pinch & Bijker, 1987) where technology is not seen as a force external to society impacting it, but rather as the outcome of a process of socialization where its meaning and impact is constructed through people's everyday use of it. Applying this paradigm to the evaluation of ICT means that assessing technology should take into account how different social groups, living in different social contexts, use and interpret technology differently based on their own experiences, problems and perceived solutions (Flichy, 1997; Van House, 2004). Concretely, this means that technology should be studied, where, when and while it is used, as part of the socio-technological set of interactions between human and machine, embedded in a given social context (Ratto, 2000). Asking users to reflect on future practices without them experiencing the context in which those practices will take place, will only lead them to express themselves in

very general terms (Stahlbröst & Bergvall-Kareborn, 2008). Starting from this idea of actions being contextually situated (see Suchman's situated action, 1987) implies the necessity for technology to be evaluated on the concrete social and everyday surrounding of users.

These developments have led the past years to the emergence of a group of organisations in Europe which characterise themselves as '*Living Labs*'. Its name reflects their common philosophy and aims to set up a research laboratory, that supports research and development and innovation activities by testing and validating them with users in their real life context and environment. Living Labs are an innovation area where users co-create with developers and researchers and are the first attempt to structure and provide governance to user involvement in a way that can be addressed by companies, research institutions, public organisations and policy makers.[iii]

However, given its early stage of development, Living Labs often worked in isolation from each other. As a result, multiple ways of executing a Living Lab emerged over the years. The past years, two needs were felt: on the one hand a certain degree of harmonisation of methods and tools in order to improve the quality of Living Labs themselves and on the other hand the need for interoperability between different Living Labs in order to provide opportunities for cross-border innovation projects.[iv] The European Network of Living Labs (Enoll - www.openlivinglabs.eu), founded in 2006, can be seen as a result of these demands and aims today to enable the exchange of experiences between different Living Labs as well as to stimulate the cooperation of Living Labs on a European scale.

With this Living Lab approach in mind, EPIC sought to ensure that the pilots would be able, at the end of the project, to provide user-friendly smart city services that citizens, businesses and city visitors would want to use and potentially willing to pay for. Secondly, against the backdrop of the demands for for harmonisation and inter-operability, EPIC itself could provide an opportunity for cross-border cooperation between Living Labs and the exchange of Living Lab experiences. Hence, in each pilot city, a Living Lab organisation sought to engage citizens and SME's in order to create a Living Lab environment as well as a Living Lab approach to facilitate user testing. Moreover, these three Living Lab organisations worked closed together in defining one common operation plan so that harmony of methods and tools could be established and exchange of lessons and experiences could take place.

4. Living Lab operations of EPIC

It is worthwhile to note that that none of the pilots were launched and tested in a pre-existing institutional Living Lab with a specific user panel at its disposal. Rather, for each of the pilots a particular Living Lab setting was created. Hence, the Living Labs were thus project-based and WP7 leads therefore had to create their own Living Lab in the city community in order to engage end-users with a particular real-life interest in the topic so as to get reliable feedback.

We now present the most important steps in the execution of our Living lab operations throughout the whole test period:

- The iterative development strategy;
- The recruitment and selection of testers and their participation;
- The panel management;
- The methodology for user feedback collection and evaluation;
- The communication between the pilots and the other project partners.
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Concrete and detailed information about the initial planning and execution of selection criteria for testers, recruitment and retention strategies as well as user support and training tactics can be found in D7.1 '*Common operations plan*' and D7.2 '*Report of 3 pilots*'.

4.1.1. Iterative development strategy

Since one characteristic of a Living Lab is to allow for iterative development, the three pilots followed a common strategy of deployment and development in three phases, each having a concrete purpose:

Figure 1 : Iterative pilot deployment strategy

(1) A **closed group** with a limited number of technically skilled people that had to test whether from an end user point of view the services were technically working;
(2) A broader **open group** focused on the experience and acceptance of the services by end-users within their everyday life context
(3) A **stakeholders evaluation phase** that consisted of an evaluation of the final version of the pilots by relevant actors (businesses, public institutions) in the pilot city that could have an interest in using the service or aspects of the service from their operations point of view.

The closed and open group consisted of multiple test cycles in which each time (a) new feature(s) was added, tested by the end user and, based on the analysis of the test results and feedback, the previous version was redesigned or improved.

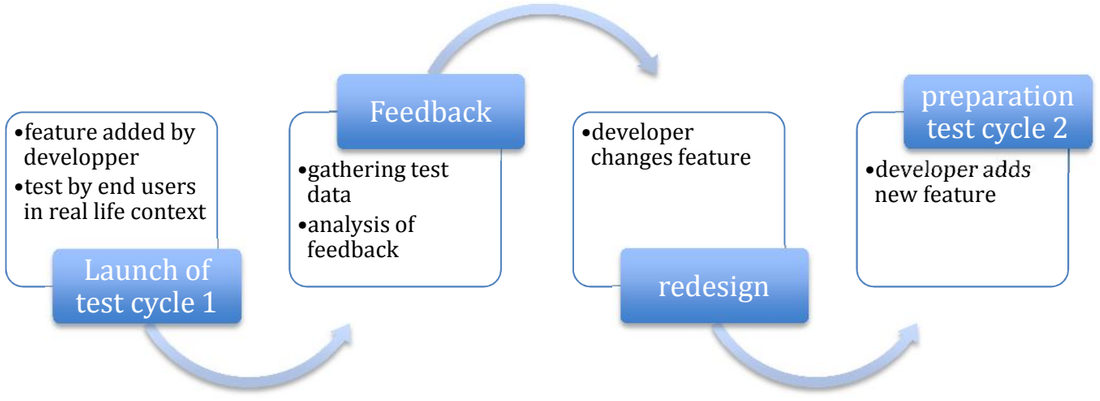

Figure 2: Test cycle

4.1.2. User test recruitment and participation

In line with the aim of the closed group, the pilot teams recruited a limited group of testers that had basic technical skills in the local city community. As the next Table shows, test users in the open group were selected and recruited in accordance with the user type and roles based on the developed pilot scenarios that guided the testing cycles (see D7.1).

Relocation			
User type	User role	Target population	Participation in test
EU – nationals relocating to Brussels for professional reasons	Find interesting property to live in Brussels	(1) EU-nationals living abroad Brussels and having an interest in moving to Brussels; (2) EU-nationals working and living in Brussels since max 2 years; (3) Belgian people living outside Brussels;	(1) One time experience testers (2) Advisory board (3) Advisory board
Urban Planning (Issy-les-Moulineaux)			
User type	User role	Target population	Participation
Citizens	Discover Issy	Citizens of Issy	One time experience testers
Municipality	Publish up-to-date information/communicaton tool for urban planning and development	Various municipality departments	One time experience testers
SME/business	Overview of business in Issy – manage media centre – interact with other business	Various SMEs active in Issy	One time experience testers
Smart Environment (Manchester)			
User type	**User role**	**Target population**	**Participation**
Domestic users	View own consumption – compare with similar properties	Citizens of Manchester	Participation in all cycles closed
Public building users	View energy consumption of the public building	Public institutions of Manchester	Participation in all cycles open

Figure 3 : Selection of user testers and participation

In terms of participation in open group testing, a difference existed between Relocation and Urban Planning on the one hand and Smart Environment on the other. Given the aim of the latter, testers recruited for either the closed or open group, had to participate in all the test cycles involved in those phases. Urban Planning and Relocation on the contrary had 'one time experience' users that participated only once in the different test cycles. Before the launch of the test cycle, a recruitment campaign therefore had to be initiated. In order to balance the results of these testers who only witnessed one step in the iterative development track, Relocation nonetheless recruited an advisory test group that participated in more test cycles and thus could balance the results of 'one time experience' testers.

In order to increase the quality of end user feedback by taking advantage of their recent relocation experience, Relocation also recruited non-Belgians that had moved to Brussels in the past two years. Also, a small group of Belgians living outside of Brussels were recruited because they were likely to face similar issues if they would have to find a place to live in Brussels today. For Smart Environment, a practical problem needed to be taken into account for domestic energy: domestic users had to accept that a energy metring device was installed in their house.

For each pilot site, the recruited users tested the application within their real-life context. Apart from the communication of the start and end of a test cycle, each of the pilot teams imposed no restrictions about the use or the context of use. The following Table summarises how many test users the pilots managed to engage (recruit + start survey after test) during the entire iterative development process for the 3 services:

Closed	**Number of cycles**	**Participants**	**Total**
Relocation web	2	Technical skilled	169
Relocation mob	1	Technical skilled	32
Urban Planning	2	Technical skilled	68
Smart Environment	1	Technical skilled domestic Technical skilled public	11 24
Open	**Number of Cycles**	**Participants**	**Total**
Relocation web	3	One time experience expats + Advisory expat group:	340
Relocation mobile and integration web/mobile	1	One time experience + Advisory expat group: Mobile only: Integration web and mobile	29 6 23
Urban Planning	3	One time experience (SMEs, citizens)	119
Smart Environment		Domestic users Public buildings	55 13

Evaluation	Cycles	Participants	Total
Relocation (web and mobile)	1	Public institutions Business Education institutions	15
Urban Planning	1	Public institutions Business	4 4
Smart Environment	1	Business: 1 Public institution: 1	2

Figure 4 : Test user participation numbers

4.1.3.: Panel management

The aim of EPIC is to develop a safe and secure environment for end users. Therefore, the pilot services could not be accessed freely, instead users had to register prior testing in order to get an access code. iMinds executed for all three pilots the registration of the recruited end users into the EPIC platform as well as granting the access rights for each tester to the appropriate pilot.

4.1.4.: Methodology for user testing and evaluation

In order to learn about the user experience and acceptance of the EPIC solution, the pilots collected quantitative and qualitative feedback from users during the pilot test phases and cycles by deploying the following methods:

Method	Aim	Relocation	Urban Planning	Smart Environment
Questionnaire	Quantitative feedback/ Qualitative feedback in open question	Closed + open	Closed + open	Closed + open
Interview	Qualitative feedback	Evaluation	Evaluation	Evaluation
Focus group/demonstrations	Qualitative feedback	Evaluation	Evaluation	Evaluation
Participant observation	Qualitative feedback	Open group mobile	N/A	N/A
Data Logs	Quantitative feedback on usage	Closed and open	Closed and open	N/A

Figure 5 : Data capture methods

Each of these methods was selected to elicit a particular kind of data and enabled a full end-to-end analysis of the pilot services. All pilots used questionnaires, interviews and demonstrations. Questionnaires allowed us to gather quantitative feedback from a large number of end users in a timely fashion about user experience and acceptance but provided also more qualitative feedback by means of open questions where testers could express the negative aspects, positive aspects and recommendations for design purposes. Interviews and focus groups allowed in the evaluation phase to gain a deeper understanding of meaningful themes, practices and relationships from the interviewee's point of view. Participant observation for the mobile component of the Relocation pilot allowed to get a close view on usage and its meaning while expats were actually 'on the move' in Brussels to find a place to live. Data Logs for Relocation and Urban Planning finally allowed to get broader insights into use patterns (time and scenario) of the pilots as well to detect access and error information.

In order to evaluate the feedback gathered by these methods underpinning the user experience and user acceptance for each pilot, a literature review was conducted, and which aided in identifying the following measures:

Experience context	
Usability/acceptance	Perceived ease of use
	Perceived Usefullness
	Content
	Attitude
	Intention
	User profile (context research)
Contribution to smart city (only evaluation by stakeholders)	

Figure 6 : Measures for user experience and participation

4.1.5.: Communication intra and between Living labs

A Living Lab approach demands close cooperation between the technical team and the user test team that organizes the user tests and gathers and analyse the feedback from testers. Communication is therefore an essential element for success. Therefore, besides meetings between technical teams and user test teams in each pilot themselves, the WP leader also attended the weekly technical meetings of the development teams. Moreover, since the ambition of EPIC was to lead Living Labs work together across boundaries and share experiences and learn from each other, the three pilots themselves set up weekly Skype meetings to discuss the ins and outs of the Living Labs. The availability of a project management tool was a great help to share documents between all involved partners.

5. Test results from a Living Lab perspective

What insights and thus benefits did the adoption of the Living Lab approach for developing the pilots show us? The results from end users taught us that its benefit are, identifying good design solutions, assessing the concrete value of the pilot within smart city objectives, and thirdly, identifying crucial points for guaranteeing the sustainability of the pilot in the long run.

5.1. Learning for current and future design solution

By engaging end users throughout an iterative process associated with a number of test cycles the first benefit of the Living Lab approach for the three pilot was the generation - on a rather short time span - of important feedback from potential customers about technical problems and design issues. .

The closed phase – a test phase with a rather small group of technical skilled users - made sure the pilots were technically working from the perspective of end users: bugs, safety-issues, installation problem of equipment at home in the case of Smart Environment as well as other technical problems that in a linear development track would only have been discovered when "going to market", could with the Living Lab approach be detected at an early stage.

The open group – a test phase with a large number of various end user groups - allowed us to identify (for each specific pilot) which implemented design options were desired by end users, what design options needed to be improved and which ones were deemed to be of lesser or no importance.

In the case of Relocation and Urban Planning, the Table below illustrates the main design lessons learned and designs implemented throughout the iterative testing for Relocation and Urban Planning:

Relocation	Urban Planning
Point of Interest: - Categorization (Public Transport, Everyday Utilities, Education,…) and hierarchic classification within category (e.g. Public transport: underground – bus – tram – taxi) - Selection of relevant categories of Point of Interest in the property search selection criteria as being the most common sought for when exploring the neighbourhood around a property (public transport, everyday utilities, healthcare facilities, educational facilities)	Better navigation options on mouse and tactile pad to move within the 3D-city map
Improved navigation options/functionalities between the different pilot tabs and pages (e.g. go from icon of house on map straight to details house instead of having to go to the List of returned properties first)	Adding specific categories within the different thematic layers to make Point of Interest more meaningful (e.g. the layer of 'development économique' with distinctions of different types of business)
A clear use of icons for houses and point of interest that improved navigation and understanding of information displayed on the web application	Better ways to update the content in the media-centres for the different Point of Interest so that they become more interesting for citizens to explore and SMEs/municipalities to use for communication
Living in Brussels page on the web application that provided general background information and interesting website links about different aspects related to organise the settling in Brussels (e.g. explanation of public transport in Brussels, school system in Belgium, social security and healthcare organisation)	Better design of the 3D map surrounding by adding timeline with sun and light and ways to help navigation in the city (highlighting certain meaningful places like parks and sport places)

Figure 7 : Implemented design based on user feedback

The user feedback also showed that for Relocation the way of saving your favourite properties should be reconsidered and for Urban Planning, as we shall see in the next section, that the communication functionalities allowing networking between SMEs were not considered worthwhile enough to be further developed.

In the case of Smart Energy, where design lessons could not be implemented due to the tight time frame of testing, the tests generated a lot of feedback from end user and stakeholders about the improvement of the proposed solution.

Smart Environment: Feedback from end users
Simplifying of dashboard: 'less is more' using standard formats users know and understand easily (like a traffic light) Clearer display of the consumption graphs to improve understanding
Speed of the data-processing
Need for clear and simple instructions, manual, benchmarking data as well as contextual data (e.g. number of occupants in house or floor surface of public building) to better understand the generated data and make comparison more meaningful
Improve ways to make sure monitoring kit is installed correctly (e.g. more engagement for control)

Figure 8 : End user feedback Smart Environment

The testers also made it clear that the design of the monitoring equipment should drastically be changed to a "plug and play" mode as well as that future versions should avoid the risk of having to reconfigure the existing technical installations at home.

The Living Lab framework not only allowed the pilots to receive end user feedback about the planned implemented features for the different cycles. Rather, end users also provided suggestions about solutions that they deemed necessary to insert in order to improve the value of the pilot from its use-context.

Relocation	Urban Planning	Smart Energy
Interface/look and feel web 2.0 way for web	Search facilities such as address and street plan to increase sense of localization and search for specific buildings	Interface/look and feel in 2.0 way

Orientation in the city for both web and mobile: search on address, make environments more meaningful by displaying known landmarks on the map (European Quarter, Atomium, Grand Place).	Enrich information in media centres	Integration with mobile app to be able to check when not at home
Enrich Point of Interest with a relevant web address so that more information can be retrieved (e.g. opening hours of supermarket)	Reduce downloading time of the 3D-map	User generated passwords and logon
Provide interaction with fellow expats via a forum, via testimonies about neighbourhoods or ratings of them by other expats	Video in media centres	Incorporate solar energy panel
Individual rating systems in order to facilitate the end selection of property to look for at the end of the search	Media centres should be able to move	Combine results with energy saving advice
Sharing of personal ratings of property, point of interest or neighbourhood with other users	More animation like traffic/ Better view on level of the street	Provide alerts

Figure 9 : Future improvements of the three pilots

Although these suggestions were not realized within the context of the EPIC project, these are nonetheless valuable ideas for cities that offer the EPIC services in the future to their citizens to increase the attractiveness of the services. What we do learn from these results on the level of design is that in order to create smart city services that users really want, a Living Lab is an viable tool to generate lots of ideas resulting from people's real-life situations (using the service). It thus provides developers with the opportunity to incorporate such ideas in the early stages of development or at least it provides them with an incentive to draw out future improvements that are of direct value to end users.

5.2: User experience and acceptance: the smart city value of each pilot

EPIC wanted to create smart city services that citizens, businesses and visitors to the city would like to use and are potentially willing to pay for. The best way to assess the impact of the Living Lab approach for reaching this target is during the final open test cycle. While, at this stage, each pilot could offer its latest version, consisting of validated features and redesigned features from the previous cycles as well as the final new features, to the testers. In addition, stakeholders in the evaluation phase were offered the same solutions to consider in their professional context. The Table below summarises the evaluation on the different measures we identified for analysing user experience and acceptance (Exact scores from surveys for test users can be found in the deliverable *D7.3 'Pilot Evaluation Report'*). We also discuss the assessment of the contribution of the pilot to smart city issues within the pilot cities by the stakeholders.

Relocation	
Measure	**Feedback (end users and stakeholders)**
Ease of use	Simple design, intuitive, easy to learn
Usefulness	Combination of property data and point of interest and web and mobile very useful
Look and feel	Out dated for web; very good for mobile
Content quality	Rich information, covering various aspects of the relocation process
Acceptance	Satisfied with amount of time to find property on pilot, essential application a city should offer
Intention to use	End users: definitely, although improvements needed (like look and feel and new design features) to increase use value Stakeholders: improvements on level of design and look and feel needed before advising to use to their customers/clients

Figure 10: User experience and acceptance Relocation

The Relocation pilot was evaluated as an easy to use, intuitive tool with a simple design underpinning the property search. End users also showed a positive attitude, being satisfied with the time it took to complete a search and find the appropriate information they needed. Its major appeal lies in its innovative character of combining (private) property data and (public) point of interests that was seen as a necessary and welcome improvement when looking for property in an unknown town. Several expats testified that such a service was something that they wish would exist in their current city and evaluated as a necessary service a city should offer. Participant observation with the mobile application also taught us that users found this device particularly useful since it allowed them to explore neighbourhoods they crossed and would normally not visit. They also clearly expressed an intention to use such an application if they would have to make the move to Brussels, although a significant part highlighted that some necessary improvements on the level of look and feel as well implementation of extra features were deemed necessary to increase the immediate use value. The major objection lies in the look and feel of the web application due to the constraints of the platform.

Stakeholders were of a similar opinion as expats. Although from a more operational point of view, they would still require a more robust finalisation of the pilot before advising their clients to use it. About paying for the service, they saw the potential of payment model with a basic service for free and a payment for additional services.

In terms of the pilot's contribution to smart city objectives, the stakeholder evaluation highlighted that the application would contribute to smart living by giving a means to expat to plan and execute their relocation process in a more efficient way, thus smoothening a process that often goes along with a lot of uncertainty and consequently stress. Also, governmental institutions acknowledged that an application as this could provide them with interesting anonymously aggregated data about expat behaviour, needs and preferences when relocating to the city, hence, allowing them to develop policy that is better suited for this particular population.

Finally, businesses stated that the data would also be beneficial to them in allowing them to better streamline their business offer to these newcomers to the city.

Urban Planning	
Measure	**Feedback**
Ease of use	Citizens/City/SME: positive but downloading time too long
Perceived usefulness	Citizens: useful for discovery of POI and urban planning project; not so much for SME features City: useful for communication Urban Planning projects and information towards citizens SME: useful for presentation of company, not interaction among SMEs
Look and feel	Citizens: positive but layers need more clarity SME/City: more features needed to increase the attractiveness of the map
Content quality	Citizen/city: Potential, but not all POI have complete content SME: ok for showcase, but feature for interaction not good
Attitude	Citizens: yes City: yes SME: moderate
Intention to use	Citizens: yes for discovery city and urban projects City: yes for presentation and information of urban projects SME: Yes, but for communication and presentation, not interaction

Figure 11: User experience and acceptance Urban Planning

The Urban Planning results also returned a general positive score on all the measures, although there are some variations between the different user types involved. All user types acknowledged the ease of use, although they all pleaded that downloading time of the 3D map should go faster in the future. A second lesson is that the use value of the 3D map also depends on the level of completion of the point of interests' media centres by the partners. We come back to this point in the next section. The user responses also show that the use value of the 3D map is moreover connected with presenting the different layers in the city and in providing and disseminating information about urban projects. Citizens ranked these functions more highly, while city administrators valuated the tool as very efficient and essential to informing citizens about future urban planning projects. SMEs acknowledged that for networking other existing tools are more useful and accurate. This also could explain the difference in attitude towards Urban Planning between citizens, city administrations and SMEs.

Consequently, stakeholders judged the Urban Planning to benefit smart mobility (discovering a city) and smart governance (informing citizens) as smart city objective. Regarding smart economy, the showcase function for SMEs was acknowledged, but linking SMEs as a crucial component of a smart economy would need other communication means or tools.

Smart Environment	
Measure	**Feedback**
Ease of use	Some usability issues in installation
Perceived usefulness	Ability to see and monitor is useful
Look and feel	Overall positive, but should be more user friendly
Content quality	Comparison functionality positive
Attitude	Information is useful and motivator for change
Intention to use	Catalyst for behaviour change; City potential on public buildings transparency

Figure 12: User experience and acceptance Smart Environment

The Smart Environment pilot was evaluated as easy to use, although the issues here related more to the installation of the kit and not as such to the dashboard. The look and feel of the latter could be improved. Nonetheless, the attraction and usefulness of the pilot was acknowledged. The ability to see and monitor energy consumption as well as to compare either public buildings or other domestic usage was useful and seen as a motivator for behaviour change. Public users also expressed the benefit of transparency towards citizens.

In their evaluation, the stakeholders confirmed the smart city value of the pilot. The designed solution has the capacity to let domestic users and public buildings contribute to carbon reduction targets by making them aware of their current consumption. In terms of smart governance, the application could generate information about benchmarking for future city environmental strategies and contribute to transparency of public buildings to the public. However, from this perspective, the service requires support but also adoption/integration in a broader policy framework about the environment and behavioural change. Finally, the Smart Environment application connects to a smart economy by stimulating the development of more 'green' applications by local companies.

The results of the user experience and acceptance of the three pilots show that the Living Lab approach clearly can be seen to contribute to the creation of smart city services. Users not only estimate the pilots not only as essential innovative smart technical solutions that their city should offer, but also expressed their willingness to use them. .

5.3. Guaranteeing sustainability of pilot

In addition to yielding insights into design changes and assessing the smart city value of the pilot, the third benefit for EPIC in adopting a Living Lab approach lies in the fact that crucial issues for keeping the use value sustainable beyond EPIC were rapidly identified.

In the case of Relocation, the main concern was the reliability, actuality, sensitivity and maintenance of the data provided. In Relocation for example, testers of the mobile application indicated some Point of interest like sport clubs that did no longer exist. On the other hand, community information needs to be handled with care. In our case, we decided not to include some of this information like air and noise pollution since they were measured some years ago. Secondly, there is also the sensitivity issue of some data: while some testers asked to incorporate crime statistics and statistics about demographic composition of neighbourhoods, we deliberately chose not to do so in order to avoid stigmatisation of certain areas. Thirdly, the Living Lab approach made it clear that open data often needs remodelling: they are collected and organised within the

logic of the institutions that gathered them and often need adaptation to the specific end user. Working out such strategies about maintenance and sensitivity are thus crucial for the sustainability of the service.

Urban Planning showed that the value of the solution, besides improvements on design and navigation done by the SME, also depend on the willingness of the different institutions and SMEs in the town to complete their media centres and thus enrich the Point of interest. Not all SMEs and other contacted institutions had done this during the test period, thus leaving the end user with a blank information box. Parties concerned with the service will have to work out clear engagement and monitoring strategies towards these players in order to assure and increase the attractiveness and use value of the service.

Finally, in the case of Smart Environment, the fact that a monitoring kit has to be installed led to the identification of the need for decent monitoring and follow–up of their (mal)functioning is crucial. Not all users are technically skilled to install these kits without problems at home or control whether they are working. Ensuring the development of rather 'plug and play' kit and establishing on-going user support will be crucial. Community champions (local key individuals who have training and knowledge) might be a solution here. Another important aspect here is to make sure that installing a kit does not require reconfiguration of already installed technical equipment. Finally, going to a broader user population will put observation of data protection and security more paramount.

6. Living Lab management: 5 lessons

Having demonstrated the benefits of adopting a Living Lab approach for the development and design of smart city services, the EPIC project also provided an opportunity to learn important issues so as to generate user feedback and manage a Living Lab in the most beneficial way. We therefore present the 5 major lessons we learned. More elaborate explanations can be found in *D7.2 'Report of 3 pilots'* that outlines the daily management of the pilot sites in great detail.

1. User test numbers: go for quality instead of quantity.

In projects such as EPIC, a pre-defined user number is normally defined as a target to reach. In the case of EPIC, the three pilots did not reach that set number. Nonetheless a relative solid number of users was recruited, providing valid insights and test results. Although some delay in technical delivery, leading to a postponement of a test cycle and hence user drop out, is a part of the explanation for this situation, yet we had the impression that the pre-defined user numbers were not per se realistic. The analysis of the feedback indicated that after a certain number of users, feedback became quite similar. Although one common critic on Living Lab approach is indeed to what extend results of small scale tests can be more generalized, we do think, based from our EPIC experience, that simply raising the number of testers to a level that seems more plausible for large scale research, is not the way forward in smart city service development, especially when the research starts from the initial proto-type phase.

2. Manage the expectations of your testers

In contrast to more traditional test settings where an almost finished prototype is presented to testers, involving potential future end users at an early stage of prototype creation, demands that users are well aware of the objectives of your experimental tests and what they are going to be confronted with. Users are not used to work with prototypes and might have too big expectations about what they are going to get. This is certainly the case in set ups like Relocation or Urban Planning where there is no tangible object like a monitoring kit such as the case for the Smart Energy Pilot. We learned in EPIC that managing end user expectations is in a iterative development track a crucial factor in avoiding drop-out but also in generating valid end user feedback that is not influenced by feelings such as disappointment.

3. Manage the end user influence during and after the test cycle

While users had an influence in the shaping of our pilots, they certainly did not all share the same view. Moreover, not all users are the same and have the same requirements and needs. In the case of Relocation, we identified expats moving alone or with their spouse/partner and/or children. In the case of Urban Planning (citizens, city authorities, SMEs) and Smart Energy (domestic users – public building users) different user types were present. What is thus worthwhile for one category might not be useful or not important for the other. Management of end user influence in your project is therefore important. Therefore, it is first important to investigate "which type of end user gave what kind of feedback" and define in advance within which parameters you will take their suggestions into account within the project. We defined that a feature should certainly be revised if more than 30% of the testers within the different profiles gave negative feedback. Secondly, within a project, you cannot implement all the user feedback. We, therefore, opted to focus on redesigning these functionalities that were part of our iteration plan. However, as we saw in our explanation of the design lessons, users provided much more useful feedback. Therefore, a third lesson we learned is that managing end user influence requires also a transparent communication (via a newsletter, updating the projects website) with the testers, explaining why some suggestions were retained and others not and what your plans are with the latter. Also, some motivated testers are likely to contact you anyway about progress. In EPIC we kind of underestimated the importance of post-test phase communication to testers and stakeholders and which results in a lack of awareness of the pilot results more broadly than the "close EPIC community" in the pilot cities.

4. Think about ways to sustain your Living Lab community in the long run.

Building upon the previous lesson, neglecting post-test phase communication confronts us today with a problem about future continuation of our work beyond the time frame of the EPIC project itself. Although we learned a lot about future development tracks for each of the pilots and identified issues of sustainability that needs to be dealt with, the problem of not having developed a real strategy for keeping the user community we build during EPIC alive, means that in the future awareness creation in the local community should be done over again in order to get end user feedback. Also, if one of the pilots will ever go to the market, we missed here an opportunity to have already a group of end users at our disposal who could be used to 'evangelize' other citizens, SMEs or local authorities to buy, adopt and use our solution and improve it with providing their feedback.

5. Clear and open communication between all partners involved is a key factor for success

A key principle in Living Lab management is a good and clear flow of communication between all partners involved. Therefore, it is important to organise and implement it well from the start of one's operations. By setting up regular meetings with the user test team and the technical team in your Living Lab you will make sure that the project stays on track, user test team and technical team keep working in harmony and potential problems can be detected and solved in time. Moreover, establishing a good communication generates the effect that people get to know and trust each other, leading to a better understanding of each other's work and challenges that may come along with it.

7. Conclusion

This paper analysed the use of the Living Lab approach within the context of the EPIC project in the creation of three smart city services that engaged with several domains of the smart city principles; that is, smart mobility, smart economy, smart governance, and smart environment. We identified the potential of deploying a Living Lab approach in supporting the innovation process of the EPIC services. This, by direct engagement of users testing the services within their everyday life context and, secondly, by understanding the challenges of harmonisation and of interoperability between Living Labs today across Europe.

The execution of the Living Lab operations detailed in this paper for each of the pilot cities showed how the three Living Labs - while respecting each other specificities - worked together towards these goals by sharing a common iterative deployment strategy and user test methodology as well as in sharing experiences via close and intense communication between the different test teams and the other project partners.

The test results highlighted the benefits of a Living Lab approach in the ideation, creation and development of smart city services. Within the confinements of the EPIC project, this approach allowed us to identify from the early stages of prototype development to the final test phase, the technical and design issues that needed improvement or removed. It also helped detecting for each pilot, a series of new features that end users, or at least some, would like to see implemented in the future in order to increase the use and market value of the services.

Our discussion of user experience and acceptance showed that engaging end users from the early development phases indeed could lead to the development of smart city services that various user and stakeholder groups evaluated as being 'easy to use' services, essential for the respective cities to incorporate supported by a 'willing to use' in the near future. Moreover, the Living Lab approach allowed the pilot teams to identify already crucial aspects concerning the sustainability of the use value of each services. Lastly, in applying the Living Lab approach to smart city service design, our experience gave us the opportunity to highlight five important Living Lab management lessons that are important to facilitate success and, thus, seem to enable the delivery of user validated smart city services.

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