

Experiences of replication and implementation

OF innovations between University Campuses



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Experiences of Replication and Implementation of Innovations between University Campuses Cross-ecosystem Methodology

This document runs as part of the European cooperation Tr@nsnet project. This European project, financed by FEDER funds, and brought to fruition by the consortium led by the French Toulouse III University - Paul Sabatier (UT3), includes the participation of the Foundation for Energy and Environmental Sustainability (Funseam), the Polytechnic University of Madrid (UPM), the University of Lisbon (FCUL), the University of Beira Interior (UBI), the University of La Rochelle (URL), CIRCE Foundation - Centre for Energy Resources and Consumption (CIRCE) and the Technological Corporation of Andalusia (CTA). It aims to contribute to the challenge of ecological transition by defining a new model of Living Lab in the context of open innovation.

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1 Benefits and challenges of Cross-ecosystem innovation

The ecosystem of a university Living Lab is determined by a set of constraints (e.g., location or governance) and features (e.g., size or knowledge orientation) that affects its internal behaviour and interaction with participants.

- **Location:** Depending on the country (or even region within a country), regulations that apply to the Living Lab processes may diverge. On the other hand, a Living Lab within the downtown area will present different constraints when compared to one located in the suburbs.
- **Governance:** Although there are common regulations, public and private universities may differ in some procedures that may affect the interaction with Living Lab participants.
- **Size:** University size (both in number of students/staff, and physical facilities) will influence the scale of the Living Lab validation, including user engagement potential.
- **Knowledge orientation:** The level of engagement of campus users will be marked by the field of knowledge that is being covered: technical, science or humanities.

The gaps or deviance in ecosystems across universities result in the appearance of new challenges that make collaboration between Living Labs difficult.

Out of all the ecosystem factors, the Tr@nsnet project is focused on the analysis of how differences in country and region affect Living Lab interaction for improving existing innovations or implementing new ones.

Contemporary research and innovation (R&I) success relies on collaboration

across organizations, disciplines, and regions [1]. International R&I collaboration is associated with higher quality standards, providing multiple benefits such as conducting comparative analysis, learning from each other or access to external knowledge ([2] and [3]). University Living Labs are unquestionable seeds for international R&I collaboration [4]. They are made up of 4 types of stakeholders: Academia, Private Sector, Public Administration and Citizens. While the initial and most common configuration will include local participants, Living Lab growth will be open to abroad contributors, especially concerning Academia and Private Sector.

This Cross-ecosystem innovation will add new challenges to those presented in chapter 3 (Governance Model):

- **National/regional/local regulations:** Although universities have certain level of autonomy, they still have to comply with national, regional and local regulations that may affect collaboration. These regulations include the installation of equipment and intellectual property of results or financing tools.
- **Cultural backgrounds:** Diverse cultural backgrounds affect not only communication, but also organizational processes and the perception of information and reality [4]. Cultural distance is likely to limit collaboration outcomes and innovation quality.
- **Technical specifications:** Technology solutions chosen need to comply choose to comply with specific technical standards (communication protocols, interfaces, power sources), which may differ across countries, regions or even universities.
- **Administrative procedures:** Differences in administrative procedures (e.g., work licences, equipment acquisition, and data protection) may result in delays or even cancellation of innovation collaboration.
- **User engagement:** Campus users (students, teachers, searchers, and staff) represent the role of Citizens at the university Living Labs. Campus user engagement with the Living Lab relies on the campus governance (level of compromise) and ecosystem (teaching-research-innovation helix).

2 Cross-ecosystem innovation in Tr@nsnet project

Transnet project international R&I collaboration in the framework of university Living Labs has taken two paths: the replication of existing solutions or components (TG1) and the implementation of new systems or elements (TG2). The common goals of TG1 and TG2 are:

- To capitalize on the experience and the lessons learned by the demonstrator's cross-transfer between universities in France, Spain and Portugal: Identify technical and non-technical barriers and propose solutions to overcome them.
- To collaborate with technology providers (companies) that will appreciate the service and advice offered by the labs in their system.

To study how end-users perceive the systems and what the benefits are in order to explain the acceptability of each technology by different cultures and type of user (education, technical background, environment awareness, etc.)

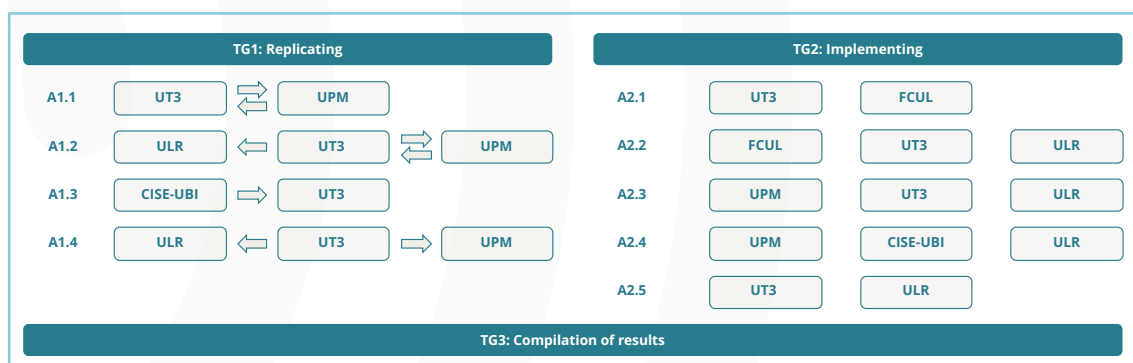


Figure 1: Participant connection in Tr@nsnet regarding Cross-ecosystem collaboration. Universities collaborate in the replication (TG1) and implementation (TG2) of innovations. Funseam compiles and analyses the process of international collaboration.

6.2.1 TG1. Replicating Innovations

The objective of TG1 is to study the processes of adaptation and transfer of a Demonstrator from one environment to another in order to capitalize on the

definition of good practices and methods that will be memorized in TG3. We offer to reproduce the demonstrators/experiments developed within one university in another university. In this section, the goals and results of each activity are summarized. TG1 is divided in four activities:

- **Replication of intelligent lighting devices (UT3, UPM)**

Hypothesis: UPM and UT3 replicate existing Smart street lighting solutions.

Results:

- UPM has replicated the Kawantech solution from the UT3 campus, deploying Kara systems and integrating them with existing BatStreetlighting solution.
- Meanwhile, UT3 has replicated the T6000 solution from the UPM campus, deploying BatStreetlighting and BatLink devices.

- **Home automation (IoT) in the Gateway Network building (UT3, UPM, ULR)**

Hypothesis: UPM, ULR and UT3 replicate existing IoT solutions for building automation.

Results:

- UPM has replicated the Neosensor solution from the UT3 campus, deploying and integrating IoT ambient sensors.
- UT3 has replicated the T6000 solution from the UPM campus, installing and integrating IoT ambient and Smart meter sensors.
- ULR has replicated the Neosensor solution from the UT3 campus.

- **Coupling electrical and thermal power generation (UT3, CISE-UBI)**

Hypothesis: UT3 and CISE-UBI replicate existing electrical-thermal power solutions.

Results:

- UT3 has replicated a combined PV and thermal installation located at CISE-UBI on a small-scale.

- **Use of digital technology on campuses, service needs in terms of services.**

Shared analysis. (UT3, UPM, ULR)

Hypothesis: UPM and ULR replicate existing survey by UT3.

Results:

- UPM has replicated the previous survey conducted in the UT3 campus.

2.2 TG2. Implementing innovations

The aim of TG2 is to design and implement new demonstrators in universities in order to acquire skills, collaborate and exchange methods and ways of working in each university. The capitalization of these experiences makes it possible to enrich the definition and specification of University Living Labs. Each demonstrator will constitute a real platform-like environment with an inter-sectorial approach. TG2 is divided in five activities:

- **Recycling batteries for solar energy storage (FCUL, UT3)**

Hypothesis: FCUL and UT3 will implement new demonstrators based on the re-utilization of spend batteries.

Results:

- FCUL has deployed a mini-grid with PV modules and second-life batteries coming from electric vehicles. This grid will power the students' rooms.
- UT3 has deployed a micro-grid with PV modules and batteries coming from golf trolleys. This grid will power the charging of electric bikes.

- **Mobility observation (FCUL/ULR/UT3)**

Hypothesis: FCUL and UT3 will characterize the mobility behaviour of campus users.

Results:

- FCUL has conducted a mobility survey and installed sensors for counting the mobility modes.
- UT3 has carried out a mobility study and installed sensors, radars, and measurement nodes across the campus.

- **Environmental interactions with human activities (UPM, UT3)**

Hypothesis: UPM will analyse the impact of users in campus wildlife. UT3 will study the impact of a natural water filter in campus environment.

Results:

- UPM has deployed bio-acoustic sensors and camera traps to collect wild-life data (for birds, bats, and mammals), and has analysed the effect of user activity (transport, works, artificial lighting).
- UT3 has developed and installed water filters based on nature-like solutions and has analysed the social and ecological impact.

- **Integration of electrical and thermal networks (CISE-UBI. UPM)**
Hypothesis: CISE-UBI and UPM will implement systems integrating electrical and thermal networks.
Results:
 - UPM has deployed a hybrid PV-aerothermal solution to power HVAC systems.
 - CISE-UBI has simulated and carried out experimental studies for the integration of renewable energy technologies, integrating different loads and storage technologies.

- **Social interactions, eco-citizens (ULR, UT3)**
Hypothesis: ULR and UT3 will implement innovations to increase citizen awareness of sustainability.
Results:
 - UT3 has developed and installed “Nacelle”, an innovative space aimed at increasing social collaboration in the framework of energy consumption.
 - ULR has been trained in the use of Nacelle and participated in different sessions.

2.3 Lessons learned from TG1 and TG2

In general terms, results are in line with the initial hypothesis of the activities from TG1 and TG2. However, there are some cases in which either one of the universities has not been able to replicate/implement the innovation or they have to overcome unpredicted issues. Lessons learned from the process and outcomes aim to complement the ENOLL Living Lab model with a guidelines/model to help future adopters of Living Labs ecosystems taking into account the cross-ecosystem collaboration.

3 Identification of challenges and user experience

Funseam has conducted a survey to collect data from tasks developed by the universities in TG1 and TG2. The questionnaire is very simple (3 questions), asking for information about the technical difficulties, the administrative difficulties and how the campus users have evaluated the replication/implementation on innovation.

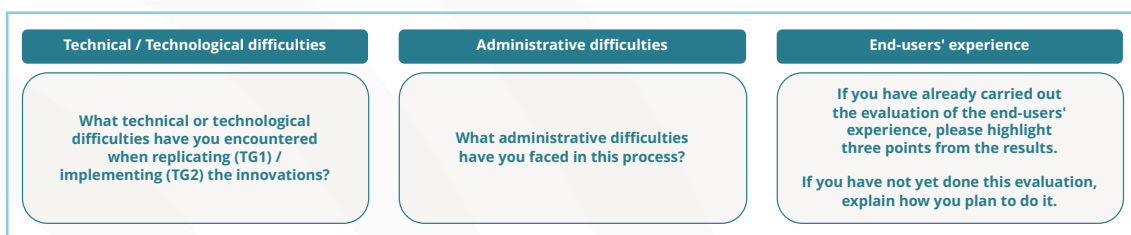


Figure 2: Survey questions to collect data on the tasks developed by the universities in TG1 and TG2 in the Tr@nsnet project.

There have 25 answers (12 for participants in TG1 and 13 for those in TG2). Notice that the survey was conducted in October 2022, with a 5-month leeway to finalize the project activities. Therefore, end-users' experience may be on-going or planned.

Regarding the replication of innovations (TG1), five participants report technological or technical difficulties, such as the configuration of devices or integration with existing platforms. More participants (7) account for administrative difficulties, including both university internal protocols and wrong procedures. As for the end-users' experience, just four of the respondents have asked campus users, either with online surveys or via a mobile app.

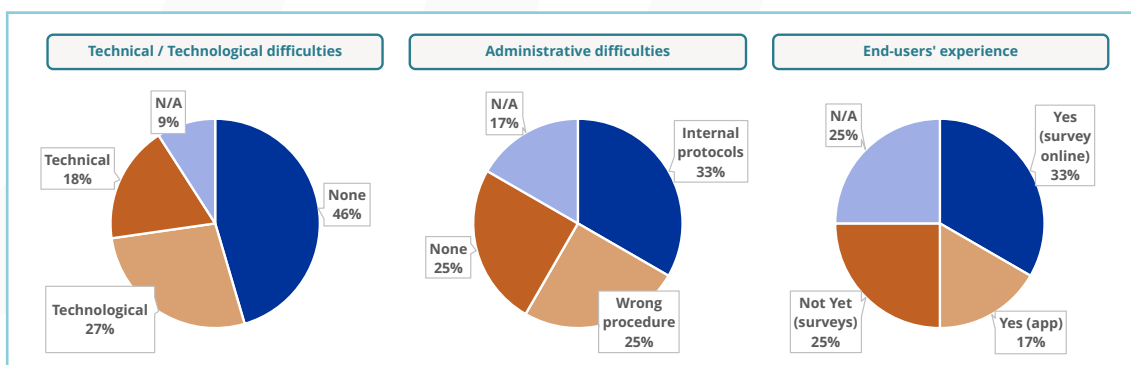


Figure 3: Replicating Innovations (TG1) overall results.

Regarding the implementation of innovations (TG2), ten participants report technological or technical difficulties, mainly because of a poor initial design of the lack of components in the market. The same number of participants (10) account for administrative difficulties, including both university internal protocols and lack of planning. As for the end-users' experience, just seven of the respondents have asked campus users, either with online surveys or via a mobile app.

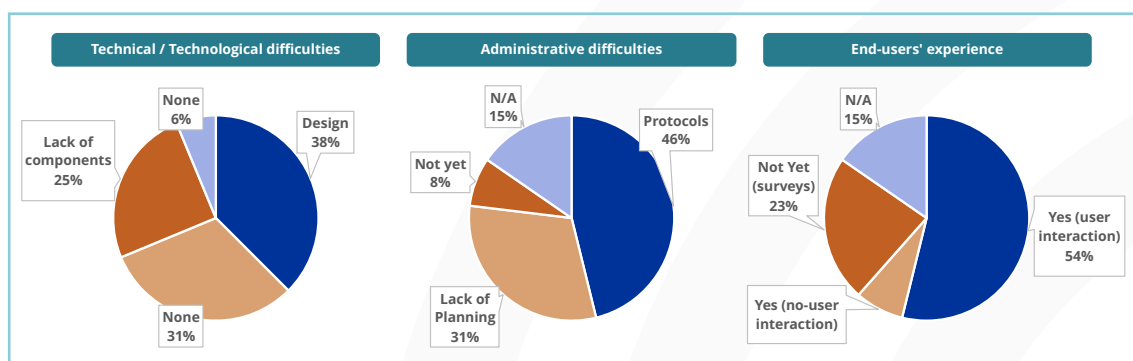


Figure 4: Implementing Innovations (TG2) overall results.

4 Methodology for (cross-ecosystem) replication and implementation of innovations

The collaboration between Living Labs of different university ecosystems entails several challenges, but it also provides new opportunities to solve the difficulties that arose during the replication and implementation of innovations.

In this section, we will provide a practical model for the cross-ecosystem collaboration, namely the definition of the most relevant elements, their interactions, the roadmap, the most common complications, and the methodology to solve them.

- The goals of the innovation (common and particular).
- Participants and their interaction.
- Draft solution (components and steps).
- Difficulties (during the development and deployment).
- Collaborative solution (Feedback and replication).

We propose to converge these aspects in a new Cross-ecosystem Methodology Canvas. This Canvas is a dynamic tool that helps Living Labs to have clear view on how to handle the appearance of difficulties in the process of replication and implementation of innovations in collaborative ecosystems across universities. The Canvas should be filled in a constructive and collaborative way among Living Labs sharing the cross-ecosystem innovation. Figure 31 presents the draft version of this Canvas used in the framework of the Tr@nsnet project. As future work, we are planning a version of this Canvas to include new variables and new aspects to be taken into account in the replication and implementation processes of cross-ecosystem innovations.

Cross-ecosystem Methodology Canvas		Ecosystem name:	Date:	Iteration:
What	Goals of the innovation (shared and particular):			
Participants	Stakeholders for each ecosystem and interaction between them:			
Draft Solution	Components, tasks, schedule:			
Stage: <input type="checkbox"/> Development <input type="checkbox"/> Deployment <input type="checkbox"/> Validation Ecosystem partner:	Technical/Technological difficulties Description: Solution proposed by the other ecosystem: Result obtained: (If not solved) Replication in other ecosystem: Final Result:	Administrative difficulties Description: Solution proposed by the other ecosystem: Result obtained: (If not solved) Replication in other ecosystem: Final Result:	User experience Description: Solution proposed by the other ecosystem: Result obtained: (If not solved) Replication in other ecosystem: Final Result:	

Figure 5: Cross-ecosystem Methodology Canvas.

In the following paragraphs, the content of each section will be explained. We illustrate the Canvas model completion with a practical example extracted from the Tr@nsnet project: Activity 1.1 Replication of intelligent lighting devices.

The goals of the innovations

This section should summarize the common goal of the innovation: e.g., the replication of an IoT technology for lowering energy consumption in university buildings or the implementation of social awareness tools to engage

campus users in the use of public transport). However, the model should also include the specific objectives from each Living Lab: e.g., the validation of a research result or the participation of local communities.

Example:

- *Common goal: Replication of existing Smart street lighting solutions.*
- *Specific goal from UPM (Spain): integration of research developments with commercial solutions.*
- *Specific goal from UT3 (France): user experience validation of Smart street lighting solutions.*

Participants

This block should list which stakeholders from each Living Lab ecosystem are taking part: e.g., faculty, research group, maintenance staff, industrial parties, campus users or neighbour citizens. Additionally, it should define the interaction among them, including intra-ecosystem (e.g., researchers and maintenance staff for the deployment of innovations) and cross-ecosystem (e.g., university administrative office and industry for the acquisition of equipment).

Example:

- *Participants:*
 - *UPM ecosystem: CEDINT R&D centre, Campus maintenance staff, University Administrative Office, Tecnica 6000.*
 - *UT3 ecosystem: Laplace Laboratory, Campus maintenance staff, University Administrative Office, Kawantech.*
- *Interaction:*
 - *Tecnica 6000 is a Spanish company that acts a technology provider for the technical solution deployed at the UPM campus.*
 - *Kawantech is a French company that acts a technology provider for the technical solution deployed at the UT3 campus.*
 - *UT3 (Laplace) has to acquire the solution from T6000 to replicate it.*
 - *UPM (CEDINT) has to acquire the solution from Kawantech to replicate it.*
 - *T6000 has to comply with French procedures with the guidance of UT3 Administrative Office, and with the technical constraints of the existing solution at UT3 campus.*

- *Kawantech has to comply with Spanish procedures with the guidance of UT3 Administrative Office, and with the technical constraints of the existing solution at UPM campus.*
- *Laplace laboratory has to agree with UT3 Campus maintenance about the deployment of the replication.*
- *CEDINT has to agree with UPM Campus maintenance about the deployment of the replication.*

Draft solution

Within the section, the design of the innovation development and deployment must be planned. On one hand, we should determine the required components (e.g., communications devices, software platform or physical infrastructures). Then, the necessary steps towards the innovation development and deployment should be calendared, including a schedule and milestones.

Example:

For replication in UPM:

- *Components:*
 - *Camera Sensor from Kawantech. Existing streetlights and dimming controllers in UPM. Power source and Internet connection for Kawantech solution.*
- *Steps:*
 - *Acquisition of Kawantech solution.*
 - *Testing in laboratory environment.*
 - *Integration with existing streetlights and IoT solution.*
 - *Real deployment.*
 - *User validation.*

For replication in UT3:

- *Components:*
 - *IoT devices from T6000, new LED luminaires with interface for the IoT devices, new poles for the integration of the new luminaires and the IoT devices.*
- *Steps:*
 - *Acquisition of T6000 solution.*
 - *Testing in laboratory environment.*

- *Integration with new LED luminaires.*
- *Integration with existing solution.*
- *Real deployment.*
- *User validation.*

Difficulties raised during the development and deployment of the innovation
During the development and deployment phases, different issues may appear, preventing the successful replication or implementation of the innovation. These difficulties can be divided into three categories: technical, administrative and user engagement.

The technical difficulties include issues related to the incompatibility of interfaces, power sources, communication protocols, software versions, operative systems, or environment, among others.

The administrative difficulties are caused by the differences between public procedures and regulations, including those for acquisition of goods and the installation and maintenance responsibilities.

Engaging campus users for the validation and enrichment of the Living Labs innovations is a complex task. Campus users (not only students but also teachers, researchers, and staff) do not tend to participate in an initiative unless they are highly interested in the topic or receive some kind of incentive.

This section brings together the difficulties for each category.

Example:

- *Technical difficulties:*
 - *UPM has problems connecting the Kawantech Camera to the Internet.*
 - *T6000 has to adapt the solution to be able to interact with the UT3 platform.*
- *Administrative difficulties:*
 - *Processes for the acquisition of equipment are very slow and tedious, delaying the next steps.*
 - *UT3 has to comply with strict regulations for installing new streetlights.*

- *User engagement difficulties:*
 - *UPM has not managed to engage campus user in innovation validation.*

Collaborative solution

One of the benefits of the cross-ecosystem towards innovation in Living Labs is the capacity to overcome difficulties in a collaborative way. The Cross-ecosystem Model Canvas proposes a two-step problem-solving methodology based on both knowledge (previous experience) and experimentation (replication).

When a Living Lab faces a new problem, it may be similar to one that has already been encountered in other Living Labs. Therefore, the first step is to ask fellow counterparts for feedback on how to proceed.

If there is not such knowledge or the problem persists after implementing the recommended solution, we should go on to the following step.

This step consists of the replication of the problem/issue in other Living Lab ecosystems. By reproducing the innovation but with different constraints from each ecosystem, it will be easier to identify the origin of the difficulties, and as a result, find a successful solution.

Example:

- *UPM is not able to engage campus users in the validation of the streetlight innovation.*
- *UPM asks UT3 for feedback.*
- *UT3 recommends UPM to launch an online survey.*
- *UPM launch the survey and while the level of engagement increases, it is still low.*
- *UPM replicates the system in UT3.*
- *UT3 identifies that the visibility of the system needs to be improved (e.g., by installing information panels in university buildings).*

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ANNEX: TECHNICAL REFERENCES

Project acronym	TR@NSNET
Project title	Living Lab Model for an ecological transition through the integration and interconnection of complex heterogeneous grids.
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