### D2.2 Evaluation Methodology for Pilots Validation

<table>
<thead>
<tr>
<th><strong>Project Acronym:</strong></th>
<th>bloTope</th>
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<tr>
<td><strong>Project title:</strong></td>
<td>Building an IoT Open Innovation Ecosystem for Connected Smart Objects</td>
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<tr>
<td><strong>Grant Agreement No.</strong></td>
<td>688203</td>
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<td><strong>Website:</strong></td>
<td><a href="http://www.bloTope-project.org">www.bloTope-project.org</a></td>
</tr>
<tr>
<td><strong>Version:</strong></td>
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<td><strong>Date:</strong></td>
<td>20. January 2017</td>
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<tr>
<td><strong>Responsible Partner:</strong></td>
<td>BIBA</td>
</tr>
<tr>
<td><strong>Contributing Partners:</strong></td>
<td>BMW, CIRB, Controlthings, CSIRO, Enervent, FVH, Greater Lyon, IRISNET</td>
</tr>
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# Revision History

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<td>Dirk Werthmann</td>
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<td>Version for 3rd review Reviewer: Emmanuel Gastaud Eric Aerden Min-Jung Yoo</td>
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<td>Jean Lancrenon Scott Hansen</td>
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Every effort has been made to ensure that all statements and information contained herein are accurate, however the bioTope Project Partners accept no liability for any error or omission in the same.
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Executive Summary

In order to evaluate the results of large-scale international projects such as bloTope a well-defined methodology is needed to track and review the implementations of the project’s pilots. Therefore, the bloTope consortium has prepared the deliverable D2.2 “Evaluation Methodology for Pilots Validation” to describe the approach that will be utilised to evaluate all pilot case implementations of the bloTope technologies in order to ensure high quality results are produced by the project. The evaluation will be used by the project management to monitor the progress of bloTope. This ensures that all work packages are on time and have achievable objectives. If necessary, actions will be taken by the project management members in order to achieve the planned objectives. Furthermore, the evaluations will be used to review the technical approaches of bloTope and refine bloTope’s Research and Technological Development (RTD) specifications if necessary.

The assessment of each bloTope pilot case is based on two different evaluation methodologies. The first evaluation methodology is the calculation of the Technology Readiness Level (TRL) and the Integration Readiness Level (IRL). Those key performance indicators (KPI) help to understand the maturity of the developed solutions.

The second evaluation methodology assesses whether the developed Business Services address user requirements through acceptance testing. Therefore, end users are involved in carrying out evaluations within test scenarios as to whether the planned improvements have been achieved by the solution developed within bloTope’s pilot cases. As a basis for the user acceptance tests, user stories, test scenarios and planned improvements for each of the pilots are provided in this deliverable.
## Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Business Service (BS)</td>
<td>A digital service helping end users to perform a task in a better way.</td>
</tr>
<tr>
<td>Development Test &amp; Evaluation (DT&amp;E)</td>
<td>A testing procedure, which is conducted during the engineering and development process to ensure that the specifications have been met.</td>
</tr>
<tr>
<td>Integration Readiness Level (IRL)</td>
<td>A metric of the integration maturity between two or more components.</td>
</tr>
<tr>
<td>Operational Test &amp; Evaluation (OT&amp;E)</td>
<td>A field test, which is conducted under realistic conditions.</td>
</tr>
<tr>
<td>Technology Maturation Plan (TMP)</td>
<td>A plan, which is aiming at bringing immature critical technology up to a desired TRL.</td>
</tr>
<tr>
<td>Technology Readiness Assessment (TRA)</td>
<td>A systematic that evaluates the maturity of technologies.</td>
</tr>
<tr>
<td>Technology Readiness Level (TRL)</td>
<td>A measurement scale used to rate technologies according to their maturity.</td>
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1. Introduction

In order to manage complex international projects such as bloTope a well-defined evaluation methodology is needed to track and review the implementations of the project’s pilots. In the end, the evaluation methodology guarantees that the overarching needs of the target users and the expected impacts of the project are met. This deliverable - “Evaluation Methodology for Pilots Validation” - provides a foundation to ensure the quality of the outcomes.

The present deliverable, D2.2 “Evaluation Methodology for Pilots Validation”, builds on D1.2 “Quality plan”, where the objectives and initial set of Key Performance Indicators (KPIs) are specified. Moreover, D2.2 validation considers D2.1 “Ecosystem Stakeholder Requirements Report and Pilots Definition”, where the pilot cases are described. Deliverables D1.2 and D2.1 are used to develop an ex-ante evaluation methodology focussing on actors, processes and interfaces, within bloTope’s pilots. This is achieved by describing the state of the art of each pilot including the planned improvements to be provided by the application services developed within bloTope. Within the ex-post evaluation of implemented pilots, the focus is on economic, societal, technical and environmental impacts. This deliverable identifies the expected impacts and detailed KPIs for measuring the impacts.

The evaluation methodology developed in this document supports the implementation of the pilot cases continuously by defining relevant improvements, which should be achieved by the pilot cases. In month 18 of the project, when Milestone 4 “First domain-specific proof-of-concepts operational” is reached, the first pilot case validation will be executed by using the evaluation methodology described within this deliverable. The second time the evaluation methodology is going to be used, is in preparation for completion of Milestone 8 “bloTope Ecosystem Operability Demonstrated in Smart City Environments” which is reached at month 36 of the project.

The developed evaluation methodology will allow bloTope to refine Research and Technological Development (RTD) specifications throughout the entire project.
2. Evaluation Methodologies

In the following chapters, the evaluation methodologies used to evaluate the pilots are described. Section 2.1 describes a concept to evaluate the project from a system perspective, whereas section 2.2 describes a concept to evaluate the project from a user perspective.

2.1. System assessment

As described in D1.2 “Quality Plan” the Technology Readiness Level (TRL) and the Integration Readiness Level (IRL) are used to assess the maturity of the solutions developed within bioTope.

The paragraphs below describe how the TRL and IRL are determined.

2.1.1. Technology Readiness Level (TRL)

TRL methodology in general

The concept of TRL was initially developed by the National Aeronautics and Space Administration (NASA) for space systems. It is an evaluation of the maturity of critical technological elements of a product. The TRL concept identifies the stages that a technology needs to pass through between research/development and production/operations. Table 1 describes the different TRL’s the U.S. Department of Defence uses to categorise and assess the status of a single application.
Table 1: Technology Readiness Levels definition [U.S. Government Accountability Office]

<table>
<thead>
<tr>
<th>Technology readiness level</th>
<th>Description</th>
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<tr>
<td>1 Basic principles observed and reported</td>
<td>Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&amp;D). Examples might include paper studies of a technology's basic properties.</td>
</tr>
<tr>
<td>2 Technology concept and/or application formulated</td>
<td>Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.</td>
</tr>
<tr>
<td>3 Analytical and experimental critical function and/or characteristic proof of concept</td>
<td>Active R&amp;D is initiated. This includes analytical studies and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.</td>
</tr>
<tr>
<td>4 Component and/or breadboard validation in laboratory environment</td>
<td>Basic technological components are integrated to establish that they will work together. This is relatively “low fidelity” compared with the eventual system. Examples include integration of “ad hoc” hardware in the laboratory.</td>
</tr>
<tr>
<td>5 Component and/or breadboard validation in relevant environment</td>
<td>Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include “high-fidelity” laboratory integration of components.</td>
</tr>
<tr>
<td>6 System/subsystem model or prototype demonstration in a relevant environment</td>
<td>Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology’s demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.</td>
</tr>
<tr>
<td>7 System prototype demonstration in an operational environment.</td>
<td>Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment.</td>
</tr>
<tr>
<td>8 Actual system completed and qualified through test and demonstration.</td>
<td>Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation (DT&amp;E) of the system in its intended operational environment to determine if it meets design specifications.</td>
</tr>
<tr>
<td>9 Actual system proven through successful operations in an operational environment.</td>
<td>Actual application of the technology in its final form and under operational conditions, such as those encountered in operational test and evaluation (OT&amp;E). Examples include using the system under operational conditions.</td>
</tr>
</tbody>
</table>

The Technology Readiness Levels were invented 1988 by NASA after the first Apollo programme failures [Sadin et al., 1989]. It initially included seven levels that were later increased to nine. TRL is a way to represent the limits of a technology, reliability and the associated risks. In 2002 NASA started to refine the methodology. It has been introduced in other government agencies, as well as industries in maritime, oil and gas, aerospace, electronics, and heavy equipment. An ISO standard for the international definition of the TRL’s has been developed with the cooperation of international space agencies and industries as well as the U.S. Department of Defence (DoD) [ISO 16290:2013].

The European Commission describes the TRL’s within its Horizon 2020 work programme. The actual definition is described in the annex of the work program. It ranges from TRL 1 to TRL 9. The TRL methodology is used for
calls for proposals regarding "Leading Role of Industry" and "Societal Challenges", mainly. The use of the TRL methodology is aiming at the promotion of products, services and processes that have already reached a certain TRL at the beginning of the project, or will reach it at the end of a project. Within Figure 1 the definitions of TRL's used by the European Commission are listed.

**HORIZON 2020 – WORK PROGRAMME 2014-2015**

**General Annexes**

G. Technology readiness levels (TRL)

Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

- **TRL 1** – basic principles observed
- **TRL 2** – technology concept formulated
- **TRL 3** – experimental proof of concept
- **TRL 4** – technology validated in lab
- **TRL 5** – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- **TRL 6** – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- **TRL 7** – system prototype demonstration in operational environment
- **TRL 8** – system complete and qualified
- **TRL 9** – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Figure 1: TRL definition European Commission, Horizon 2020 [European Commission]

The TRL definition of the European Commission is not been clarified in detail – in particular, with respect to assessment. For this reason, within bloTope the TRL definitions established by the U.S. Government Accountability Office, described in Table 1, are going to be used.

**TRL assessment process**

This part describes the process for establishing credible TRL's by going through a Technology Readiness Assessment (TRA). These steps follow a disciplined and repeatable process to meet the needs of all stakeholders, which rely on the information to make decisions. All of the people involved in the TRL assessment, from programme managers to research and technology developers, must have a good understanding of the process and how to use the information it generates.

The following six steps defined by the Government Accountability Office’s (GAO) TRA Guide lead to credible TRLs [U.S. Government Accountability Office]. Based on those TRLs relevant decisions can be made.

- Step 1 Design the overall technology maturity assessment strategy for the programme or project.
- Step 2 Define the individual TRA’s purpose; develop a TRA plan and assemble the assessment team.
• Step 3 Select critical technologies.
• Step 4 Evaluate critical technologies.
• Step 5 Prepare, coordinate and submit TRA report.
• Step 6 Using TRA results and developing a Technology Maturation Plan (TMP).

The first step identifies all the technology needs for the overall programme strategy. This includes reaching an understanding of the technology needs of a programme and the assessment strategy reflecting those needs. The schedule and events are discussed and documented in the strategy documents and the technology maturity assessment strategy is oriented to the systems engineering plan or similar plans.

The second step is to establish a TRA plan, schedule and team. The TRA plan includes a method for an assessment of critical technologies. Afterwards, a dedicated team should be formed with members who are experts and independent of the programme.

The third step selects the critical technologies, through the process described in Figure 2. Intermediate steps are included to conduct the criteria as well as to identify and select critical technologies for evaluation and to define responsible parties to facilitate the selection of technologies. Therefore, it is necessary to identify the programme’s purpose, system and performance characteristics, as well as a work breakdown structure, process flow sheet to characterize the system, subsystems and elements to choose a critical technology.

![Figure 2: Steps for Selecting Critical Technologies [U.S. Government Accountability Office]](image)

The fourth step evaluates critical technologies. This requires disciplined and repeatable steps and criteria described in Figure 3 to perform the assessment and make credible judgements about their maturity. Each critical technology evaluation must be based on evidence such as data, analyses, test demonstrations, pilots, simulations and other evidences used to evaluate the readiness of critical technologies. A crucial part of this step is that the programme manager, developer, and the team agree on a particular TRL, target, or the goal of the results.
The fifth step includes the preparation, coordination and submission of the TRA Report. An official TRA Report contains the documented actions taken in steps one to four described on page 13. Figure 4 illustrates the five intermediate steps to prepare the TRA Report in detail.

The last step is about using the results of the TRA assessment and developing a Technology Maturation Plan (TMP). This part describes how the technology developers, project managers, and the team use the TRL results to make decisions and how concerns and potential risks are identified and used. It includes steps and actions for the development of a plan to mature critical technologies that have been evaluated as immature. In addition, it aims to establish a road map for maturing technologies to a higher technology readiness level.

### TRL Questionnaire

In the following tables, from Table 2 to Table 11, a framework is provided for calculating TRLs within bloTope. The framework is based on the AFRL Hardware and Software Transition Readiness Level Calculator, Version 2.2 developed by the Air Force Research Laboratory (AFRL) [Air Force Research Laboratory]. This tool is aligned with the TRL elements defined by the U.S. DoD.

To calculate a TRL for a relevant technology, the answers within Table 2 have to be answered, starting from the top of the table. The first question answered with YES leads to the potentially right TRL. In order to check
whether this first estimation is right, more detailed facts are going to be analysed. Those checks are provided in Table 3 to Table 11. All facts listed within each of the tables have to be answered with YES to achieve the corresponding TRL.

When the TRL assessment will take place within bloTope’s intermediate and final pilot evaluation, the Technology Readiness Level Questionnaire will be provided to the pilot cases to evaluate specific bloTope technology components. In order to make the evaluation as easy as possible for the assessment team provides the questionnaire as Excel spreadsheet.

Table 2: Top Level View of selection TRL’s [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TOP LEVEL VIEW -- Demonstration Environment (Start at top and pick the first correct answer)</th>
<th>Checkbox (y/n)</th>
<th>Continue with</th>
</tr>
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<tr>
<td>Has an identical technology component been successfully used in an operational scenario or in an identical configuration?</td>
<td></td>
<td>TRL 9</td>
</tr>
<tr>
<td>Has an identical technology component been demonstrated in an operational scenario, but in a different configuration/system architecture?</td>
<td></td>
<td>TRL 8</td>
</tr>
<tr>
<td>Has an identical technology component been qualified for an operational scenario but not operationally demonstrated?</td>
<td></td>
<td>TRL 8</td>
</tr>
<tr>
<td>Has a prototype technology component been demonstrated in an operational scenario?</td>
<td></td>
<td>TRL 7</td>
</tr>
<tr>
<td>Has a prototype been demonstrated in a relevant scenario, on the target or surrogate platform?</td>
<td></td>
<td>TRL 6</td>
</tr>
<tr>
<td>Has a breadboard technology component been demonstrated in a relevant (typical; not necessarily stressing) scenario?</td>
<td></td>
<td>TRL 5</td>
</tr>
<tr>
<td>Has a breadboard technology component been demonstrated in a laboratory (controlled) scenario?</td>
<td></td>
<td>TRL 4</td>
</tr>
<tr>
<td>Has analytical and experimental proof-of-concept been demonstrated?</td>
<td></td>
<td>TRL 3</td>
</tr>
<tr>
<td>Has a concept or application been formulated?</td>
<td></td>
<td>TRL 2</td>
</tr>
<tr>
<td>Have basic principles been observed and reported?</td>
<td></td>
<td>TRL 1</td>
</tr>
<tr>
<td>None of the above</td>
<td></td>
<td>TRL 0</td>
</tr>
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</table>

Table 3: Technology Readiness Level 1 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 1 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Back of envelope&quot; environment</td>
<td></td>
</tr>
<tr>
<td>Physical laws and assumptions used in new technologies defined</td>
<td></td>
</tr>
<tr>
<td>Have some concept in mind that may be realizable in software</td>
<td></td>
</tr>
<tr>
<td>Know what software needs to do in general terms</td>
<td></td>
</tr>
<tr>
<td>Paper studies confirm basic principles</td>
<td></td>
</tr>
<tr>
<td>Mathematical formulations of concepts that might be realizable in software</td>
<td></td>
</tr>
<tr>
<td>Have an idea that captures the basic principles of a possible algorithm</td>
<td></td>
</tr>
<tr>
<td>Basic scientific principles observed</td>
<td></td>
</tr>
<tr>
<td>Research hypothesis formulated</td>
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### Table 4: Technology Readiness Level 2 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 2 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
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<tbody>
<tr>
<td>Customer identified</td>
<td></td>
</tr>
<tr>
<td>Potential system or component application(s) have been identified</td>
<td></td>
</tr>
<tr>
<td>Paper studies show that application is feasible</td>
<td></td>
</tr>
<tr>
<td>Know what scenario the technology will support</td>
<td></td>
</tr>
<tr>
<td>An apparent theoretical or empirical design solution identified</td>
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</tr>
<tr>
<td>Desktop environment</td>
<td></td>
</tr>
<tr>
<td>Customer expresses interest in application</td>
<td></td>
</tr>
<tr>
<td>Some coding to confirm basic principles</td>
<td></td>
</tr>
<tr>
<td>Initial analysis shows what major functions need to be done</td>
<td></td>
</tr>
<tr>
<td>System architecture defined in terms of major functions to be performed</td>
<td></td>
</tr>
<tr>
<td>Experiments performed with synthetic data</td>
<td></td>
</tr>
<tr>
<td>Requirement tracking system defined to manage requirements creep</td>
<td></td>
</tr>
<tr>
<td>Rigorous analytical studies confirm basic principles</td>
<td></td>
</tr>
<tr>
<td>Analytical studies reported in scientific journals/conference proceedings/technical reports</td>
<td></td>
</tr>
<tr>
<td>Individual parts of the technology work (No real attempt at integration)</td>
<td></td>
</tr>
<tr>
<td>Know what hardware software will be hosted on</td>
<td></td>
</tr>
<tr>
<td>Know what output devices are available</td>
<td></td>
</tr>
<tr>
<td>Investment Strategy Sheet</td>
<td></td>
</tr>
<tr>
<td>Know capabilities and limitations of researchers and research facilities</td>
<td></td>
</tr>
<tr>
<td>Know what experiments you need to do (research approach)</td>
<td></td>
</tr>
<tr>
<td>Qualitative idea of risk areas (cost, schedule, performance)</td>
<td></td>
</tr>
<tr>
<td>Have rough idea of how to market technology (Who’s interested, how will they find out about it?)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5: Technology Readiness Level 3 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 3 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic environment</td>
<td></td>
</tr>
<tr>
<td>Analytical studies verify predictions, produce algorithms</td>
<td></td>
</tr>
<tr>
<td>Outline of software algorithms available</td>
<td></td>
</tr>
<tr>
<td>Preliminary coding verifies that software can satisfy an operational need</td>
<td></td>
</tr>
<tr>
<td>Laboratory experiments verify feasibility of application</td>
<td></td>
</tr>
<tr>
<td>Cross technology effects (if any) have begun to be identified</td>
<td></td>
</tr>
<tr>
<td>Paper studies indicate that system components ought to work together</td>
<td></td>
</tr>
<tr>
<td>Metrics established</td>
<td></td>
</tr>
<tr>
<td>Experiments carried out with small representative data sets</td>
<td></td>
</tr>
<tr>
<td>Algorithms run on surrogate processor in a laboratory environment</td>
<td></td>
</tr>
<tr>
<td>Know what software is presently available that does similar task (100% = Inventory completed)</td>
<td></td>
</tr>
<tr>
<td>Existing software examined for possible reuse</td>
<td></td>
</tr>
<tr>
<td>Know limitations of presently available software (Analysis of current software completed)</td>
<td></td>
</tr>
<tr>
<td>Scientific feasibility fully demonstrated</td>
<td></td>
</tr>
<tr>
<td>Analysis of present state of the art shows that technology fills a need</td>
<td></td>
</tr>
</tbody>
</table>
### Table 6: Technology Readiness Level 4 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 4 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross technology issues (if any) have been fully identified</td>
<td></td>
</tr>
<tr>
<td>Formal system architecture development begins</td>
<td></td>
</tr>
<tr>
<td>Overall system requirements for end user's application are known</td>
<td></td>
</tr>
<tr>
<td>Analysis provides detailed knowledge of specific functions software needs to perform</td>
<td></td>
</tr>
<tr>
<td>Requirements for each function established</td>
<td></td>
</tr>
<tr>
<td>Algorithms converted to pseudocode</td>
<td></td>
</tr>
<tr>
<td>Analysis of data requirements and formats completed</td>
<td></td>
</tr>
<tr>
<td>Stand-alone modules follow preliminary system architecture plan</td>
<td></td>
</tr>
<tr>
<td>Technology demonstrates basic functionality in simplified environment</td>
<td></td>
</tr>
<tr>
<td>Controlled laboratory environment</td>
<td></td>
</tr>
<tr>
<td>Experiments with full scale problems and representative data sets</td>
<td></td>
</tr>
<tr>
<td>Individual functions or modules demonstrated in a laboratory environment</td>
<td></td>
</tr>
<tr>
<td>Some ad hoc integration of functions or modules demonstrates that they will work together</td>
<td></td>
</tr>
<tr>
<td>Low fidelity technology “system” integration and engineering completed in a lab environment</td>
<td></td>
</tr>
<tr>
<td>Stand-alone modules follow preliminary system architecture plan</td>
<td></td>
</tr>
</tbody>
</table>

### Table 7: Technology Readiness Level 5 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 5 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross technology effects (if any) identified and established through analysis</td>
<td></td>
</tr>
<tr>
<td>System interface requirements known</td>
<td></td>
</tr>
<tr>
<td>System software architecture established</td>
<td></td>
</tr>
<tr>
<td>External interfaces described as to source, format, structure, content, and method of support</td>
<td></td>
</tr>
<tr>
<td>Analysis of internal interface requirements completed</td>
<td></td>
</tr>
<tr>
<td>Interfaces between components/subsystems are realistic (Breadboard with realistic interfaces)</td>
<td></td>
</tr>
<tr>
<td>Coding of individual functions/modules completed</td>
<td></td>
</tr>
<tr>
<td>High fidelity lab integration of system completed, ready for test in realistic/simulated environments</td>
<td></td>
</tr>
<tr>
<td>Laboratory environment modified to approximate operational environment</td>
<td></td>
</tr>
<tr>
<td>Functions integrated into modules</td>
<td></td>
</tr>
<tr>
<td>Individual functions tested to verify that they work</td>
<td></td>
</tr>
<tr>
<td>Individual modules and functions tested for bugs</td>
<td></td>
</tr>
<tr>
<td>Integration of modules/functions demonstrated in a laboratory environment</td>
<td></td>
</tr>
<tr>
<td>Algorithms run on processor with characteristics representative of target environment</td>
<td></td>
</tr>
<tr>
<td>Requirements matrix with thresholds and objectives developed</td>
<td></td>
</tr>
<tr>
<td>Physical work breakdown structure available</td>
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</tbody>
</table>
### Table 8: Technology Readiness Level 6 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 6 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross technology issue measurement and performance characteristic validations completed</td>
<td></td>
</tr>
<tr>
<td>Operating environment for eventual system known</td>
<td></td>
</tr>
<tr>
<td>System performance simulated in an operational environment</td>
<td></td>
</tr>
<tr>
<td>Representative model / prototype tested in high-fidelity lab / simulated operational environment</td>
<td></td>
</tr>
<tr>
<td>Realistic environment outside the lab, but not the eventual operating environment</td>
<td></td>
</tr>
<tr>
<td>Inventory of external interfaces completed</td>
<td></td>
</tr>
<tr>
<td>Analysis of timing constraints completed</td>
<td></td>
</tr>
<tr>
<td>Analysis of database structures and interfaces completed</td>
<td></td>
</tr>
<tr>
<td>Prototype implementation includes functionality to handle large scale realistic problems</td>
<td></td>
</tr>
<tr>
<td>Algorithms partially integrated with existing hardware / software systems</td>
<td></td>
</tr>
<tr>
<td>Individual modules tested to verify that the module components (functions) work together</td>
<td></td>
</tr>
<tr>
<td>Representative software system or prototype demonstrated in a laboratory environment</td>
<td></td>
</tr>
<tr>
<td>Laboratory system is high-fidelity functional prototype of operational system</td>
<td></td>
</tr>
<tr>
<td>Limited software documentation available</td>
<td></td>
</tr>
<tr>
<td>Engineering feasibility fully demonstrated</td>
<td></td>
</tr>
</tbody>
</table>

### Table 9: Technology Readiness Level 7 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 7 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each system/software interface tested individually under stressed and anomalous conditions</td>
<td></td>
</tr>
<tr>
<td>Algorithms run on processor(s) in operating environment</td>
<td></td>
</tr>
<tr>
<td>Operational environment, but not the eventual platform</td>
<td></td>
</tr>
<tr>
<td>Most functionality available for demonstration in simulated operational environment</td>
<td></td>
</tr>
<tr>
<td>Operational testing of laboratory system in representational environment</td>
<td></td>
</tr>
<tr>
<td>Fully integrated prototype demonstrated in actual or simulated operational environment</td>
<td></td>
</tr>
<tr>
<td>System prototype successfully tested in a operational environment</td>
<td></td>
</tr>
</tbody>
</table>

### Table 10: Technology Readiness Level 8 Questionnaire [Air Force Research Laboratory]

<table>
<thead>
<tr>
<th>TRL 8 (Check all that apply)</th>
<th>Checkbox (y/n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components are form, fit, and function compatible with operational system</td>
<td></td>
</tr>
<tr>
<td>System is form, fit, and function design for intended application</td>
<td></td>
</tr>
<tr>
<td>Form, fit, and function demonstrated in eventual platform</td>
<td></td>
</tr>
<tr>
<td>Interface control process has been completed</td>
<td></td>
</tr>
<tr>
<td>Final architecture diagrams have been submitted</td>
<td></td>
</tr>
<tr>
<td>Software thoroughly debugged</td>
<td></td>
</tr>
<tr>
<td>All functionality demonstrated in simulated operational environment</td>
<td></td>
</tr>
<tr>
<td>System qualified through test and evaluation on actual platform (DT&amp;E completed)</td>
<td></td>
</tr>
<tr>
<td>DT&amp;E completed, system meets specifications</td>
<td></td>
</tr>
</tbody>
</table>
2.1.2. **Integration Readiness Level (IRL)**

In addition to the assessment of the TRLs for each relevant technology within bloTope the Integration Readiness Level (IRL) is assessed for each technology as well. Similar to the TRL, the IRL defines the maturity level of the integration of a technology. Based on the assessment of IRLs, critical integration levels can be identified and if necessary, solutions can be developed to improve the IRL.

Integration readiness level is especially relevant within bloTope, because a lot of the systems and technologies will be integrated in bloTope’s system of systems, in which the systems are interconnected to a larger set of systems serving a common purpose. This results as a system of systems consisting of sub systems that are able to fulfill their goals even when detached from the rest of the system of systems, but reach the higher level of synergy and efficiency when attached.

Table 12 describes the different IRLs, which are used to assess the status of an integration of an application with other applications.

**Table 12: Integration Readiness Level (IRL) [Sauser]**

<table>
<thead>
<tr>
<th>Integration readiness level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Semantic</td>
<td>An interface between technologies has been identified with sufficient detail to allow characterization of the relationship.</td>
</tr>
<tr>
<td>2 Syntactic</td>
<td>There is some level of specificity to characterize the Interaction (i.e. ability to influence) between technologies through their interface.</td>
</tr>
<tr>
<td>3</td>
<td>There is compatibility (i.e. common language) between technologies to orderly and efficiently integrate and interact.</td>
</tr>
<tr>
<td>4</td>
<td>There is sufficient detail in the quality and assurance of the integration between technologies.</td>
</tr>
<tr>
<td>5</td>
<td>There is sufficient control between technologies necessary to establish, manage, and terminate the integration.</td>
</tr>
<tr>
<td>6</td>
<td>The integrating technologies can accept, translate, and structure information for its intended application.</td>
</tr>
<tr>
<td>7</td>
<td>The integration of technologies has been verified and validated and an acquisition/insertion decision can be made.</td>
</tr>
<tr>
<td>8 Pragmatic</td>
<td>Actual integration completed and qualified through test and demonstration, in the system environment.</td>
</tr>
<tr>
<td>9</td>
<td>Integration is proven through successful operations in the system environment.</td>
</tr>
</tbody>
</table>

For assessing the IRL Table 12 provides definitions and description for each IRL level. Based on these descriptions the IRL for every relevant technology within bloTope is going to be analysed. Therefore, the different IRLs are described in detail in Table 13.
<table>
<thead>
<tr>
<th>IRL</th>
<th>Definition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>An interface between technologies has been identified with sufficient detail to allow characterization of the relationship.</td>
<td>This is the lowest level of integration readiness and describes the selection of a medium for integration.</td>
</tr>
<tr>
<td>2</td>
<td>There is some level of specificity to characterize the interaction (i.e. ability to influence) between technologies through their interface.</td>
<td>Once a medium has been defined, a “signaling” method must be selected such that two integrating technologies are able to influence each other over that medium. Since IRL 2 represents the ability of two technologies to influence each other over a given medium, this represents integration proof-of-concept.</td>
</tr>
<tr>
<td>3</td>
<td>There is compatibility (i.e. common language) between technologies to orderly and efficiently integrate and interact.</td>
<td>IRL 3 represents the minimum required level to provide successful integration. This means that the two technologies are able to not only influence each other, but also communicate interpretable data. IRL 3 represents the first tangible step in the maturity process.</td>
</tr>
<tr>
<td>4</td>
<td>There is sufficient detail in the quality and assurance of the integration between technologies.</td>
<td>Many technology integration failures never progress past IRL 3, due to the assumption that if two technologies can exchange information successfully, then they are fully integrated. IRL 4 goes beyond simple data exchange and requires that the data sent is the data received and there exists a mechanism for checking it.</td>
</tr>
<tr>
<td>5</td>
<td>There is sufficient control between technologies necessary to establish, manage, and terminate the integration.</td>
<td>IRL 5 simply denotes the ability of one or more of the integrating technologies to control the integration itself; this includes establishing, maintaining, and terminating.</td>
</tr>
<tr>
<td>6</td>
<td>The integrating technologies can accept, translate, and structure information for its intended application.</td>
<td>IRL 6 is the highest technical level to be achieved, it includes the ability to not only control integration, but specify what information to exchange, unit labels to specify what the information is, and the ability to translate from a foreign data structure to a local one.</td>
</tr>
<tr>
<td>7</td>
<td>The integration of technologies has been verified and validated and an acquisition/insertion decision can be made.</td>
<td>IRL 7 represents a significant step beyond IRL 6; the integration has to work from a technical perspective, but also from a requirements perspective. IRL 7 represents the integration meeting requirements such as performance, throughput, and reliability.</td>
</tr>
<tr>
<td>8</td>
<td>Actual integration completed and qualified through test and demonstration, in the system environment.</td>
<td>IRL 8 represents not only the integration meeting requirements, but also a system-level demonstration in the relevant environment. This will reveal any unknown bugs/defect that could not be discovered until the interaction of the two integrating technologies was observed in the system environment.</td>
</tr>
<tr>
<td>9</td>
<td>Integration is proven through successful operations in the system environment.</td>
<td>IRL 9 represents the integrated technologies being used in the system environment successfully. In order for a technology to move to TRL 9 it must first be integrated into the system, and then proven in the relevant environment, so attempting to move to IRL 9 also implies maturing the component technology to TRL 9.</td>
</tr>
</tbody>
</table>
2.2. User Acceptance Testing

In order to ensure that the Business Service developed within bIoTope will be accepted by its intended user group, each Business Service will be evaluated from user perspective. These evaluations are going to be done two times during bIoTope with results reported at months M18 and M36. Second, a final evaluation will be done almost at the end of the project. For further information about the evaluation schedule please refer to section 3.1.

During the evaluation procedure, each Business Service is prototypically implemented and tested in the real world. Of course, before the overall evaluation of the services they will be integrated and tested by the developers working on the Business Services. Therefore, developers are working according to agile software development methods. Those agile methods are based on the principles of regular deployment and testing of the developed software. The software development and the evaluation approach of bIoTope is depicted in Figure 5.

Figure 5: Evaluation procedure integrated into the Business Service development process

End users will be involved in testing the functionalities of each Business Service against the requirements defined within bIoTope (see D2.1) during the two evaluation procedures.

In order to evaluate the integrated systems against the requirements described within D2.1 “Ecosystem Stakeholder Requirements Report and Pilot Definition” a user acceptance testing will be done. The user
acceptance testing is done according to Hambling and von Goethem [Hambling and von Goethem]. The process followed is summarized in Figure 6 and explained in the subsequent paragraphs.

2.2.1. Set Up/Plan

This phase involves the main planning tasks for user acceptance testing. This means that all the procedures are shaped, planned and prepared.

User acceptance testing within bloTope is based on D1.3 “Project Management Handbook”. Within D1.3 the whole evaluation procedure for bloTope’s pilots was prepared and published. A summary of the schedule of the evaluation procedure can be seen in Figure 8 of this deliverable.

Moreover, use cases have been already designed and described within D2.1 “Ecosystem Stakeholder Requirements Report and Pilot Definition”. Based on the designed use cases, user stories, named “Processes”, were described for each use case within chapter 5 of this document. Those “Processes” document how the procedures should look after the implementation of bloTope’s system-of-system concept. The “Processes” will be used to design the test procedures, necessary data interfaces as well as user interfaces.

To have an overall understanding of what is expected by each use case implementation, planned improvements from different perspectives were identified. The identified improvements for each use case are clustered into economical, societal, technical and environmental improvements and listed in chapter 5. The improvements contribute to the following achievements of bloTope’s pilots, defined in bloTope’s Part B of the Description of Actions:

- 30% increased length of battery operation of electric car on a daily basis – Smart Mobility pilot
- 20% increased electric car battery life time – Smart Mobility pilot
- 20% energy-reduction in smart building pilot – Smart Building
- 25% enhanced predicted failure rate regarding HVAC equipment – Smart Building pilot
- 50% enhanced early pollution detection – Smart Air Quality pilot
- 80% time reduction for creating new services based on available information sources coming from different application domains – Cross-Domain Smart City Pilots
- ≥50% acceptance of services by citizens (collecting user feedback with a specific UIaaS widget)

The evaluation procedures are analysed, whether the defined improvements can be realized by the implemented Business Services. In other words, the express it the other way round, the Business Services just need to work in a preconditioned environment and do not need to cover all exceptions. Moreover, the...
Business Services do not need to be fully ready for industrial launch at the end of the project. This will be done by the companies, which intend to offer those services on the market. Those companies will also hardening and preparing the prototype technologies for industrial use after the end of bloTope. During the evaluation process, the focus is on the functions of the Business Services, which address the requirements defined in chapter 5 of this document.

In order to execute a meaningful evaluation procedure, it is necessary to set up a test schedule and a test logging mechanism. In Table 14 the structure of the bloTope test schedule used within the evaluation procedures is presented. The order of the tests should be according to their importance, to make sure that the most important tests can be examined during the evaluation procedure.

The test log used within bloTope can be seen in Table 15. Focus of the test-log is to document the results of the evaluation procedure. In particular, defects are described within the document. Those defects are rated regarding their severity with numbers from 1 to 3. The lowest severity is indicated by 3 and 1 is the highest severity. In order to make sure that relevant defects are solved, the resolution status is also tracked within the test log.
**Table 14: bioTope test schedule structure [Hambling and von Goethem]**

<table>
<thead>
<tr>
<th>Sequence no.</th>
<th>Requirement</th>
<th>Service</th>
<th>Test case no.</th>
<th>Test case description</th>
<th>Input data</th>
<th>Expected output</th>
<th>Test script ID</th>
<th>Tester</th>
<th>Process</th>
<th>Date completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>
Table 15: bioTope test log structure [Hambling and von Goethem]

<table>
<thead>
<tr>
<th>Issue no.</th>
<th>Test script ID</th>
<th>Tester Step no.</th>
<th>Date raised</th>
<th>Service tested</th>
<th>Test case description</th>
<th>Incident description, briefly</th>
<th>Incident severity [1-3]</th>
<th>Repeated</th>
<th>In scope [Y/N]</th>
<th>Assigned to</th>
<th>Issue resolution status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>
2.2.2. Design Tests

Based on the identified requirements a formal test scenario was developed in order to involve end users of the developed Business Services. Within the evaluation procedure every requirement has to be tested at least once. If some requirements are very critical, more than one test case should be defined to make sure that the requirement is really covered even in different scenarios. This will be done mostly by testing functionalities of the Business Services. In order to make sure that the test cases are of relevance for using the system in a real world involve the end users in designing the test cases. Involving the end users into the test cases improves the interest and motivation of the test users.

When developing a test, the following three aspects have to be addressed:

1. **Test condition**
   An item or event of a Business Service developed within bloTope that could be evaluated by a test case. Those test conditions linked to the requirements of the Business Service are going to be listed in the bloTope test condition matrix, which is shown in Table 16.

2. **Test case**
   To test a condition, a test case needs to be defined, including the description of input values, pre-conditions, expected results and post-conditions. Those test cases are described within the bloTope test schedule, which was previously shown in Table 14.

3. **Test procedure specification**
   This is specified within the bloTope test script, which can be seen in Table 17 that specifies a sequence of actions executed during the test.

Table 16: bloTope test condition matrix [Hambling and von Goethem]

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Requirement</th>
<th>Reference</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>Condition 4</th>
<th>Condition 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
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<tr>
<td>2.</td>
<td></td>
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<td></td>
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<tr>
<td>3.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 17: bloTope test script structure [Hambling and von Goethem]

<table>
<thead>
<tr>
<th>Test case no.</th>
<th>Purpose</th>
<th>Pre-conditions</th>
<th>Test data</th>
<th>Process steps</th>
<th>Expected Results</th>
<th>Post-condition</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
When defining the test cases, the following methods should be considered to make sure that the system can deal with all possible input data.

4. **Equivalence partitioning**  
This method assumes all values of the same type will be handled by the software similarly. Therefore, just one value of each type needs to be taken into account in the test case. For example, one valid value and one invalid value.

5. **Boundary value analysis**  
This method is used in combination with the first method. It assumes that values being at the boundaries or edges of data are critical in particular and should be tested additionally. For example, if the valid characters do have a minimum and a maximum of characters the software is tested with the smallest and the largest number.

For an efficient and realistic user acceptance test the test cases should be linked to practical scenarios, as far as reasonable, to simulate real world processes. This means post-conditions of one test case are the pre-conditions of the following test case. By going through the scenario, different conditions will be tested in sequence in an efficient way.

Because especially within research projects time and resources are limited, the test should focus on the most important or most critical requirements. Those requirements can be characterized for example by being very critical for the whole system or a single Business Service or those requirements are very relevant to reach expected improvement(s), defined within bioTope.

In order to address the users’ needs, the test scripts should be a mixture of high level and detailed descriptions of the test cases. Detailed test cases make sure that all relevant aspects are evaluated. Nevertheless, if the test case description is high level, users can go along as they would during real use of the Business Service or the system. Therefore, the positive effects of a high level test case description are that the testing considers the behaviour of the Business Service like it would be in a practical scenario. In addition, a high level test case description becomes more interesting for the tester.

Although it is not explicitly considered within the test scripts, the test should also focus on the user interface and the performance of the system. Both aspects should be considered during the execution of the test cases. If any incidents regarding poor usability or response time of the system or Business Service occur, they should be noted within the test log.

Briefly described test scenarios for each use case are documented in chapter 5 of this deliverable. In order to ensure a smooth and meaningful evaluation procedure, the design of the test cases needs to be specified in more detail along with the development of the Business Services within the different use cases and pilots. Therefore, test conditions, test cases and test procedures will be detailed during the operation of the project by the partners involved in bioTope.

### 2.2.3. Implement Tests

In this step the designed test scenarios are implemented and the tests are executed involving the end users of the Business Services. This is done according to the prepared bioTope test schedule structure, shown in Table 14, as well as the bioTope test log structure, shown in Table 15. Before it is possible to implement the test schedule, the relevant test scripts and the testing environments need to be in place.

As already mentioned, the most important tests should be executed first. The evaluation procedures are limited regarding time and resources so it should be assured that the most important tests are executed during the testing period.
For having the end users involved, which are the most important testers when doing user acceptance test, the availability of the end users has to be assured. Therefore, potential end users have to be selected in time. In addition, the testers should agree on a date, when the test could be executed.

When executing the user acceptance tests, the results of the test should be recorded very carefully. This has to be done to draw conclusions from the test in order to improve the developed software components. The structure for logging the results can be seen in the bloTope test log structure in Table 15. If necessary and possible from a technical perspective additional information should be captured digitally, for example in log files of the considered systems.

If incidents occur during the test, they should be recorded roughly in the test log and in detail in an incident report. The structure of the bloTope incident report can be seen in Table 18. Those reports inform the software developers about the incidents in detail. Based on the provided information the developers can check whether the software needs to be changed. If changes are necessary, the resolution process should be tracked within the test log as well. After the resolution is completed the relevant test cases should be repeated to make sure that the incident does not occur anymore.

Table 18: bloTope incident report structure [Hambling and von Goethem]

<table>
<thead>
<tr>
<th>Incident report</th>
<th>Incident no.</th>
<th>Incident date/time</th>
<th>Tester</th>
<th>Test script ID</th>
<th>Incident severity</th>
<th>Repeatable[Y/N]</th>
<th>Incident description in detail</th>
</tr>
</thead>
</table>

For doing the testing as efficient as possible, the test cases should be streamlined as far as possible. So, if pre-conditions of one test are the post-conditions of another test, those tests should be executed consecutively.

2.2.4. **Assess test results and Report**

Based on the recorded test results an evaluation against the planned improvements will be done. Compared to user acceptance tests, which are focussing on systems going live after successful testing, the evaluation procedure within bloTope is looking on prototypes. Therefore, it is not the question about, whether the systems tested could go live. In fact, the test should examine whether the planned improvements can be realized by the Business Services developed within bloTope.

Nevertheless, bloTope’s system of system in combination with each Business Service should achieve the improvements listed in chapter 5. Those criteria have to be assessed in order to decide, whether the developed system and the developed Business Services meet the evaluation criteria. If not, it has to be decided in the following how to proceed.

For giving a quick overview on the outcomes of the test a completion report is going to be filled. This report is one of the main items, which are used for coming up with a decision based on the evaluation procedures.
### 2.2.5. Evaluate assessed test results and decide about next steps

As mentioned above, the Evaluation Reports will be used in deciding how to proceed. Therefore, the results generated during the evaluation procedure need to be reflected by the project management.

If some planned improvements are not met by the implemented Business Services, a decision must be made about whether the deviation from the planned improvements is acceptable or not. If not, the project partners have to decide what needs to be done to meet the planned improvements.

In addition, the documentation of the results of the intermediate evaluation can be helpful for upcoming work within bloTope. Therefore, Business Services, which are going to be developed during the second half of the project, can consider the evaluation results, if similar or previous problems occur.

In addition, identified incidents, which are not relevant for the success of the research project bloTope, can be beneficial for the companies offering solutions based on bloTope’s outcome. During the development of business solutions, which are going live after deployment, the documented results of the evaluation procedures can be used to improve the software as well.

### Table 19: bloTope completion report [Hambling and von Goethem]

<table>
<thead>
<tr>
<th>Table 19: bloTope completion report [Hambling and von Goethem]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion report</td>
</tr>
<tr>
<td>Introduction</td>
</tr>
<tr>
<td>Overview</td>
</tr>
<tr>
<td>Acceptance criteria</td>
</tr>
<tr>
<td>Constraints</td>
</tr>
<tr>
<td>Test results summary</td>
</tr>
<tr>
<td>Test incident summary</td>
</tr>
<tr>
<td>Acceptance criteria evaluation</td>
</tr>
<tr>
<td>Overall assessment</td>
</tr>
<tr>
<td>Recommendations</td>
</tr>
</tbody>
</table>

All results of the executed tests are going to be documented in the deliverables D2.6 “Evaluation Report 1 of the bloTope Pilots” and D2.9 “Evaluation Report 2 of the bloTope Pilots”.

### Table 19: bloTope completion report [Hambling and von Goethem]

<table>
<thead>
<tr>
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<td>Acceptance criteria</td>
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<tr>
<td>Test results summary</td>
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<tr>
<td>Acceptance criteria evaluation</td>
</tr>
<tr>
<td>Overall assessment</td>
</tr>
<tr>
<td>Recommendations</td>
</tr>
</tbody>
</table>
3. Evaluation Procedure

In the following chapters the different steps of the evaluation procedure within bloTope are described and scheduled.

3.1. Schedule of the Evaluation Procedure

The steps shown in Figure 7 will be executed to reach the Milestones of bloTope.

![Figure 7: Milestones of the evaluation procedure](image)

Figure 7: Milestones of the evaluation procedure

Figure 8 shows how the evaluation procedures are going to be executed along with the progress of bloTope. The starting point for all evaluation procedures was in July 2016, when work on this deliverable D2.2 “Evaluation Methodology for Pilots validation” began. As soon as a domain-specific pilot is implemented, it is going to be evaluated according to the evaluation methodologies described in this deliverable. An intermediate evaluation of all pilots will be published at the end of June 2017 within D2.6 “Evaluation Report 1 of the bloTope Pilots”. At the end of the project, all running domain-specific pilots as well as cross-domain specific pilots will be fully evaluated. The evaluation will be executed as soon as a pilot is running, according to the evaluation methodologies described in this deliverable, which may be updated based on experience gained from the intermediate evaluations earlier in the project.

<table>
<thead>
<tr>
<th>Continuous Evaluation of running domain-specific Pilots</th>
<th>Continuous Evaluation of running domain-specific Pilots &amp; cross-domain specific Pilots</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.08.2016</td>
<td>...</td>
</tr>
<tr>
<td>16.05.2017</td>
<td>16.11.2018</td>
</tr>
<tr>
<td>30.06.2017</td>
<td>31.12.2018</td>
</tr>
<tr>
<td>D2.2 Evaluation Methodology for Pilots Validation</td>
<td>D2.9 Evaluation Report 2 of the bloTope Pilots</td>
</tr>
<tr>
<td>published</td>
<td>published</td>
</tr>
<tr>
<td>work started</td>
<td>work started</td>
</tr>
<tr>
<td></td>
<td>published</td>
</tr>
</tbody>
</table>

Figure 8: Evaluation Procedure of bloTope
3.2. State of the Art Evaluation of the Pilots (M8)

Until month 8 of bloTope an ex-ante evaluation of each pilot will be executed.

As part of the state of the art evaluation, the major stakeholders influencing and influenced by each objective of each pilot will be identified. The objectives of each pilot were named by the “Stakeholder Viewpoints” of each pilot within D2.1 “Ecosystem Stakeholder Requirements Report and Pilot Definition”. The identified stakeholders will be clustered into the following groups.

- **Stakeholders in general**
  An accountant, group, organization, member, or system that affects or can be affected by the implemented Business Services.

- **End User**
  An accountant, group, organization, member, or system that uses the implemented Business Services.

Moreover, the current processes addressed by the Business Services, which will be developed within bloTope, will be described in written form for each pilot.

In addition, today’s user interfaces are described in a written form. The data sources providing the necessary information for today’s processes are going to be listed respectively the user interfaces.

From the perspective of month 8 of bloTope it will be described in written form how the processes should look like after the implementation of the Business Services. This is going to be done based on the “Layered Viewpoint” of each pilot included in D2.1 “Ecosystem Stakeholder Requirements Report and Pilot Definition”.

The interfaces used by the developed Business Services will be listed also based on the “Layered Viewpoint” of each pilot included in D2.1 “Ecosystem Stakeholder Requirements Report and Pilot Definition”.
Following the methodology described in chapter 2.2, the improvements achieved through the implementation of the developed Business Services will be listed. If possible the improvements should be quantified by metrics addressing the different KPIs, which could be reached during bioTope. The KPIs have to follow the SMART criteria listed below [Yemm].

- **S – Specific**
  The criterion should make the need for an explicit goal so that there is no room for misinterpretation. A specific goal will usually answer the six 'W' questions: Who, What, Where, When, Which and Why.

- **M – Measurable**
  The next criterion means that goals must be measurable on the basis of concrete, operational criteria. Usually, the entire goal statement is a measure for the project, but there are several short-term or smaller measurements built into the goal.

- **A – Achievable**
  This criterion should make sure that the goals are realistic and also attainable. That means it must be possible to achieve the goal. However they need to be stretching, ambitious and not too easy, because it will not be motivating.

- **R – Relevant**
  The fourth criterion Relevant means to choose goals that matter. Goals that are relevant for the employees, the team or the organization will receive needed support and drive the team forward.

- **T – Time-bound**
  The last criterion Time-bound is about setting the timeframe within which any identified objectives should be achieved. A commitment to a deadline helps a team focus their efforts towards completion of the goal.

The planned improvements will be grouped into the following criteria.

- Planned Economical Improvements (KPIs)
- Planned Societal Improvements (KPIs)
- Planned Technical Improvements (KPIs)
- Planned Environmental Improvements (KPIs)

In order to evaluate those improvements in month 18 and month 36, one or more test scenarios will be described for each improvement. Within the test scenarios end users should be involved.

By using the methodology described in chapter 2.1 the current TRLs will be assessed for each use case within bioTope. For the evaluations in month 18 and 36 of bioTope the planned TRLs will be listed for each platform.

### 3.3. Intermediate Evaluation of the Pilots (M18)

In month 18 of bioTope an ex-post evaluation, based on the methodology described in chapter 2.2, of already running domain-specific pilots will be published.

For each test scenario a test plan is going to be prepared to evaluate the improvements defined in month 8 within D2.2 “Evaluation Methodology and Pilots Validation”. In order to evaluate the improvements realized by the implemented pilots, end users should be involved.

After the test scenario execution, the achievements of the objectives will be analysed based on the recorded test results.
In addition to the test scenarios involving end users, the TRLs will be assessed for each platform, by using the methodology described in chapter 2.1.

The evaluation will be used by the project management members to monitor the progress of bloTope, in order to ensure that features to be developed in each of the R&D work packages for the intermediate evaluations are completed in time. If necessary, actions will be taken by the project management members, in order to achieve the planned objectives. Furthermore, the evaluation will be used to review the technical approaches of bloTope and refine bloTope’s Research and Technological Development (RTD) specifications if necessary.

All results of the intermediate evaluation will be published in D2.6 “Evaluation Report 1 of the bloTope Pilots”.

3.4. Final Evaluation of the Pilots (M36)

In month 36 of bloTope the final ex-post evaluation of the whole bloTope ecosystem will be published, according on the methodology described in chapter 2.2. This will be done by evaluating all domain-specific pilots as well as cross-domain specific pilots.

A test plan will be prepared for each test scenario to evaluate the improvements defined in month 8 within D2.2 “Evaluation Methodology and Pilots Validation”. In order to evaluate the improvements realized by the pilots implemented, end users should be involved.

After executing the test scenarios, the achievements of the objectives will be analysed based on the recorded test results.

In addition to the test scenarios involving end users, the TRLs will be assessed for each platform, by using the methodology described in chapter 2.1.

The evaluation will be used to analyse the achieved improvements by bloTope. Finally, common lessons learnt will be derived from the evaluation results, which will be used to improve the implementation of bloTope’s ecosystems and Business Services.

All results of the final evaluation are going to be published in D2.9 “Evaluation Report 2 of the bloTope Pilots”.
4. State of the art in the Pilots

The following chapters describe the state of the art within bioTope’s pilots as well as relevant stakeholders of each use case.

4.1. Cross-domain Smart City Pilots

4.1.1. Pilot: Brussels – Capital Region

4.1.1.1. Use Case: Safe Roads for Children

**Stakeholders**

Stakeholders in general:

- State Secretary of the Brussels-Capital Region Bianca Debaets and her cabinet
- CIRB/CIBG General management
- Irisnet General management
- Directors of 4 pilot schools in Brussels Capitol region
- Parent unions of 4 pilot schools in Brussels Capitol region
- Drivers
- Public transport companies
- Bike providers

End User:

- Children
- Parents
- Teachers

**Processes before bioTope**

- High sense of insecurity around schools
- Non-integrated safety information

**User Interfaces before bioTope**

- No user interface
- Mobility plan for schools on PDF

4.1.1.2. Use Case: Smart Mobility for Emergency Services

**Stakeholders**

Stakeholders in general:

- Brussels Mobility Agency
- Public Cleanliness Agency
- Public Transport Agency

End User:

- Emergency service (SIAMU)

**Processes before bioTope**

- No real-time information (traffic jams, accidents, road works, ...) integrated into navigation systems
- Lack of information about dedicated roads used by public transport
- Lack of information about intervention sites

**User Interfaces before bioTope**

- Navigation system named CityNav
4.1.2. Pilot: FVH – Forum Virum Helsinki

4.1.2.1. Use Case: Electrical Car charging service using IoT BnB concept

Stakeholders

Stakeholders in general:
- Charging station service provider:
  - Liikennevirta, Fortum, other companies with equipped parking slots, private owners
  - Consumers
  - Car service operators
  - Manufacturers of electrical vehicles
  - E-payment providers
  - Cities

End User:
- Drivers

Processes before bioTope
- Different service providers, which are not connected to each other
- Have to find them in advance and clarify payment methods
- The service is only available from the provider’s web pages

User Interfaces before bioTope
- For searching the service
- For checking the service availability
- For navigation to the service
- If applicable – for payment

---

1 Formerly called “Equipment” regarding D2.1
4.1.3. Pilot: Greater Lyon

4.1.3.1. Use Case: Bottle Banks

Stakeholders

Stakeholders in general:
- Metropolis
  - Metropolis waste management department
- Bottle bank supplier
- Bottle banks collection subcontractor
- Citizens
- End User:
  - Tour manager
  - Truck driver
  - Citizen

Processes before bioTope

- Numerous of bottle banks are emptied whereas they are only 30% or less full
- Some bottle banks are full for several hours or days
- No knowledge at Metropolis regarding the collection activity, which is managed by a subcontractor
- Penalty applied to the subcontractor in case of full bottle banks
- Collection tours are managed by experience, and not adapted to contextual conditions

User Interfaces before bioTope

- Bottle banks positions available on a map on the metropolitan web site www.grandlyon.com
- Truck navigation system
4.1.3.2. Use Case: Heat Wave

Stakeholders

Stakeholders in general:
- Metropolis
- Researchers
- Private digital service developers
- Private contractor in charge of trees and vegetation

End User:
- Citizen
- Metropolis departments
  - Climate plan unit
  - Trees and landscape unit
  - Water management unit

Processes before bioTope

- Young trees are watered if soil humidity is insufficient
- Temperature and humidity measures are collected through manual campaigns
- Very few temperature and humidity data is available

User Interfaces before bioTope

- TensionManager platform: data visualization and irrigation recommendations for the trees of “Rue Garibaldi”
4.2. Domain-specific Pilots

4.2.1. Pilot: Smart Mobility

4.2.1.1. Use Case: Charging Station Selection Service

Stakeholders

Stakeholders in general:
- Charging station providers
- Electric vehicle manufacturers
- Electricity Providers
- E-Payment Providers
- Cities

End User:
- Driver

Processes before bioTope

- Different clustered charging station directories
- No coherent payment available
- Driver has to consult several different sources to find a suitable charging station
- No comprehensive service levels and quality assurance

User Interfaces before bioTope

- Interface for searching for charging stations
- Interface of the navigation system
- Interface for payment
  - Usually connected to the charging station provider network through charging station or smartphone app

4.2.1.2. Use Case: Route Planning Service

Stakeholders

Stakeholders in general:
- Car Manufacturer
- Cities
  - Traffic Management centres
  - Public transport
- Traffic Provider

End User:
- Driver

Processes before bioTope

Route planning based on offline data or single-sourced traffic information supplied by a traffic provider

User Interfaces before bioTope

- Interface of the navigation system
4.2.1.3. **Use Case: Electric Car Gear Service**

**Stakeholders**

Stakeholders in general:
- Car Manufacturers
- Smart Home Systems Manufacturers

End User:
- Driver and Smart Home inhabitants

**Processes before bioTope**

Driver has to set a certain time when he wants the car to be preconditioned or starts the preconditioning process manually.

**User Interfaces before bioTope**

- Mobile App Interface
- In-Car Interface

4.2.2. **Pilot: Smart Building and Equipment**

4.2.2.1. **Use Case: Smart Building interaction with Smart Mobility**

**Stakeholders**

Stakeholders in general:
- Parking lot service provider
  - Home owners with own parking space which can sporadically be made available for others

End User:
- Parking lot service consumers
  - Electric vehicle drivers in the city
  - Car drivers in the city

**Processes before bioTope**

Home parking spaces are not utilized when people are away from home (at work for instance).

**User Interfaces before bioTope**

- Mobile app for discovering available parking lots in the area of interest
- Mobile app for publishing own private unused parking slot to the service directory
- For purchasing the service
- If applicable – for payment
4.2.2.2. Use Case: Smart Equipment

Stakeholders

Stakeholders in general:
- Equipment manufacturer
- Weather service provider
- Service company
- Property management company

End User:
- Facility manager
- Service technician
- Premise user

Processes before bioTope

At present, the premise user contacts either a service technician or equipment manufacturer. Currently the service technician does not have any remote access to the Air Handling Unit. The problem becomes pinpointed remotely (using manufacturers live monitoring and control features), and a solution is found. In bad cases, the premise user is not the owner, and ignores the problem. The owner might not be aware of it and the problem will not be solved.

Currently, air quality problems can be detected as smell/odours, uncomfortable enthalpy level (combination of indoor air temperature and humidity) by human senses. A high CO₂ level can cause tiredness. People feel that air quality is bad without any indication and they will turn up ventilation manually. The ventilation level will probably remain high even the air quality has improved.

A common problem that can occur is e.g. clogged extract air filter (or heat exchanger with frost), causing less extract air flow and thus reduces the heat recovery efficiency. Currently, the filters need to be replaced on a time-based interval. The energy expensive defrost mechanism runs unnecessarily often due to inadequate self-awareness.

Currently, outdated air handling unit software raise problems in future operation. The equipment manufacturer or the service company schedules a visit, a technician drives by car to the end user for manually updating software and parameters, which is laborious for the user.

Currently upcoming changes in weather conditions are unnoticed, thus the system reacts on current outdoor circumstances.

User Interfaces before bioTope

- eAir user panel
- eAir web
4.2.3. Pilot: Smart Air Quality

4.2.3.1. Use Case: Identify polluted areas

**Stakeholders**

Stakeholders in general:
- AQMP (Air Quality Monitoring and Prediction) users who contribute and consume
- Municipalities which subscribe to AQMP service
- AQMP information consumers who subscribe to the service and consume only

End User:
- End users are the same as stakeholders, namely, municipalities concerned with air quality in their areas, end users who jog, ride bikes, walk, and local businesses who could be potential polluters and who want to subscribe to AQMP to monitor local air quality

**Processes before bIoTope**

Air pollution is a significant threat in urban environments since it is known to cause respiratory problems as well as various lung diseases. Therefore, continuous air quality monitoring, visualization, dissemination to customers is very important, especially in (Smart) Australian state capitals. For example, in Melbourne, the EPA has a network of air quality monitoring stations where each station covers a few suburbs and the network consists of 11 stations for the whole city of 4 million people. Since the air contamination is usually location-dependent (e.g., transport junctions and industrial areas increase air pollution), the air quality should be monitored in city areas at finer granularity, both in space and time. This is currently not feasible by static measurement stations, but can be achieved by involving citizens in the air quality monitoring process (crowd sensing or crowd-sourcing) so that they carry wearable sensors measuring various air pollutant gases while moving through the city.

**User Interfaces before bIoTope**

- Web-based using standard browsers

4.2.3.2. Use Case: Provide better experience to push bike riders

**Stakeholders**

Stakeholder in general:
- Push bike riders
- Informal associations of push bike riders, like Brisbane Bike Institute
- Municipalities who offer share ride services
- Recreation Park management

End User:
- Push bike riders

**Processes before bIoTope**

Bike-riders are getting information about air quality from public sources and EPA web-site. No push notifications or alerts are generated.

**User Interfaces before bIoTope**

- Web-based, through a web-browser
4.2.3.3. Use Case: Provide councils a view of their city

Stakeholders

Stakeholders in general:
- Municipalities
- City authority

End User:
- Municipalities
- City authority
- Environment monitoring agencies

Processes before bioTope

EPA provided offline reports

User Interfaces before bioTope
- In some cases web-based
- Individual apps developed on city initiatives
5. **bloTope Implementations in the Pilots**

5.1. **Cross-domain Smart City Pilots**

5.1.1. **Pilot: Brussels – Capital Region**

5.1.1.1. **Use Case: Safe Roads for Children**

**Processes based on bloTope**

Itinerary optimisation for schoolchildren in order to increase their security. By influencing the traffic in the school zones, creating groups of children commuting together, promoting public transport, guiding parents towards other means of transport instead of the private car, pushing other traffic members away from school zones during rush hours ...

**Data Interfaces used by the Business Services**

- Telecom operator information
  - position (GPS coordinates)
  - type of transport
- Contextual information
  - road events
  - real time traffic conditions
  - weather forecast
  - events calendar

**User Interfaces needed for the new Business Process**

- Android and iOS app
- Webpage showing dashboards similar to the dashboard available in the app

**Planned Economical Improvements (KPIs)**

- Lowering the amount of accidents in school zones and on the itinerary of the children
- Shortening the average daily commute time of children and their parents
- Lowering traffic jams in around schools

**Planned Societal Improvements (KPIs)**

- Increase the effective security of school children, to be measured via perceived sense of security
- Increase usage of other transport methods than the personal car
- Lowering the amount of accidents in school zones

**Planned Technical Improvements (KPIs)**

- Bundling different sources (sensors) via O-DF/O-MI

**Planned Environmental Improvements (KPIs)**

- Route planning of children keeps into account overall pollution along possible itineraries
Test Scenario

A survey with children and their parents is foreseen to determine the situation prior to the project and 3 months after the project has been deployed. This survey will evaluate children’s and their parents’ perception on the following:

- Sense of (in)security of the children and their parents
- Commute time of children separately
- The need of parents to accompany children on children's commute
- Mode of transport (including children separately and/or together with the parents)
- Shifts in any of the above

5.1.1.2. Use Case: Smart Mobility for Emergency Services

Processes based on bioTope

Information about intervention are automatically transmitted to the App. The co-pilot can visualise the predefined itinerary from the fire station to the intervention site. Based on traffic jams, road work and so on visualised on the App, the co-pilot can suggest alternative roads. All convoy vehicles are localised in real time.

Data Interfaces used by the Business Services

- Mobility information
  - Predefined itinerary
  - Traffic jams
  - Road works
  - Specific roads used by public transport
  - ...
- Real Time information
  - Fire vehicle’s localisation
  - Public transport vehicle’s localisation
  - Waste vehicles localisation

User Interfaces needed for the new Business Process

- Mobile App
- or customisable Navigation System

Planned Economical Improvements (KPIs)

- Reduce average length of time taken for the emergency response vehicle

Planned Societal Improvements (KPIs)

- Reduce interventions concerned by traffic jams

Planned Technical Improvements (KPIs)

- Emergency vehicle dispatches facilitated by computer aided dispatch
- Urban intersections providing priority signals for emergency blue light forces
- Emergency vehicle dispatch systems linked to traffic management interventions

Planned Environmental Improvements (KPIs)

- Less carbon dioxide emissions due to optimized itinerary
Test Scenario

- Testing interoperability and ease of use
  - The dispatching takes a call, introduces detailed information about intervention and dispatches to firemen
  - The officer in charge of the convoy receives intervention coordinates and analyses traffic conditions in order to optimize the route
  - The following values are recorded:
    - Start time of the first vehicles
    - Arrival time on the intervention site
    - Theoretical kilometres
    - Effective kilometres
- Status (Effective, aborted …)
5.1.2. Pilot: FVH – Forum Virum Helsinki

5.1.2.1. Use Case: Electrical Car charging service using IoT BnB concept

Processes based on bIoTope

For the driver the solution provides several services: notification about the need for charging, the existing charging stations in the driven area and their availability (the charging stations are from all possible suppliers), the payment policy and methods, and the alternative routes to the selected charging station. For the supplier the solution provides the possibility to register/unregister the charging system in the system and to setup payment mechanisms.

Data Interfaces used by the Business Services

- Charging station
  - Location
  - Status and availability
  - Power, connector
  - Payment policy and method
  - Owner/operator
- Car
  - Remaining battery
  - Connectors/power

User Interfaces needed for the new Business Process

- Navigation system
- Payment system
- User interfaces
  - Configuration of preferences for search, navigator ...
- Admin UI
  - Registration for new stations
  - Admin tasks
  - User registration

Planned Economical Improvements (KPIs)

- Provide equal possibilities to the companies, individuals, and organizations to participate in creation of ecosystems for electrical cars
- Reduce risks of monopolization of charging services by utilities companies
- Tremendous increase in the amount of charging stations – less distances to charge, less energy consumption
- Increase sales of electrical cars

Planned Societal Improvements (KPIs)

- Enables mass roll out of electrical cars in Northern countries that was somewhat slow due to a lack of suitable charging stations
- Less traffic due to better navigation and improved service
- Public and private assets optimization

2 Formerly called “Equipment“ regarding D2.1
Planned Technical Improvements (KPIs)
- Single entry point for all charging stations, easy and fast to search
- Easy to pay
- Seamless adding of new stations and suppliers without programming and integration effort

Planned Environmental Improvements (KPIs)
- Less CO2 emission due to increased amount of electrical vehicles

Test Scenario
Testing of user story 1 – selection of charging station.
- Driver of electrical vehicle is searching for a charging station (dashboard, mobile application?).
- The system shows the charging stations and their availability in the area and recommends the charging station, which is the closest or the one which can be achieved the fastest (suitable for the driver’s type of connector and car).
- The driver selects the station and sees information about the station, payment, time to reach.

Testing of user story 2 – adding the charging station into the system
- The owner of equipped charging station registers to the system and complies with the pre-defined criteria.
- The owner configures the station characteristics, location, and power.
- The owners defines payment policy and methods.
- After accepting the station, its status and its characteristics, the information is visible for all users.

Testing of user story 3 - adding the new payment method (system requirement).
5.1.3. Pilot: Greater Lyon

5.1.3.1. Use Case: Bottle Banks

Processes based on bloTope

The trucks navigation system suggests automatically to the driver the next bottle bank to empty. Citizens can report full or unavailable bottle banks. Citizens can get information about bottle bank availability.

Data Interfaces used by the Business Services

- Bottle bank information
  - position (GPS coordinates)
  - internal temperature
  - availability
  - fullness rate
  - residential area indicator
- Truck data
  - departure point
  - maximum load
- Process parameters
  - forbidden collection time slots in residential areas
- Contextual information
  - road events
  - real time traffic conditions
  - weather forecast
  - events calendar
- Metropolitan itinerary calculator
- User preferences
  - favourite bottle bank
  - alternative bottle bank

User Interfaces needed for the new Business Process

- Truck navigation system
- Citizen web portal or mobile application

Planned Economical Improvements (KPIs)

- Collection costs lowered, due to less use of trucks
- Bottle bank costs lowered, due to less emptying operations on the banks and control of bottle banks handling
- Better equality between operators in tender procedures regarding the discarded glass collection

Planned Societal Improvements (KPIs)

- Citizens satisfied because they are informed of bottle bank availability, they can report problems and most of the time bottle banks are not full
- Less trucks in the streets, less traffic
- The metropolis has a better knowledge of the waste glass collection activity
Planned Technical Improvements (KPIs)

• Interaction between a digital system owned and managed by the metropolis (the bottle banks’ sensors network) and a digital system owned and managed by a subcontractor (the trucks navigation system)
  o With bloTope standards the introduction of a new subcontractor with a different navigation system should be easy

Planned Environmental Improvements (KPIs)

• Less noise in the streets
• Less noise in residential areas, respect of “quiet” time slots
• Less pollution due to the reduction of the use of trucks through collections optimization

Test Scenario

• Truck route optimization. The test is conducted in two different urban areas: a high density area (centre of Lyon) and a low density area (suburban city).
  o A truck with a bloTope compliant navigation system begins a collection tour
  o Each bottle bank to empty is suggested by the navigation system, verification with the bottle bank dashboard that the suggestion is right
  o A bottle bank is artificially filled nearby the truck: verification of system adaptation in order to empty the full bottle bank
  o Comparison of distances travelled between a classical tour, without the system, and the tour optimized with the system
• Citizens information and contribution
  o The web portal or mobile application informs users when their favourite bottle bank is full
  o If a user reports a full bottle bank, even if the bottle bank sensor does not, this has an impact on the truck’s route

5.1.3.2. Use Case: Heat Wave

Processes based on bloTope

If watering is needed (based on various parameters like soil humidity, trees’ evapotranspiration level, heat wave situation...), possible (enough water in the tank) and appropriate (no rain prevision in the next hours), watering manager is informed. A time slot and watering duration is proposed on his user interface and he can modify the watering parameters and then he confirms the watering schedule.

Data Interfaces used by the Business Service

• Trees data
  o Evapotranspiration level
  o Local temperature and humidity
  o Soil humidity level
• Water tank information
  o Water level
• External information
  o Weather forecast
• Watering rules based on the information above
• Watering manager parameters
  o Watering time slot
  o Watering duration
  o Water debit
**User Interfaces needed for the new Business Process**

- Watering manager user interface

**Planned Economical Improvements (KPIs)**

- Less water consumption, use of rainwater
- Less trees in bad health to replace

**Planned Societal Improvements (KPIs)**

- Increased citizen’s well-being
- A better life quality due to green spaces in good health
- The metropolis demonstrates its commitment in climate change adaptation

**Planned Technical Improvements (KPIs)**

- Smart watering solution involving various sensors and actuators and external data/information
- The solution could be extended easily to others streets

**Planned Environmental Improvements (KPIs)**

- Heat wave mitigation based on a natural solution

**Test Scenario**

- Comparison of temperature and humidity measures on three distinct areas of the street:
  - An area with trees but without bloTope smart watering system
  - An area with bloTope smart watering system
  - A reference area without trees
- Tests are conducted in different conditions:
  - Heat wave
  - Normal conditions
- Temperature and humidity measures are recorded during and after watering
5.2. Domain-specific Pilots

5.2.1. Pilot: Smart Mobility

5.2.1.1. Use Case: Charging Station Selection Service

Processes based on bioTope

If charging is needed, the best fitting charging station is suggested automatically by the navigation system, next to the destination chosen by the driver. The driver just needs to confirm the charging station or to select an alternative charging station suggested by the navigation system. The payment process is also integrated into the new Business Process; therefore, no additional action must be taken by the driver. The driver just needs to confirm the amount of money he wants to spend for charging the vehicle, at the charging station, then the charging process starts automatically.

Data Interfaces used by the Business Services

- Charging station information
  - location
  - connector
  - payment methods
  - electrical output
  - availability
- Payment service
- Navigation system
- Vehicle data
  - remaining battery capacity
  - compatible connector types
- User preferences
  - Maximum charging time available
  - Max distance to destination
  - Willingness to pay extra to meet criteria

User Interfaces needed for the new Business Process

- Navigation system
- Charging station user interface

Planned Economical Improvements (KPIs)

- Less energy consumption, resulting in less costs due to the reduction of saved kilometres searching for appropriate charging stations
- Increased number of sold electric vehicles due to a more convenient search for appropriate charging stations
- Increased number of sold charging stations due to the increased number of electric vehicles
- Single payment method for at least 3 different charging station providers

Planned Societal Improvements (KPIs)

- Less traffic caused by searching for appropriate charging stations
- Better usage of space and existing charging stations
Planned Technical Improvements (KPIs)

- Reduced complexity to integrate a charging station selection service into navigation systems due to standardized data interfaces
- Reduced complexity to integrate different payment solutions into the charging stations
- Effort to add additional charging stations into process is reduced
  - On boarding of additional charging station providers is ideally done by the provider themselves
- Charging stations taken into account are from different providers (min 3; max (amount of providers in area))

Planned Environmental Improvements (KPIs)

- Less carbon dioxide emissions due to the increased number of electric vehicles
- Better air quality in the city due to the increased number of electric vehicles
- Less resource consumption due to less traffic caused by the search for appropriate charging stations

Test Scenario

- Testing interoperability and ease of use
  - An electric vehicle enters the city with a certain destination and the need to charge the vehicle
  - The test is performed in two ways: with and without connection to the biTope ecosystem
  - The following values are recorded:
    - Total time used searching for a charging station
    - Total time spend on enabling and paying at the charging station
    - Total number of different apps/directories/search engines used to find a suitable charging station
    - Distance of the charging station to the destination
  - The test will be performed in a biTope-enabled smart city
- Testing effort of using the Services of biTope (XaaS)
  - Compare the usefulness of information about charging stations from biTope and other, existing charging station directories:
    - type of plug
    - location
    - payment method
  - Compare the live information about charging stations from biTope and other, existing charging station directories:
    - Availability (free, blocked, out of order)
    - Enhanced options like booking and estimations of availability

5.2.1.2. Use Case: Route Planning Service

Processes based on biTope

Information about traffic and road situation is included into the route planning. The driver does not know about the specifics of the area/the city but the data is available as linked data and can be used directly by the routing system
Data Interfaces used by the Business Services

- City / authorities
- Traffic Management Centres
- Navigation System
- Context Generation System
- Vehicle Data
- User Preferences

User Interfaces needed for the new Business Process

- Navigation System

Planned Economical Improvements (KPIs)

- Better use of existing infrastructure
- Increased number of sold vehicles / navigation systems due to more convenient route planning services

Planned Societal Improvements (KPIs)

- Less unnecessary traffic in specific areas; e.g. school zones
- Less stress impact on drivers due to unnecessary hazards

Planned Technical Improvements (KPIs)

- Reduced effort to integrate new route-relevant data sources into the service
- Higher accuracy of data can be used for additional service generation.

Planned Environmental Improvements (KPIs)

- Less pollution due to reduced unnecessary driving and traffic jams

Test Scenario

- Routing with and without additional information
  - For each information that is integrated into routing,
    - The goal of the integration has to be defined (e.g. avoid school zones while children are in the area)
    - Evaluation of the routing with and without the additional information: Has the defined goal been achieved (e.g. a useful detour is calculated around the school zones)
    - If feasible, do real world live-tests with (at least) two vehicles: one following the bloTope-enabled routing, the other one choosing the conventional route. Expected result: win-win-situation for driver and city (e.g. by avoiding very slow and stressful routes through school zones)
  - Questionnaire and Interviews with involved parties (e.g. with developers)
    - Partly done already while implementing/incorporating the additional information:
      - Supplier side
      - Receiver side
    - Summary of ease of use of the developed interfaces
5.2.1.3. Use Case: Electric Car Gear Service

Processes based on bloTope

The Smart Home and the electric vehicle are able to interact with each other: While being connected to the power outlet of a charging station, the vehicle can be pre-heated (or pre-cooled in summer) using power from the charging station. The Smart Home can identify when the user is going to leave the house and sends a trigger to the vehicle to start preconditioning. When the driver arrives at the vehicle, the vehicle is already preconditioned without having used any battery capacity.

Data Interfaces used by the Business Services

- Vehicle Remote Services
- Smart Home
- User Preferences
- Charging Station Status

User Interfaces needed for the new Business Process

- Smart Home Control
- Vehicle Remote Service Smartphone App

Planned Economical Improvements (KPIs)

- Efficient use of energy, as the preconditioning is triggered based on the actual events and no fixed time schedule
- Reduced overall costs for batteries in particular hot or cold countries and urban mobility

Planned Societal Improvements (KPIs)

- Electric Vehicles have a bigger effective range, reducing the range anxiety and increasing the attractiveness of electric vehicles in urban areas
- Future combination of Smart Home and Smart Mobility

Planned Technical Improvements (KPIs)

- Reducing the cost for creating cross-domain based services

Planned Environmental Improvements (KPIs)

- Less pollution by using electric energy rather than fossil pre-heating
Test Scenario

- Tests should be performed in times of
  - Low temperature (winter) \(\rightarrow\) Heating
  - High temperature (summer) \(\rightarrow\) Air Conditioning
  - Mid temperature

- Typical test, each with and without the smart car gearing service activated:
  - Inhabitant of a Smart Home leaves home and follows a daily schedule
  - The range of the electric vehicle is recorded after each reached destination
  - The availability of a usable charging station at the destination is noted
  - The overall remaining range of the electric vehicle at the end of the day is recorded

- Questionnaire/Interview with inhabitants, how the smart preconditioning of the car
  - helps to avoid range anxiety
  - leads to considering to use an electric vehicle for daily tasks
  - can be extended with additional information, possibly leading to additional cross-domain use cases by using offered data from the bioTope ecosystem
5.2.2. Pilot: Smart Building and Equipment

5.2.2.1. Use Case: Smart Building interaction with Smart Mobility

Processes based on bIoTope

Home users are able to provide their unused own private parking lot for car drivers in the city. They can publish the availability of their parking slot (using a Smart Home mobile app) on a service catalogue (IoTBnB), and the car users can discover this service either using a smart parking mobile app, or using BMW’s in-dash navigation system.

Data Interfaces used by the Business Services

- IoTBnB
  - Parking slot
    - Location
    - Status and availability
    - Charging possibility?
      - Power, connector
    - Payment policy and method
    - Owner/operator
- Mist
  - Reference to service provider

User Interfaces needed for the new Business Process

- Smart Home mobile app, for publishing own parking as a service
- Smart parking mobile app, for discovery and purchase (unless BMW owner)
- BMW navigation system

Planned Economical Improvements (KPIs)

- Tremendous increase in the amount of parking (and power outlet) alternatives – less distances to parking, less energy consumption
- Provide equal possibilities to the companies, individual, and organizations to participate in creation of ecosystems for parking
- Improved competition between parking alternatives

Planned Societal Improvements (KPIs)

- Increased parking alternatives, more likely to find close to destination
- Less traffic due to more parking alternatives and less parking challenges
- Public and private assets optimization

Planned Technical Improvements (KPIs)

- Single entry point for all charging stations, easy and fast to search
- Easy to pay
- Seamless adding of new parking suppliers without programming and integration effort

Planned Environmental Improvements (KPIs)

- Improved utilisation of parking lots
- Less CO2 emission due to reduced kilometres resulting originally from driving round and searching for available parking lots
Test Scenario

Testing of user story 1 – selection of charging stations.
- The driver provides the max time he will need a parking lot for, and the desired area (dash board, mobile application)
- The system shows the alternatives available (according to desired max time) in the area and suggests the closest alternative
- The driver receives information about the parking slot, payment methods, ETA and confirms the selection

Testing of user story 2 – publishing own parking lots in the system
- The owner of a parking lot describes the parking lot’s position and characteristics (and possible power socket type), and provides a journey description
- The owners define the payment policy and payment methods
- After accepting the station, its status and characteristic are visible for all users.

5.2.2.2. Use Case: Smart Equipment

Processes based on bioTope
- Data transfer between air handling unit, mobile app/supervisory system and possible external sensors/transmitters is done by using the Mist/WiFi technology (O-MI/O-DF).
- The air handling unit detects abnormal conditions and informs the facility manager about it.
- The system provides real time information about the indoor air quality and what was making it uncomfortable. The end user is provided with a mobile application that indicates the indoor air quality.
- Facility manager is able to remotely use the mobile app to upgrade the air handling unit software.

Data Interfaces used by the Business Services
- Mist
- WiFi

User Interfaces needed for the new Business Process
- Air handling Unit Smartphone App (MobileApp)

Planned Economical Improvements (KPIs)
- Reduced service costs
- Reduced energy costs

Planned Societal Improvements (KPIs)
- Increased human productivity due to better indoor air quality
- Healthier buildings
Planned Technical Improvements (KPIs)

- Smooth connectivity due to Mist/WiFi technology (O-MI/O-DF)

Planned Environmental Improvements (KPIs)

- Less energy consumption, less CO2 emissions

Test Scenario

- Mist/WiFi/MobileApp test setup
  - Mist/WiFi functionality
  - MobileApp functionality
  - Mist/WiFi interoperability
  - MobileApp and Mist/WiFi cooperation functionality
- Abnormal situation is simulated in air handling unit and it should send the information to MobileApp
- Indoor air quality is monitored by different sensors e.g. CO2 and increased levels should be indicated in MobileApp
- Upgrade of the air handling unit’s software is tested with MobileApp
5.2.3. Pilot: Smart Air Quality

5.2.3.1. Use Case: Identify polluted areas

Processes based on biTope

The proposed system complements EPA air quality data streams with crowd-sourced data coming from individuals who subscribe to the app (iPhone and Android). The data is fused, heat maps are built on local devices, and the data is shared through the IoT platform for notifications and alerts to users and stakeholders. The system should be unobtrusive, smart, friendly, adaptive, context-aware, distributed and selective where the data processing should occur: locally or in a distributed way. The system should interact with EPA stations which are usually in the open data domain. The system should be able to discover relevant data from in-building air quality sensors and make use of it. A large network of volunteer weather stations and off-the-shelf commercial air quality sensors are becoming increasingly available. Users are exposing the data their devices generate on the web and the proposed system might make use of discovering the public-contributed data for better monitoring and prediction with incentives to open up more data sources.

Data streams from EPA stations are flowing and periodical reports are supplied to interested stakeholders. Alert mechanism is basic and does not differentiate between various situations. Air pollution is a significant threat in urban environments since it is known to cause respiratory problems as well as various lung diseases. Therefore, continuous air quality monitoring, visualization, dissemination to customers is very important, especially in (Smart) Australian state capitals. For example, in Melbourne, the EPA8 has a network of air quality monitoring stations where each station covers a few suburbs and the network consists of 11 stations for the whole city of 4 million people. Since the air contamination is usually location-dependent (e.g., transport junctions and industrial areas increase air pollution), the air quality should be monitored in city areas at a finer granularity, both in space and time. This is currently not feasible by static measurement stations, but can be achieved by involving citizens in the air quality monitoring process (Crowd sensing or crowd-sourcing) so that they carry wearable sensors measuring various air pollutant gases while moving through the city.

Data Interfaces used by the Business Services

- EPA data streams
- Crowd-sourced air quality measurements from smartphone connected sensors

User Interfaces needed for the new Business Process

- Heat maps visualised through the web-browser
- Smartphone app based interface customised to user’s role
- Notification service programmed to monitor pollution levels and notify in the event the level is exceeded.

Planned Economical Improvements (KPIs)

- Complementary AQMP measurements
- Revenue stream for local councils aware of and fining air polluters

Planned Societal Improvements (KPIs)

- Increased trust of air quality measurements by EPA and local councils
- Personalised heat maps for healthier environments
- Cleaner air for communities

Planned Technical Improvements (KPIs)

- Crowd-sourced complementary measurements of air quality
- Personalised awareness of air quality through a smartphone app
- Evolutionary learning and improvement of air quality predictions
Planned Environmental Improvements (KPIs)

- Increased density of air quality measurements
- Cleaner air as the result of continuous monitoring and awareness of air quality

Test Scenario

- Equip a group of selected users with air quality measurement devices
- Identify city areas covered by complementary crowd-sourced air quality measurements
- Access historical EPA data for the identified areas
- Collect air quality data for several periods of time from crowd-sourcing
- Compare EPA heat maps with heat maps generated as a result of data fusion between EPA and crowd-sourced data
- Demonstrate increased accuracy, timeliness and benefits of the proposed system/app

5.2.3.2. Use Case: Provide better experience to push bike riders

Processes based on bioTope

The proposed system complements EPA air quality data streams with crowd-sourced data coming from individuals who subscribe to the app (iPhone and Android). The data is fused, heat maps are built on local devices as well as the data is shared through the IoT platform for notifications and alerts to users and stakeholders. The system should be unobtrusive, smart, friendly, adaptive, context-aware, distributed and selective where the data processing should occur: locally or in a distributed way. The system should interact with EPA stations which are usually in the open data domain. The system should be able to discover relevant data from in-building air quality sensors and make use of it. A large network of volunteer weather stations and off-the-shelf commercial air quality sensors are becoming increasingly available. Users are exposing the data their devices generate on the web and the proposed system might make use of discovering the public-contributed data for better monitoring and prediction with incentives to open up more data sources.

Use case users of AQMP would be push bike riders. Air quality sensors could be embedded into bikes. Bikeriding Institute (QLD), bike-riders, Melbourne Bike Share are stakeholders in this scenario. Bike-riders will be getting information about air quality from AQMP.

Data Interfaces used by the Business Services

- WiFi
- WAN
- EPA data streams
- Shared heat maps

User Interfaces needed for the new Business Process

- Smartphone app
- Push notifications about monitored and predicted air quality along the usual bike route delivered by multi-mode app interface

Planned Economical Improvements (KPIs)

- Better awareness of air quality for bike riders and incentivizing the number of bike riders
- Personalised heat maps

Planned Societal Improvements (KPIs)

- Personalised heat maps for healthier environment
- Cleaner air for communities
- Aware and informed about air quality bike riders
Planned Technical Improvements (KPIs)
Heat maps, notifications and alerts delivered to user smartphones and depending on user activity, selecting the best interface (sound or visual) to deliver the message.

Planned Environmental Improvements (KPIs)
- Increased density of air quality measurements
- Cleaner air as the result of continuous monitoring and awareness of air quality

Test Scenario
- Equip a group of selected bike riders with air quality sensing devices and install an Android app on their smartphones
- Start collecting data, visualising heat maps, providing accurate air quality data, sending notifications and personalising bike riding experience

Survey the group, receive their feedback, analyse, compare and demonstrate benefits of the scenario.

5.2.3.3. Use Case: Provide councils a view of their city

Processes based on bioTope
The proposed system complements EPA air quality data streams with crowd-sourced data coming from individuals who subscribe to the app (iPhone and Android). The data is fused, heat maps are built on local devices as well as the data is shared through the IoT platform for notifications and alerts to users and stakeholders. The system should be unobtrusive, smart, friendly, adaptive, context-aware, distributed and selective where the data processing should occur: locally or in a distributed way. The system should interact with EPA stations which are usually in the open data domain. The system should be able to discover relevant data from in-building air quality sensors and make use of it. A large network of volunteer weather stations and off-the-shelf commercial air quality sensors are becoming increasingly available. Users are exposing the data their devices generate on the web and the proposed system might make use of discovering the public-contributed data for better monitoring and prediction with incentives to open up more data sources. AQMP will deliver heat maps to councils, generate alerts, and colour specific areas with predicted air quality and evaluation of risks to various communities. These heat-maps will be available through council/city portals.

Data Interfaces used by the Business Services
- Web
- WiFi
- EPA data streams
- Crowd-sourced air quality measurements

User Interfaces needed for the new Business Process
- Web browser based city dashboard. City dashboards should have active zones for air quality monitoring and prediction, including heat maps and visual effects to attract attention in case pollution levels exceed regular thresholds
- Smartphone personalised dashboard for city authorities

Planned Economical Improvements (KPIs)
- Complementary AQMP measurements
- Revenue stream for local councils aware of and fining air polluters
Planned Societal Improvements (KPIs)

- Personalised heat maps for healthier environment
- Cleaner air for communities
- Aware and informed about air quality city authorities

Planned Technical Improvements (KPIs)

- Personalised dashboards
- Near real-time air quality monitoring alerting and predicting

Planned Environmental Improvements (KPIs)

- Increased density of air quality measurements

Test Scenario

- Collect crowd-sourced data for several periods of time
- Fuse EPA data with crowd-sourced data
- Demonstrate improved accuracy, better awareness, friendlier interfaces
- Compare before-bloTope and after-bloTope experience
6. Conclusion

The D2.2 “Evaluation Methodology for Pilots Validation” defines a consistent evaluation plan based on meaningful and easy to use evaluation methodologies. Based on the evaluation results the project management members monitor the progress of bloTope. If necessary, actions will be taken by the project management members, in order to achieve the planned objectives. Furthermore, the evaluation will be used to review the technical approaches of bloTope and refine bloTope’s Research and Technological Development (RTD) specifications if necessary.

The D2.2 “Evaluation Methodology for Pilots Validation” helps the project partners to evaluate their project results. Therefore, user stories and test scenarios are described within this document. Moreover, relevant KPIs are identified, which need to be evaluated. During the project the project partners will detail the test scenarios in order to ensure a trustworthy evaluation of the use cases. The results of the use case evaluations will be published within D2.6 “Evaluation Report 1 of the bloTope Pilots” and D2.9 “Evaluation Report 2 of the bloTope Pilots”.

7. References


