Living Labs in medical device development

a case study

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TUDelft

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a case study

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The law of chaos is the law of ideas,
Of improvisations and seasons of belief.

Wallace Stevens, 'Extracts from
Addresses to the Academy of
Fine Ideas'

Preface

Before you lies my master thesis report, which has been written in conclusion of my double degree of the masters Biomedical Engineering and Communication Design for Innovation. In this integrated thesis I investigate the role of Living Labs in medical device development and how communication can support the Living Labs in their endeavours. During my thesis I got the chance to interview the people that work in the Living Lab the ResearchOR. In this Living Lab, engineers, doctors and companies work together to develop medical devices that can be tested in a real operation room.

Ever since I started my two masters, I have been fascinated by the complex processes and collaborations that come with medical device development. How do you make sure you create innovations that truly have value for the user? The way Living Labs work on this matter reminds me of how cells work together, and how they exchange information and recourses (see the cover). I am grateful I got to speak with people from the field who assess this question every day. It has given me inspiration and motivation to strive to find my own answer in my future career. I hope my findings in this thesis will give the same inspiration to people that create innovations in medical device development, or any in other field.

I have written this thesis times of the Corona pandemic. Strange times that have made me struggle to find my way from time to time. How to perform research in a hospital when you are not allowed to enter it? I have been amazed by the flexibility and adaptivity of the stakeholders of the ResearchOR, my supervisors and fellow students. Their Skype, Zoom and phone calls have been indispensable on both a social and professional level.

I want to thank Steven Flipse and John van den Dobbelsteen for their guidance, patience and enthusiasm during this project. I really appreciate the way you have collaborated with me and with each other. It was a very open and efficient way of working. It has taught me a lot. I want to thank Maarten van der Sanden and Ferdoos Esrail for their feedback and inspiration, and Maarten van der Elst for his insights during the interview. Furthermore, I want to thank my parents, sister and boyfriend for their support. You were always there when I needed you the most. Especially the 'afstudeer appelflappen' were crucial for the completion of this thesis.

Anneke Schouten

Leiden, 20–11–2020

Executive summary

When in 2008 the financial crisis set it in Europe, consequences for the healthcare systems were inevitable (Parmar, Stavropoulou, & Ioannidis, 2016). Health budgets were reduced, and since the beginning of the crisis, 1.5 million additional people in Europe have had an unmet need for healthcare (A. Reeves, McKee, & Stuckler, 2015). A key challenge is both to achieve and to maintain the quality of healthcare, including new technologies within constrained budgets (Godman et al., 2016). This puts facilities such as hospitals in a difficult position. They are required to balance the contradictory and competing demands of efficiency and specialization, low operating costs and high-end amenities, minimized capital costs and optimum clinical quality (Clough et al., 2011).

Innovation is a key concept in healthcare, because innovation engineering and management allow for more efficient development of better concepts of medical devices (Lamé, Yannou, & Cluzel, 2018). This is essential for sustainable healthcare systems in the future (Ellner et al., 2015). In this light, there has been an increased interest in the Living Lab concept (Bergvall-Kåreborn, Eriksson, Ståhlbröst, & Svensson, 2009). In a Living Lab, multiple relevant stakeholders work together in a real life setting. Despite the growing recognition and use of Living Labs throughout society, literature on this phenomenon remains scarce (Dell'Era & Landoni, 2014).

In literature, drivers and barriers for the functioning of Living Labs can be identified. Drivers for succesfull Living Labs can be a clear strategic intention (Veeckman, Schuurman, Leminen, & Westerlund, 2013) and early user involvement (Mäkäräinen-suni, 2008). Barriers for Living Labs can be the need for diverse stakeholders with matching values (Guzmán et al., 2016) and the fact that Living Labs tend to be difficult to manage (Heikura & Schaffers, 2010). Overall, it is often problematic for Living Labs to exist on the long term. Communication can play an important role in enlarging Living Lab drivers and overcoming Living Lab barriers, with the ulitmate goal of making Living Labs a more stable way of collaborating. That means working in a strucutred way, without loosing the adaptivity that is requried for the open innovation that is typical for Living Labs.

It was the aim of this project to design a tool that supports coordinators of Living Labs by the means of communication, hereby enabling them to realize successful innovations on the healthcare market. The main research question was therefore formulated as follows: ***How can communication help the ResearchOR to work in a structured way without loosing its adaptivity?***

To this end, a literature study was conducted in which case studies of Living Labs have been analysed for drivers and barriers. After obtaining this perspective from theory, practice was investigated by conducting a case study. For this purpose, a Living Lab called the ResearchOR has been studied. The ResearchOR performs research and develops medical instruments and track and trace systems for operation rooms of hospitals. Participants of the ResearchOR have been interviewed, and the interviews too have been analysed for drivers and barriers. The results from the literature study and case study were analysed by looking at the different perspectives in literature and practice and by investigating causalities between drivers and barriers. Based on the drivers and barriers found in literature and practice a critical node has been identified. The critical node was the starting point for the design of a communication tool with the aim to support the coordinators of the ResearchOR.

Implementing medical innovations in healthcare is extremely complex. Collaboration between healthcare professionals, engineers, the industry and the government is crucial. Bridging between other parties that have views that are so very different from your own, however, is difficult. It is necessary to let some of your own habits go to be able to come to a mutual understanding of the innovation you are working on. This is precisely what happens in Living Labs. This does not mean, however, that the complex dynamics from the world of healthcare are not present in the Living Labs. The people in Living Labs tend to be very openminded and driven for the cause of the Living Lab. However, with different Living Lab projects come different stakeholders. That means that the network of a Living Lab is always changing. This has great impact on the functioning of the Living Lab, for the network brings the required expertise and resources.

Connected to the different levels of collaboration and the dynamic network is the problem statement of this thesis. The Living Lab method is relatively new, and Living Lab participants are rarely entrepreneurs. The result tends to be an unclear Living Lab structure with little focus on management. A consequence is that the overall structure, activities and vision are not always clear. Due to these unclarities, management might take more time than necessary. That makes that the participants in this case study tend to have a preference to keep the whole collaboration low key. However, valuable collaborations, research opportunities and funding might be lost.

Creating structure in Living Lab collaborations can save participants lots of time and frustration. It is crucial however, to maintain the free and open way of collaborating, which is characteristic for Living Labs. The key in finding the sweet spot between working like a community and a bureaucracy might be systematically tracking of involved Living Lab stakeholders. Much of the Living Lab structure and organization will be dependent on local circumstances. And that is both the strength and the curse of the Living Lab. But, being able to systematically track your stakeholders, their responsibilities and contributions by the means of a protocol could save many Living Labs a lot of time and unpleasant surprises.
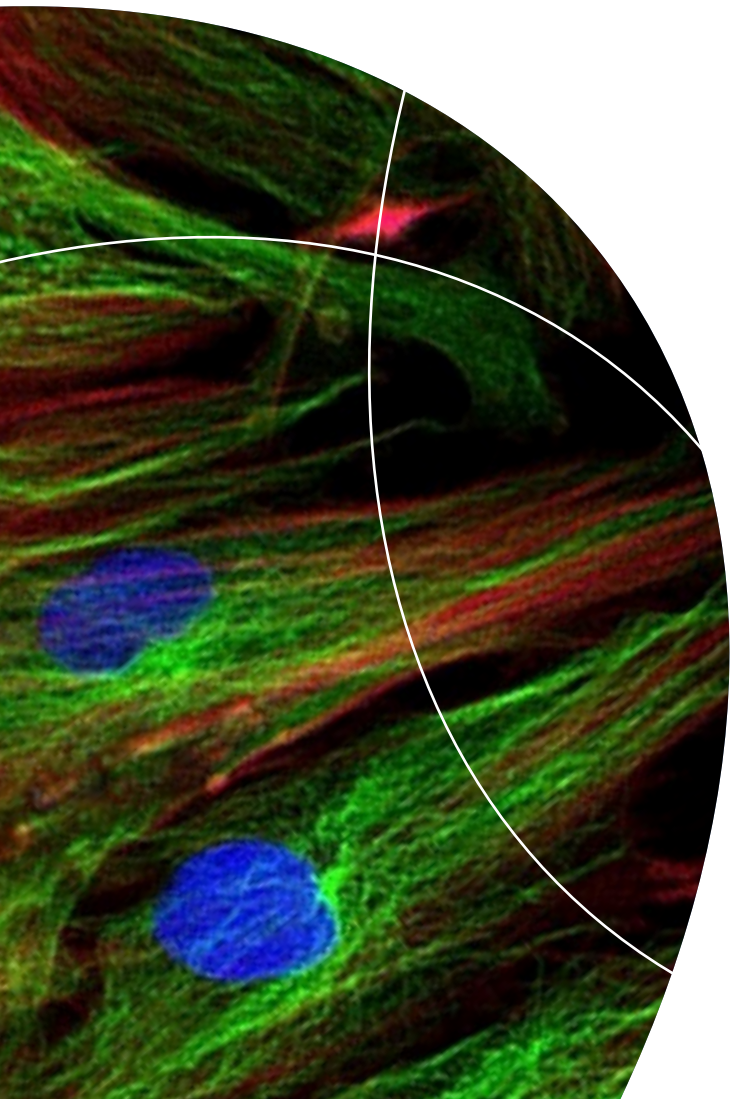
To this end, a guide was designed that supports the mapping of Living Lab stakeholders. The first step is to determine the strategic position of the Living Lab in both its network and in field of profession. This will help to create a Living Lab structure: the Living Lab knows what it means to its stakeholders and what role it would like to play. Determining internal stakeholder roles and responsibilities is accommodated by this knowledge. Furthermore, mapping previous, current and future projects can reveal trends the Living Lab was unaware of and support the creation of a shared Living Lab mission and vision. The mission and vision form the basis for the creation of synergy and clear goals in future Living Lab projects. The Living Lab structure also supports the mapping and evaluation of the Living Lab management, since it provides clarity in where the management should lead to. There is an evaluation loop between the search for balance between management and research in the Living Lab, and the mapping of the current management structure.

To conclude, the answer to the main research question (*How can communication help the ResearchOR to work in a sturctured way without loosing its adaptivity?*) might lie in mapping the vast changing composition of stakeholders Living Labs have to cope with. By clearly communicating who is involved and why, structure can be provided without turning the Living Lab into a static bureaucratic organization.

Content

1. Introduction

When the financial crisis struck Europe in 2008, consequences for the healthcare systems were inevitable (Parmar, Stavropoulou, & Ioannidis, 2016). Health budgets were reduced, and since the beginning of the crisis, 1.5 million extra people in Europe have had an unmet need for healthcare (A. Reeves, McKee, & Stuckler, 2015). A consequence is that healthcare systems are under pressure and struggle with restrained budgets and high workload. One of the key challenges is to both achieve and maintain the quality of healthcare, including new technologies within constrained budgets (Godman et al., 2016). This puts facilities such as hospitals in a difficult position. They are required to balance the contradictory and competing demands of efficiency and specialization, low operating costs and high-end amenities, minimized capital costs and optimum clinical quality (Clough et al., 2011).

Luckily, compelling opportunities and novel tools are emerging to solve these problems. Research provides us with insights that underscore the central importance of social, behavioural and environmental factors for people's health throughout their life span. Furthermore, technology is reshaping every dimension of healthcare. Think of the ability to treat organ system failure, the capacity to visualize metabolic processes in real time and the possibility of sharing and assessing care experiences (Dzau et al., 2017). It can be stated that innovation is a key concept in healthcare, because innovation engineering and management allow for more efficient development of better concepts (Lamé, Yannou, & Cluzel, 2018). This is essential for the sustainability of healthcare systems in the future (Ellner et al., 2015).

1.1 Implementing innovations in healthcare

Implementing innovations in healthcare is complex. Decision-making in healthcare often favours static efficiency. This means little or no change and goes at the expense of incentives to innovate. Obtaining valuable innovation, which is dynamic efficiency, is then a difficult thing to do (Ciani et al., 2016). Furthermore, since regulatory approval hinges on claims of similarity to previously approved devices, the current process may encourage the development of devices that provide only small improvements, often at a higher cost than their predecessors (Suter et al., 2011). This way of "playing it safe" decreases radical innovation and rebounds on the sustainability of healthcare systems (Ciani et al., 2016). Especially the large players in the industry, with a lot of capital, choose the safe path.

Not everyone follows this direction though. The smaller players such as engineers and entrepreneurs have the tendency to focus on the more radical innovations. However, to turn these radical innovations into products, their creators need the capital of the larger industry (Ackerly, Valverde, Diener, Dossary, & Schulman, 2009). This phenomenon is associated with the valley of death: a gap between development of science and development of commercial products, which makes that promising and valuable ideas remain undeveloped (Kirzner, 1997).

Overall, based on literature it can be stated that:

- The industry is interested in discoveries that guarantee positive response of customers, over which they can have ownership and compete (Sanami et al., 2017).
- Academia are losing their focus in making things that actually have benefit for patients. There is great interest in fields that are just 'discovering biology' (Sanami et al., 2017). The same goes for excitement of engineers about 'cool mechanisms'. Furthermore, academia who do want to make products that are of value for the market lack experience in entrepreneurship (Barr, Baker, Markham, & Kingon, 2009).
- Funding and regulation of the government is insufficient. Politicians want to hand out (strategic) favours and think of re-election (Nemet, Zipperer, & Kraus, 2018).

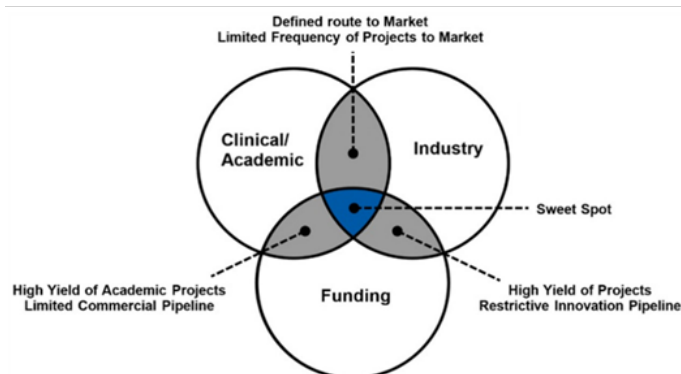But, for successful innovation, you need all three of them:

Figure 1 Identifying the combination of fields for successful innovation in healthcare (Sanami et al., 2017).

1.2 A new way of collaborating: Living Labs

In this light, there has been an increased interest in the Living Lab concept (Bergvall-Kåreborn, Eriksson, Ståhlbröst, & Svensson, 2009). In a Living Lab, multiple relevant stakeholders work together in a real-life setting (quite similar to Figure FIXME of Sanami et al.). Despite the growing recognition and use of Living Labs throughout society, literature on this phenomenon remains scarce (Dell'Era & Landoni, 2014). One of the reasons for the limited literature could be the difficult to define nature and limited data availability of Living Labs. Dell'Era & Landoni state that many definitions of Living Labs have been provided, but that these definitions do not highlight the original new product development approach as implied by the Living Lab methodology. Two main concepts in the literature are shared however: the real-life experimentation environment and the involvement of users in co-creation. Dell'Era & Landoni therefore define Living Labs as follows:

> "A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting."

Literature reports several promising Living Lab settings. Particularly when different Living Labs are networked, a systematic innovation strategy with desired outcomes appears to be possible (Feurstein et al., 2008). Excecution of succesfull Living Labs, however, also has its challenges. The most important ones are, as marked by Feurstein et al., related to the integration of infrastructure, the alignment of methodolgical aspects and the convergence of policy factors. These factors influence the sustainability of a Living Lab, which in turn is important for the value of a Living Lab. In other words, collarobrations within a Living Lab over a longer period of time lead to valuable innovations (Mastelic, Sahakian, & Bonazzi, 2015). Mastelic et al., argue that, for a Living Lab to be sustainable, a strong model based on a long-term strategy is needed that considers funding structures, target audiences and revenue streams. These factors should be assessed not only at one moment in time, but over time, across multiple Living Labs.

1.3 Communication in Living Labs

Dell'Era & Landoni have analysed Living Labs from a methodoglocial perspective. They state, for example, that other analyses from an organisational or institutional perspective would be usefull to gain a better understanding of Living Labs. Complementary to the methodology, one would then focus more on the interaction between the different groups within and connected to a Living Lab. In this light, communication appears to be an important but yet unexplored factor. More research is therefore required.

In literature, drivers and barriers for the functioning of Living Labs can be identified. Drivers for succesfull Living Labs can be a clear strategic intention (Veeckman, Schuurman, Leminen, & Westerlund, 2013) and early user involvement (Mäkäräinen-suni, 2008). Barriers for Living Labs can be the need for diverse stakeholders with matching values (Guzmán et al., 2016) and the fact that Living Labs tend to be difficult to manage (Heikura & Schaffers, 2010). Overall, it is often problematic for Living Labs to exist on the long term. Communication can play an important role in enlarging Living Lab drivers and overcoming Living Lab barriers, with the ulitmate goal of making Living Labs a more stable way of collaborating. That means working in a strucutred way, without loosing the adaptivity that is requried for the open innovation that is typical for Living Labs.

2. The aim and research questions

It is the aim of this project to design a tool that supports coordinators of Living Labs by the means of communication, hereby enabling them to realize successful innovations on the healthcare market. To design such a tool, this project will have the shape of a double diamond (Reeves, 2006). That means a process was followed in which divergating and convergating alternate. When a diamond widens, the process is in a divergating phase. When the shape of a diamond narrows, the process is in a divergating phase. This way, broad exploration can take place without the risc of loosing focus. Throughout the design process the Living Lab ReserachOR will be used as a case study.

Complementary to the aim of the project, the main research question is formulated as follows: ***How can communication help the ResearchOR to work in a structured way without loosing its adaptivity?*** To answer the main question, sub questions were formulated. First, drivers and barriers are investigated in both literature and practice. By doing so, the insights of the field can be taken into account and case specific factors can be explored. The third research question focusses on how the insights of literature and practice can be put to use for the ReserachOR (Living Lab Requirements). The three sub questions are descibed in the following sections. Per question, the relevant parts of the double diamond structure are displayed.
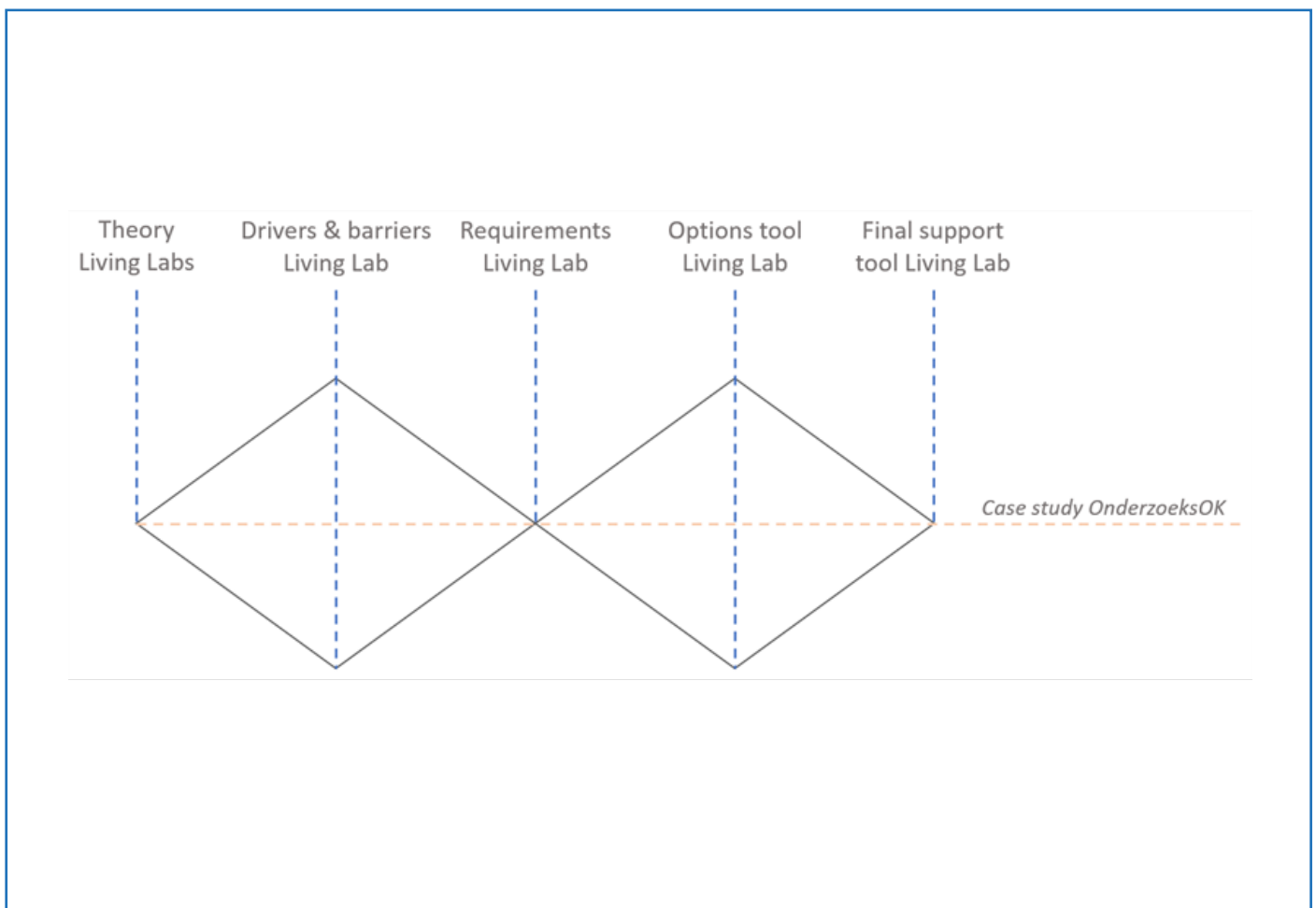
Figure 2 Overall outline of the double diamond shaped study**.**

2.1 Sub questions

1. What factors are important for the functioning of a
   Living Lab look according to *theory?*
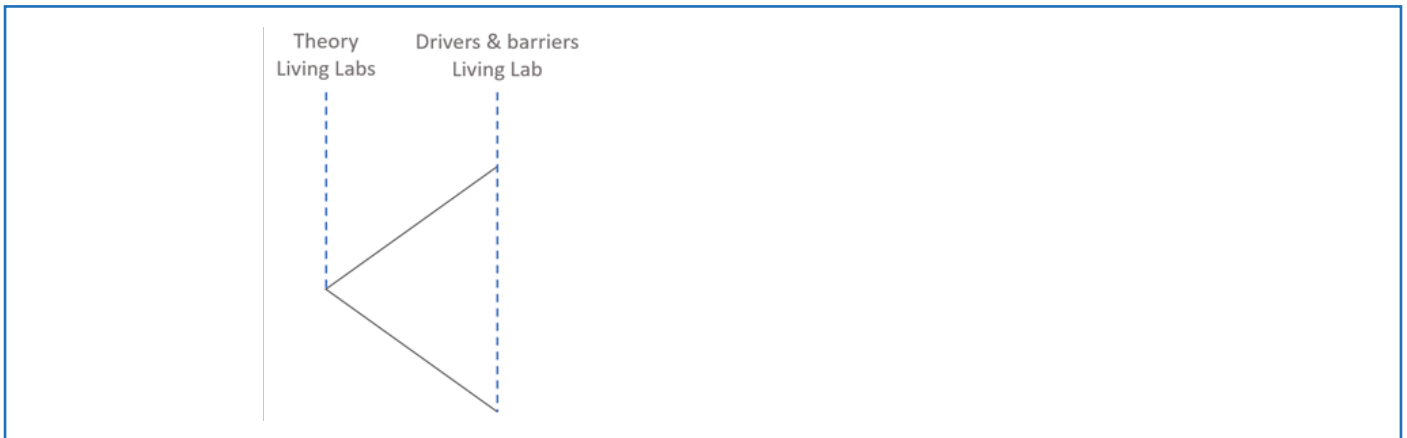

Figure 3 Discovery phase double diamond.

2. What factors are important for the functioning of a
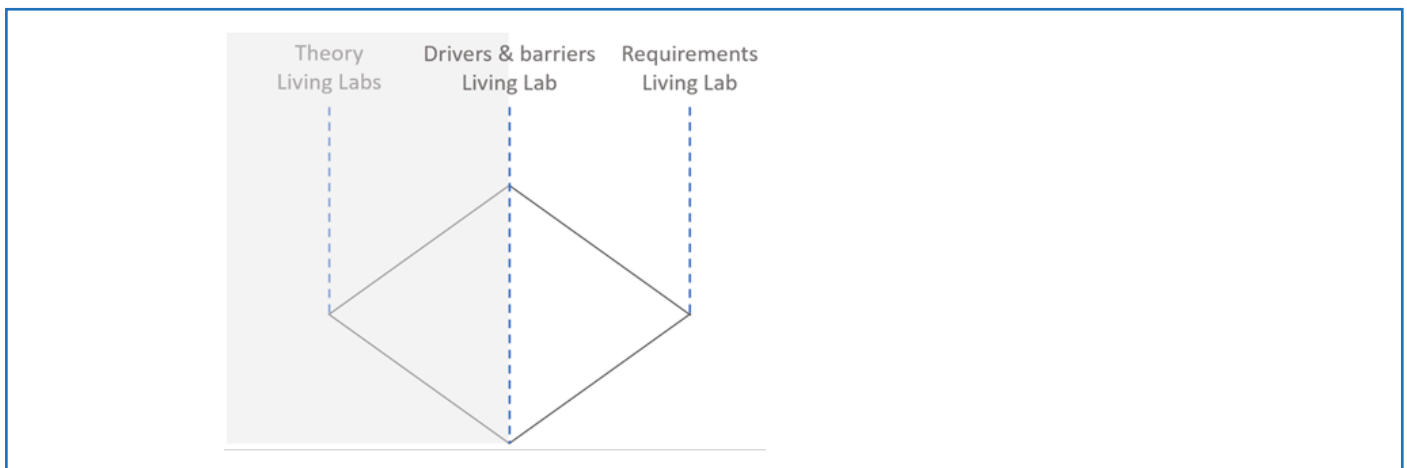   Living Lab according to *practice?*

Figure 4 Defining phase double diamond.

3. What communication elements could support the
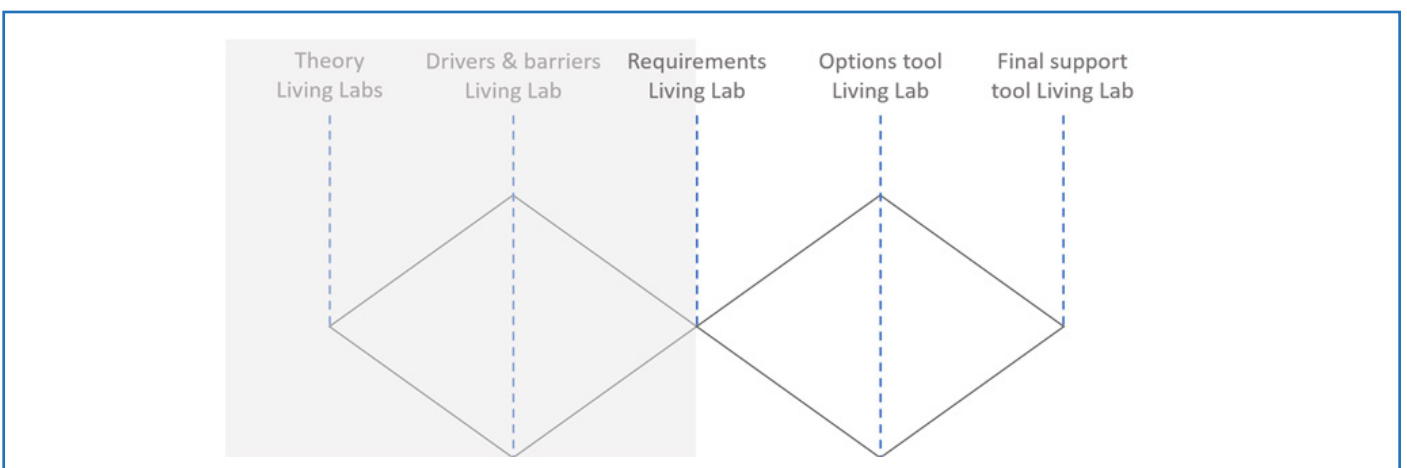   organizational structure of a Living Lab

Figure 5 Developing and delivering phase double diamond.

3. Background

To create a more precise focus on the subject of Living Labs, this chapter will describe how Living Labs look like and how they work according to literature. Furthermore, the Living Lab that is used as a case study in this research is introduced.

3.1 What is a Living Lab

The question of what a Living Lab is brings us back to the definition of Dell'Era and Landoni (2014): ***"A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting."*** In this definition a Living Lab is defined as a methodology. To further specify, Dell'Era and Landoni identify four different specifications for this methodology: open, closed, value capturing and value creation (Figure 6). These specifications are based on two variables that specify the two main peculiarities of the Living Lab methodology: the interaction with users and decisions regarding platform technology.

Closed Living Labs enable for more focused and in-depth user feedback, but require the capacity to select participants and limit access to the experience setting. Open Living Labs are easier to implement and allow for more diverse feedback, but require the capacity to filter all the results and manage a greater number of users.

The second variable Dell'Era and Landoni identify is the role of platform technology. Here, a distinction is made between value appropriation and value creation strategies. A Living Lab with a value creating strategy focuses on the exploration of opportunities generated by new technologies. A Living Lab with a value appropriation strategy are focused on exploiting opportunities provided by existing technologies. For value creating strategies one could argue that the creation of strategic assets is not enough to obtain and maintain a competitive position in the market, and that strategies of value appropriation are crucial for transforming strategic assets into effective results and maintaining them over time.
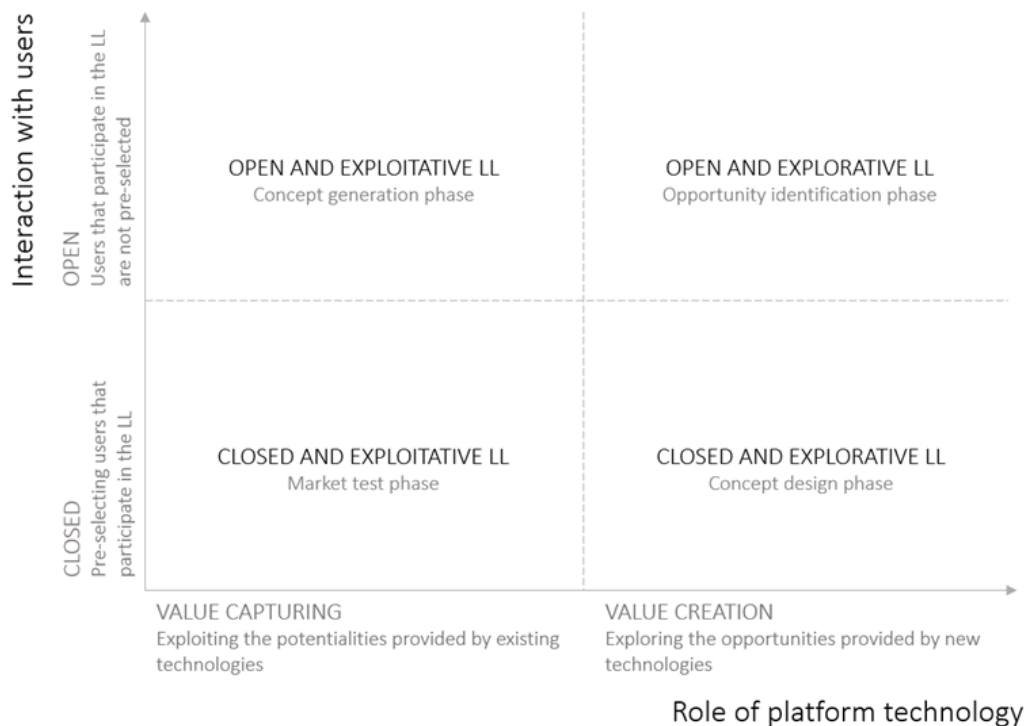
Figure 6 Specifications of the Living Lab methodology, by the means of the variables 'interaction with users' and 'role of platform technology' as described by Dell'Era and Landoni (2014).

The first variable, interaction with users, takes into account that all Living Labs involve aware users in the co-creation process. However, participation may be open to all potential users in some Living Labs, while in other Living Labs the users are pre-selected. This is a distinction worth looking at, because a change in perspective occurs from a user-centred design process to a design process centred upon participatory experiences (Sanders, 2002).

3.1.1 Different types of Living Labs

The intersection of these two variables results in four different kinds of Living Labs. The differences between these Living Labs mainly occur in certain phases of the design process. The kind of Living Lab and the design phase for which their strategy is most suited is shown in the four quadrants of the matrix in Figure 6.

Next to Dell'Era and Landoni, others have aimed to identify different types of Living Labs as well. Leminen et al. (2012) define Living Labs as open-innovation networks. Similar to Dell'Era and Landoni, they identify four different types of Living Labs. Their distinction however is based on the type of central party whose interests dominate the network's operation. This results in a Utilizer-driven, Enabler-driven, Provider-driven or User-driven Living Lab (Table 1).

Schuurman et al. (2012) take the four types of Living Labs of Leminen as a starting point in their search for Living Lab typologies. Based on literature study and 64 case studies they identify four Living Lab types, making the distinction more on their working principle than on the dominant stakeholder of the network (Table 2).

Table 1 The four types of Living Labs adapted from Leminen et al. (2012).

	Utilizer-driven	*Enabler-driven*	*Provider-driven*	*User-driven*
Purpose	Strategic R&D activity with pre-set objectives	Strategy development through action	Operations development through increased knowledge	Problem solving by collaborative accomplishments
Outcomes	New knowledge for product and business development	Guided strategy change into a preferred direction	New knowledge supporting operations development	Solutions to users' everyday-life problems
Lifespan	Short	Short/medium/long	Short/medium/long	Long

Table 2 The four types of Living Labs of Schuurman et al. (2012).

	Living Labs for collaboration and knowledge support activities	*Original 'American' Living Labs*	*Living Labs as extension to testbeds*	*Living Labs supporting context research and co-creation*
Description	Multi-stakeholder collaboration, focus on collaborative platforms, knowledge sharing and community development	Laboratory made to resemble the real-world, smaller scale, data capturing, can also be in-home research on a small scale focusing on ethnographic methods	Environments within which users and stakeholders can collaborate in the creation and validation of ICT services	Environments aimed to support innovation processes focusing on the early development phases of needs analysis and early design
Corresponding LL types Leminen et al. (2012)	Enabler-driven	Provider-driven	Provider-driven infrastructure with utilizer-driven projects	Utilizer-driven

3.1.2 Living Lab building blocks

Despite the many different Living Lab types and their approaches, one can look at the overall building blocks of a Living Lab. Veeckman et al. (2013) identified Living Lab characteristics and divided them on a generic level (i.e. the Living Lab environment) and on a project level (i.e. the Living Lab approach). Through this approach, they also identify the Living Lab Triangle: the triangulation between the environment, approach and outcome in Living Labs (Figure 7). With this framework the interplay between the setup of the Living Lab environment and the output of the projects can be studied. Hereby, all eleven characteristics of a Living Lab are scored and connected to the outcome of the Living Lab.

Overall, it appears not an easy task to describe what a Living Lab is in a more precise way than the general definition of Dell'Era and Landoni. There are many different ways of bringing the Living Lab methodology into practice, and many different types of Living Labs can be identified based on their structure, network and way of working. It is worthtaking notice, however, that all these different types of Living Labs also imply different outcomes.

Especially in Table 1 with the Living Lab types of Leminen et al., it becomes apparent that some Living Labs produce knowledge, some strategy and others tangible solutions. This is in line with the causal relationship that is described by Veeckman et al. between the Living Lab environment and outcome. It is questionable how aware Living Lab participants are of all these different types of Living Labs and their outcomes, and how consciously the choice has been made to shape the Living Lab they are in.
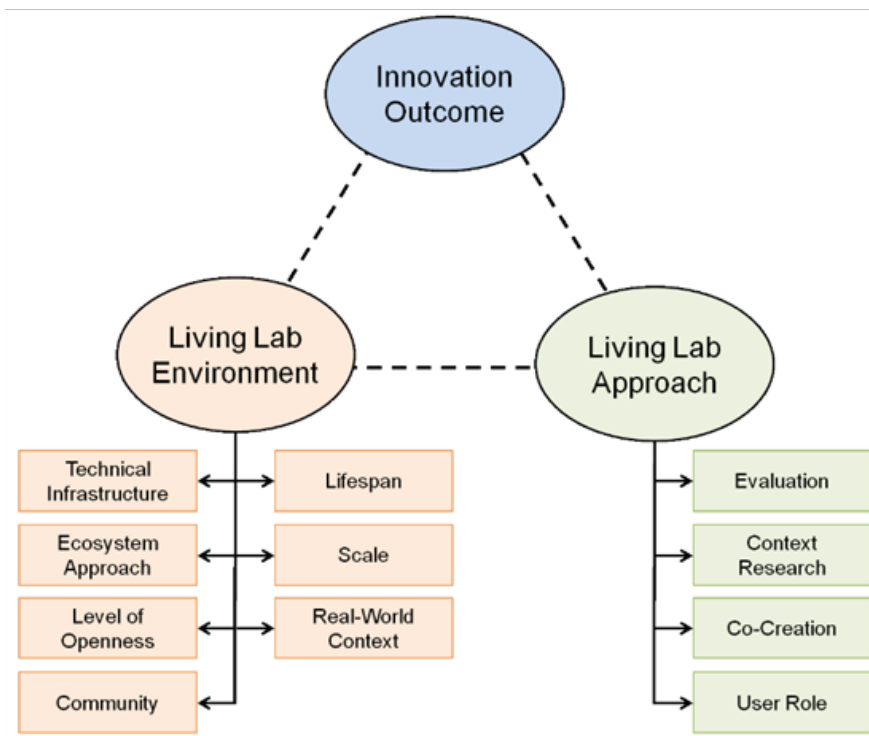

Figure 7 The Living Lab Triangle; the triangulation between environment, approach and outcome in Living Labs (Veeckman et al., 2013).

3.2 Living Lab performance

Living Labs may come in many shapes and sizes, the world of literature is unanimous about their great potential. Great potential to bring inventions to the market (Van Geenhuizen, 2018), to become a development platform for new technology, innovative ideas and new services (Mäkäräinen-suni, 2008), and to facilitate collaboration between users, industry and research stakeholders. Indeed, a study of Schuurman, De Marez, & Ballon (2016) including 27 Living Lab projects showed that Living Labs can open up company boundaries towards user contributions and that user contributions led to modifications of the innovation. Moreover, two-thirds of the projects resulted in market introduction or further development. Overall Schuurman et al. conclude that Living Labs can be successful facilitators for open innovation in start-ups and SMEs.

Living Labs also face challenges. A core advantage of the Living Lab concept is the multi-contextual sphere in which innovations are developed. However, this also means Living Labs have a heterogeneous infrastructure. This can make collaboration within Living Labs very challenging (Feurstein et al., 2008). Standardisation and certification are marked as important factors to address. Feurstein et al. also point out that in many cases the decision to use a certain working method in a Living Lab seems to be arbitrary, and based on regional developments rather than on a methodological selection of best practices in the field. Overview and a coherent toolset to select best practices for Living Labs are therefore required. A third challenge identified by Feurstein et al. concerns policy. The political will of stakeholders has to converge to allow for successful endeavours. This requires actions of Living Lab stakeholders to understand political goals and the vision their Living Lab follows.

3.3 Living Labs in healthcare

Living Labs have great potential for open innovation, but shaping and managing one is complicated. How does this work for Living Labs in healthcare? Due to pressure on healthcare budgets the need for quick implementation of innovations rises (Van Geenhuizen & Guldemond, 2013). Van Geenhuizen & Guldemond observe however that bringing such medical innovations to the market and have them customized requires a lot of research and therefore time. These are efforts in which Living Labs can be considerably helpful. In order to do so, Van Geenhuizen & Guldemond have identified six critical factors for Living Labs in healthcare:

1. An appropriate selection of users, risk groups and hospital personnel, hereby paying attention to their needs, motivation, capabilities, representativeness, social influence, loyalty etc.

2. Sufficient trust and alignment between partners, such as the medical faculty, supplying faculties, academic hospital and non-academic hospital, multinationals and smaller firms. Hereby it is important to find a balance between sufficient alignment in vision and diversity in disciplines.
3. Business models that divide tasks and distribute costs/benefits, but also allow for openness. Also included should be value chains that are fully integrated to enable economic success. After some yeas, evaluation of the leading concept should follow.
4. A one-stop-shop for medical researchers at university and academic hospital and for user-groups, and a structured innovation process, no matter the nature of the invention, with clear go/no go decisions, and with attractive project formulation to raise the interest of investors.
5. Attention for technology as a means for monitoring of patients and risk groups at home and for analysis of user-response to the inventions, but avoiding dominance of technology and the rise of barriers.
6. Dealing with potentially disturbing legal issues, such as intellectual ownership protection and legal liability issues following from the collaborative nature of Living Labs and the involvement of human health.

3. 4 Contribution of this research to Science Communication and Biomedical Engineering

Living Labs could play an important role in establishing the sweet spot between the clinical/academic field, the industry and funding that is required for successful innovation in healthcare. The field of Biomedical Engineering is part of this sweet spot. Improving the collaboration within Living Labs contributes to the development of better medical devices.

From a Science Communication point of view, investigating Living Labs will give insight in how very different stakeholders work closely together. Related communication topics are Communities of Practice and social capital. The investigation of multidisciplinary collaboration in Living Labs can be of great value for many other organizations that work on innovation.

3.5 Case description: the ResearchOR

In this research, a case study will be conducted to validate findings in literature and to create specific case to design for. For this purpose, a Living Lab called the ResearchOR has been studied. The ResearchOR performs research and develops medical instruments and track and trace systems for operation rooms of hospitals. The ResearchOR was initiated in 2015. It started with a project of the TU Delft, Reinier de Graaf hospital and the company Doublesense. This project was called DORA (Digital Operating Room Assistant). After this successful collaboration more projects followed (Figure 8). For easier access to the OR and better organization of finance a multidisciplinary team was formed, including surgeons, engineers, OR and innovation managers, and medical technical companies. A Living Lab was born.

The centre of this Living Lab lies in the name: the Research OR. The Reinier de Graaf Hospital has a special operation room (OR), equipped with an infrastructure of sensors, camera's and other materials which allow for non-instructive testing testing, observing and monitoring processes and possible new products.. Two constant partners are the Reinier de Graaf Hospital and the TU Delft. Furthermore, the ResearchOR was registered as a Living Lab in 2017 at Medical Delta.
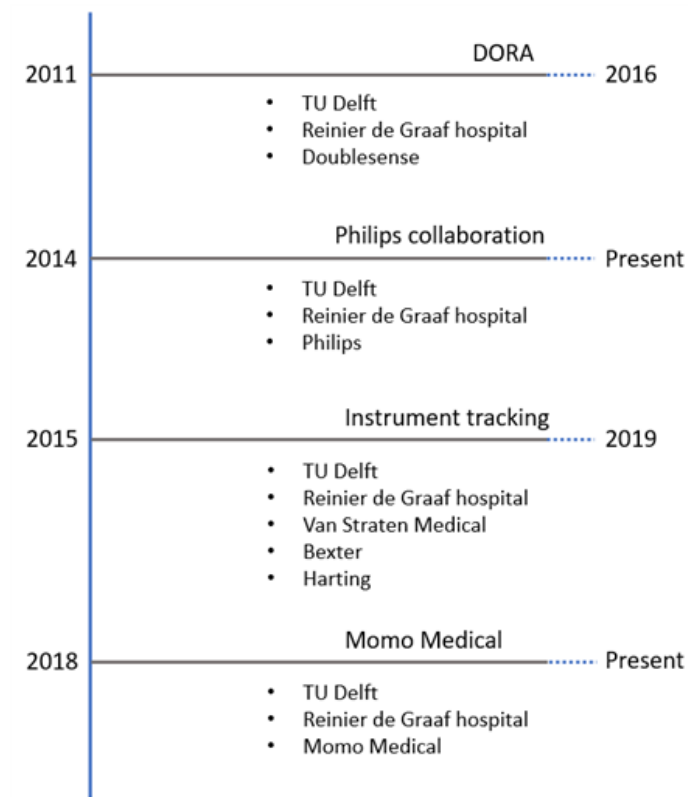
Figure 8 Timeline with some of the projects and stakeholders of the ResearchOR.

4. Thesis structure

This thesis consists of seven parts, with the first diamond containing part 1, 2,3 and 4 and the second diamond containing part 5, 6 and 7 (Figure 9). The first part is a literature study in which case studies of Living Labs have been analysed for drivers and barriers. The second part is a case study in which participants of the ResearchOR have been interviewed. The interviews too have been analysed for drivers and barriers. In part 3 and 4 the results from the literature study and case study are analysed by looking at the different perspectives in literature and practice and by investigating causalities between drivers and barriers.

The second diamond consists of a design process. Based on the drivers and barriers found in literature and practice a critical node has been identified. The critical node is the starting point for the design of a communication tool with the aim to support the coordinators of the ResearchOR. In the rest of the report, the 7 parts will be described in more detail by illustrating the aim, method, results and interpretation per section.

RIGHT: Figure 9 Double diamond with the seven parts of the thesis and the steps they consist of.

PART			
PART 1	27 case studies from literature	17 drivers from literature	**10 commandments of Literature**
		10 barriers from literature	
PART 2	7 interviews with ResearchOR stakeholders	11 drivers from practice to participate	**10 commandments of Practice**
		8 barriers from practice to participate	
		10 drivers from practice for LL projects	
		13 barriers from practice for LL projects	
		10 Ideal LL factors	
PART 3	Drivers & barriers from *literature*	Perspective matrix	**Overview perspectives literature & practice**
	Drivers & barriers from *practice*		
PART 4	Drivers & barriers from *literature*	Causal diagram	**Critical node and problem statement**
	Drivers & barriers from *practice*		
PART 5	Problem statement	Design criteria / Morphological chart elements / Management literature	**Morphological chart**
PART 6	Morphological chart	Concept 1 / Concept 2 / Concept 3 / Harris profile	**Final design**

Answer sub question 1

Answer sub question 2

Answer sub question 3

PART 7

23

5. **PART 1** Drivers and barriers in literature

In this chapter, Living Lab drivers and barriers are identified after an extensive search of literature. Drivers and barriers from this literature study were combined in the 10 Commandments of Literature and form the answer to the first sub question.

5.1 Aim

To answer the first sub question, *What factors are important for the functioning of a Living Lab according to literature?*, a systematic literature study was conducted around this question. In this study, it was the aim to extract drivers and barriers from case studies on Living Labs.

5.2 Method

Table 3 displays the used search terms, criteria and results used in this study. As can be seen from Table 3, 27 articles were included. These articles have been imported in Atlas.ti 8. Features and factors in the case studies that were indicated as positive influencers on Living Labs have been labelled as drivers. Features and factors that were indicated as negative influencers were labelled as barriers. The drivers and barriers of the 27 articles have been exported to Excel, sorted per different article and author (Table 4).

Table 3 Search terms, criteria and results used for the systematic literature study to answer the first sub question.

Search terms	Search engine	Results	Criteria	Filtered result	After reading abstracts & removing duplicates	Result after reading the articles in full
Living Lab AND case study	Scopus	193	Living Lab and case study are mentioned in abstract	68	59	27
						27

Table 4 Example of an analysed article with corresponding drivers and barriers.

Article	Reference	Driver	Barrier
Living Labs in Health Innovation: Critical Factors in their Application	(Van Geenhuizen & Guldemond, 2013)	'The involvement of users, particularly the need for close and intensive interaction.'	'Differences in values, etc. between university and industry'
		'The composition of stakeholders and the required functionalities of the networks, in view of creation of vertical cooperation in the value chain.'	'Improve financial factors and reduce financial risks'
		'First, an appropriate selection of users, such as patients, risk groups and hospital personnel, regarding their needs, motivation, capabilities, representativeness, social influence, loyalty, etc.'	'Dealing with potentially disturbing legal issues, such as intellectual ownership protection and legal liability issues following from the collaborative nature of living labs and the involvement of human health.'

Next, the drivers and barriers have been clustered in themes. Drivers within the same theme were given the same code, the same goes for the barriers. Table 5 shows an example of two articles and some of their coded drivers and barriers. The blue blocks show drivers within the same theme, the orange blocks show barriers within the same theme. For validation, a fellow communication master student has checked the labelling of the drivers and barriers.

After the clustering, the themes were named based on the contend of the drivers and barriers in them. Table 6 (next page) shows an example of the theme's D_4 and B_3, and the drivers and barriers assigned to them. Themes that only included one driver or barrier have not been included in further analysis based on the argument of too little validation. The themes will be from this point on be referred to as the overall drivers and barriers.

Table 5 An example of two analysed articles and some of their drivers and barriers, to illustrate how the drivers and barriers have been clustered in themes. The blue blocks show drivers within the same theme, the orange blocks show barriers within the same theme.

Article	Reference	Driver	Code	Barrier	Code
Living Labs in Health Innovation: Critical Factors in their Application	Van Geenhuizen & Guldemond, 2013	'The involvement of users, particularly the need for close and intensive interaction.'	D_4	'Differences in values, etc. between university and industry'	B_3
		'The composition of stakeholders and the required functionalities of the networks, in view of creation of vertical cooperation in the value chain.'	D_7	'Improve financial factors and reduce financial risks'	B_5
		'First, an appropriate selection of users, such as patients, risk groups and hospital personnel, regarding their needs, motivation, capabilities, representativeness, social influence, loyalty, etc.'	D_4	'Dealing with potentially disturbing legal issues, such as intellectual ownership protection and legal liability issues following from the collaborative nature of living labs and the involvement of human health.'	B_7
Best Practices, Innovation and Development: Experiences from Five Living Lab Innovation Environments	Mäkäräinen-suni, 2008	'Early involvement of users'	D_4	'Avoid large numbers of actors, powerful/dominant actors and strong interdependency; avoid actors that do not comply with living lab values'	B_3

Table 6 Example of the Driver theme D_4 and the Barrier theme B_3, including some of the corresponding drivers and barriers and their sources.

D_4 *Early user involvement and good communication with users*	Source	B_3 *Inequality or incompatibility in the Living Lab*	Source
'The involvement of users, particularly the need for close and intensive interaction.'	Van Geenhuizen & Guldemond, 2013	'Differences in values, etc. between university and industry'	Van Geenhuizen & Guldemond, 2013
'First, an appropriate selection of users, such as patients, risk groups and hospital personnel, regarding their needs, motivation, capabilities, representativeness, social influence, loyalty, etc.'	Van Geenhuizen & Guldemond, 2013	'Avoid large numbers of actors, powerful/dominant actors and strong interdependency; avoid actors that do not comply with living lab values'	Mäkäräinen-suni, 2008
'Early involvement of users'	Mäkäräinen-suni, 2008		
'the project illustrates that it is not the quantity of user involvement that determines the categorization, but rather the influence that is wielded by the users.'	Bergvall-kåreborn, Howcroft, Ståhlbröst, & Wikman, 2010		
'Treating users as equal co-creators instead of research objects'	Leminen & Westerlund, 2012		

5.3 Results

The systematic literature study resulted in 17 overall drivers and 10 overall barriers (Table 7). The full table with sources and number of sources are presented in Appendix 1. See Appendix 1 for the coded drivers and barriers and the themes they are clusterd in. In Appendix 2 the drivers and barriers are described in more detail.

5.4 Interpretation

As can be seen from Table FIXME, some drivers and barriers are of a similar theme, but with an opposite perspective. If there is sufficient money, it can be a driver. If there is a lack of money, it is a barrier. The drivers and barriers have therefore been combined in 10 'commandments' who are of influence on the performance of a Living Lab. These commandments are composed based on their coherence in subject and an evaluation of the drivers and barriers in Table 7 with one of the coordinators of the ResearchOR. The 10 commandments and corresponding drivers and barriers are displayed in Table 8.

Table 7 Overview of the drivers and barriers of Living Labs according to literature.

Drivers (D)		Barriers (B)	
1	Living Labs should have a clear strategic intention	1	Legal issues (IP etc.)
2	Shared values amongst stakeholders	2	Inequality amongst participants in Living Labs
3	Openness and trust amongst stakeholders	3	Financial risks
4	Early user involvement and good communication with users	4	There is little awareness about Living Labs
5	Motivated participants	5	It is hard to show (long term) value of Living Labs
6	Good working method and plan	6	Need for diverse stakeholders with matching values
7	Adequate participants	7	Management of living labs proves to be difficult
8	Mixed set of tools to discover new opportunities	8	Strict regulations in healthcare
9	Be able to handle conflicts in the Living Lab network	9	Low user involvement
10	Have a physical common space	10	The step from living lab to market can be difficult to make
11	Be compliant with policies/regulations		
12	Attractive network		
13	Money		
14	Living labs can be a facilitator of market transition		
15	Display of successful projects/collaborations		
16	Living labs create knowledge and value for their stakeholders		
17	Living labs allow for more freedom to make mistakes		

Commandment	Drivers		Barriers	
1 A Living Lab must be managed	D_1	Living Labs should have a clear strategic intention	B_7	Management of Living Labs proves to be difficult
	D_6	Good working method and plan		
	D_8	Mixed set of tools to discover new opportunities		
2 Living Lab participants should have diverse backgrounds and shared values	D_2	Shared values amongst stakeholders	B_6	Need for diverse stakeholders with matching values
	D_7	Adequate participants		
	D_10	Have a physical common space		
3 Living Lab participants must be equals	D_3	Openness and trust amongst stakeholders	B_2	Inequality amongst participants in Living Labs
4 Users must be involved in Living Lab projects from the start	D_4	Early user involvement and good communication with users		
	D_5	Motivated participants		
	D_9	Be able to handle conflicts in the Living Lab network		
5 Living Labs must understand their position in their network and field of profession	D_11	Be compliant with policies/regulations	B_1	Legal issues (IP etc.)
			B_8	Strict regulations in healthcare
6 Living Labs should invest in creating an attractive network	D_12	Attractive network		
7 Living Labs need money	D_13	Money	B_3	Financial risks
8 Living Labs should exploit their role as facilitator of market transition	D_14	Living Labs can be a facilitator of market transition	B_10	The step from Living Lab to market can be difficult to make
	D_17	Living Labs allow for more freedom to make mistakes		
9 Living Labs should display their successful projects and collaborations	D_15	Display of successful projects/collaborations	B_4	There is little awareness about Living Labs
	D_16	Living Labs create knowledge and value for their stakeholders	B_5	It is hard to show the (long term) value of Living Labs
10 Living Labs must be alert to conflict in their projects and network			B_9	Low user involvement

5.4.1 Answering the first sub question

The first sub research question was: *what factors are important for the functioning of a Living Lab according to literature?* As an answer, the 10 commandments give an indication of how a Living Lab should be constructed and organized according to literature.

Literature commandment 1: A Living Lab must be managed

For Living Labs to be sustainable and be stable over a longer period of time, they should be run properly. This means a clear strategic intention and working method (Leminen & Westerlund, 2012). Furthermore, a mixed set of tools to discover new opportunities such as projects and collaborations is beneficial for the stability of the Living Lab (Guzmán et al., 2016). However, the management of Living Labs proves to be difficult (Heikura & Schaffers, 2010). Participants of a Living Lab are stakeholders because their profession connects them with the project. This means most participants have a main job and that management of the Living Lab is something on the side. Investing time and money in the management of the Living Lab as a whole might then not be a very inviting thing to do.

Literature commandment 2: Living Lab participants should have diverse backgrounds and shared values

For maximal performance, project groups in Living Labs should consist of a diverse group of stakeholders (Canzler et al., 2017). These stakeholders should be adequate, and bring something to the table in terms of knowledge or resources (Van Geenhuizen & Guldemond, 2013). This way, the new product or service can be evaluated from the different points of view that are relevant in 'the real world'. However, for a group of people with different backgrounds and points of view to work together it is important they have shared values (Van Geenhuizen, 2018). Furthermore, a physical common workspace also improves the collaboration (Baltes & Gard, 2006).

Literature commandment 3: Living Lab participants must be equals

Despite a certain level of shared values, Living Lab participants will always have interests of their own. Openness and trust amongst stakeholders is important for good collaboration (Veeckman et al., 2013). For the unique situation in a Living Lab is that you know the interests of all stakeholders, and that you try to combine them in the project that you share. This could also create a safe environment that allows for more freedom to make mistakes (Canzler et al., 2017). Important for openness and trust is equality. If one participant is a lot more powerful than the rest, his or her interests could get more priority (Mäkäräinen-suni, 2008). Trusting this party and being open about your own interests can then become difficult.

Literature commandment 4: Users must be involved in Living Lab projects from the start

One of the things that characterizes the Living Lab method is how the user is involved. The user should be involved from the start. Good communication with the user is crucial to keep the users both involved and motivated (Bergvall-kåreborn et al., 2010).

Literature commandment 5: Living Labs must understand their position in their network and field of profession

When a group of people from different organizations works together in a Living Lab, having a legal status and clarity about Intellectual Property can help to avoid many problems. Furthermore, especially for Living Labs in the healthcare sector, it is important to be compliant with the corresponding policies and regulations. Besides avoiding legal issues, it is beneficial to be aware of relevant policies and regulations because then the right stakeholders (such as the government) can be tied to the network of the Living Lab . This can open doors and make the network more powerful (Van Geenhuizen & Guldemond, 2013).

Literature commandment 6: Living Labs should invest in creating an attractive network

Naturally, an attractive network attracts new stakeholders to the Living Lab. This can ensure both projects and funding (Heikura & Schaffers, 2010).

Literature commandment 7: Living Labs need money

As with most projects and organisations, a minimal amount of money is required for good functioning of a Living Lab (Schuurman et al., 2011). The majority of current Living Labs is dependent on funding of external parties. This could increase financial risks and give stakeholders with financial resources more influence. At the same time, being a non-profit organization could also increase focus on the quality of the research and knowledge gained instead of profit.

Literature commandment 8: Living Labs should exploit their role as facilitator of market transition

Living Labs offer the possibility to test products and services in settings in practice. Therefore, Living Labs can have an important role in the success of the market entrance of the products that arise from their projects (Baltes & Gard, 2006). The transition from Living Lab project to market can be difficult, for in many cases only a small number of users participated in the projects (Schuurman et al., 2011). If this small number is representable for the full market segment can be questionable. Still, Living Labs offer a unique opportunity of testing in practice, which can attract stakeholders with interesting projects and already create potential customers before the product has reached the market.

Literature commandment 9: Living Labs should display their successful projects and collaborations

To attract the right stakeholders and secure funding, it is important to show the long term value of the Living Lab (Engels et al., 2019). Display of successful projects and collaborations (in other words marketing) can therefore be useful.

Literature commandment 10: Living Labs must be alert to conflict in their projects and network

To ensure good collaboration and a positive experience of parties involved in the Living Lab, people within the Living Lab should be alert to conflict in their projects and in the Living Lab network. They should aim to resolve these conflicts (Mäkäräinen-suni, 2008; Paskaleva et al., 2015).
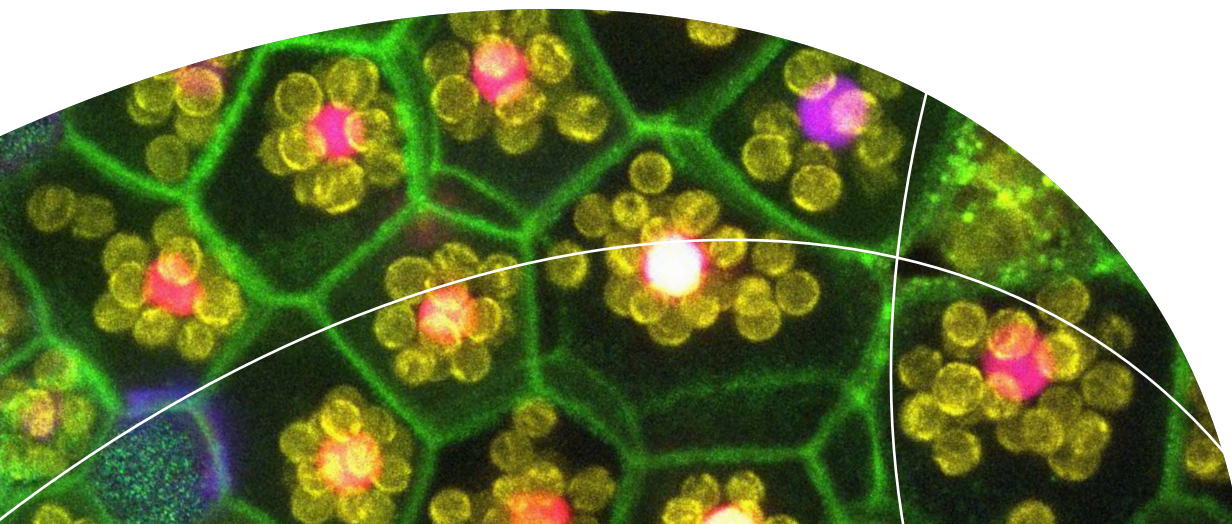
6. **PART 2** Drivers and barriers in practice

In this chapter, Living Lab drivers and barriers are identified in practice by the means of interviews with the participants of the ResearchOR. The drivers and barriers were combined in the 10 commandments of practice and form the answer to the second sub question.

6.1 Aim

To answer the second sub question, *What factors are important for the functioning of a Living Lab according to practice?*, semi-structured interviews have been conducted with seven participants of the ResearchOR. The aim of the interviews was to identify drivers and barriers specific to this case study, and to verify the drivers and barriers found in literature.

6.2 Method

6.2.1 Orientation: Mapping the ResearchOR

To create an overview and to understand the context of the ResearchOR, an extensive session has been held with one of the two coordinators of the Living Lab. In this session the five most important projects of the ResearchOR have been discussed, by filling in an Excel with the project name, the aim of the project, the time span, current status, stakeholders, drivers and barriers per stakeholder according to the coordinator, results and desired results of the project. Table 9 summarizes the results of this session. With this first impression of the stakeholders of the ResearchOR and their context, an interview protocol for semi-structured interviews has been set up and interviews with some of the stakeholders have been conducted.

Table 9 Overview the five most important projects of the ResearchOR, their aim, time span, current status and partners.

Project	Dora	Instrument tracking	[no name]	MoMo Medical	Colorpal
Aim	Development of a monitoring system for OR safety	Monitoring the use of instruments on the OR. By following the use of instruments the phase of the operation can be determined.	Efficiency monitoring of processes of the OR and Intervention room	Avoid bed sores	Put a balloon around a trocar to create a sterile environment in it.
Time span	2011 - 2016	2015 - 2019	2014 - present	2018 - present	2012 - 2014
Current status	Finished and on market	Is currently on hold. Monitoring with RFID (radio frequency identification) turns out to be difficult. There is a researcher who might continue on this subject however.	Up and running	Just received CE certification for the product	
Partners	TU Delft Reinier de Graaf Doublessense	TU Delft Reinier de Graaf Van Straten Medical Bexter Harting	TU Delft Reinier de Graaf Philips	TU Delft Reinier de Graaf MoMo Medical	TU Delft LUMC Medishield

6.2.2 Interview design

To validate the drivers and barriers in a structured way, the questions in the interviews were designed with the help of the Living Lab perspective matrix in Figure 10. During the literature study, I noticed a difference in perspective some articles take when assessing the success of Living Labs. Some take the functioning of the Living Lab network as a starting point. For example, Heikura & Schaffers (2010) state that Living Lab operations appear to be based on individuals that are deeply embedded into the member organization functions and structures. Other articles tend to use the functioning of Living Lab projects as a way to measure Living Lab success. Bergvall-Kåreborn et al. (2010) state that it can be a risk for Living Labs if the link between successful design and successful implementation is weak or non-existent.

Both statements can be true as they do not exclude each other. But by looking at the interaction between the functioning of Living Labs in terms of projects and in terms of network I believe I can ask more precise questions and investigate the perspectives in practice better. Therefore, this matrix makes a distinction between the functioning of the Living Lab stakeholders, and the functioning of the Living Lab projects. Furthermore, a distinction is made between micro and macro level. This way nine quadrants are created with perspectives that can be used for investigating the functioning of a Living Lab.

In the quadrants the stakeholder incentive (drive to work) and stakeholder involvement (ability to work) are linked to project success on different levels. From the top left corner with a single stakeholder and a single project, to a Living Lab network and the entire Living Lab community in the lower right corner. To validate the design of the Living Lab perspective matrix, sessions were held with three communication experts in which the matrix was evaluated.

On both micro and macro level questions have been asked about the functioning of the network and the (innovation) output of the projects in the ResearchOR. This way, participants have been asked to describe their role in the ResearchOR, what they perceive as drivers and barriers, and how they would describe their ideal Living Lab.
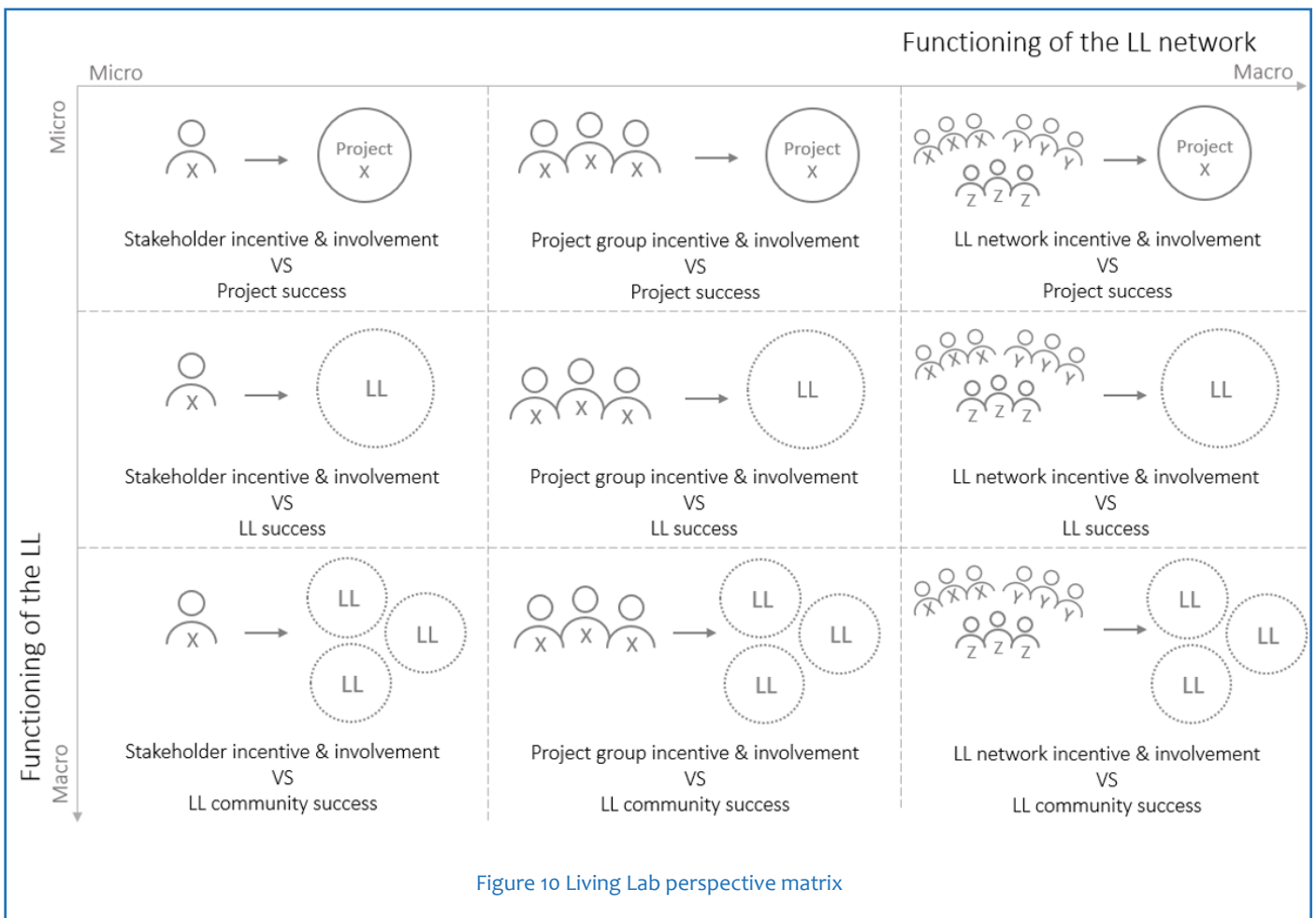

Figure 10 Living Lab perspective matrix

6.2.2 Drivers and barriers to participate and drivers and barriers for the Living Lab projects

The interviews have been recorded and written out. The written out versions have been labelled in Atlas.ti 8 for drivers to participate and drivers for the projects, and barriers to participate and barriers for the projects. The drivers and barriers have been exported to Excel. Table 10 shows an example of one interviewee and some of the (translated) drivers and barriers that were mentioned in the interview.

Next, in similar to the method used in the literature study, the drivers and barriers have been clustered in themes. Drivers within the same theme were given the same code, the same goes for the barriers. Table 11 shows an example of three interviewees and some of their coded drivers and barriers for projects. The blue and green blocks show drivers within the same theme, the orange blocks show barriers within the same theme.

Table 10 Example of one of the interviewees and the corresponding drivers to participate, drivers for the projects, barriers to participate and barriers for the projects.

Interviewee	Driver to participate	Driver project	Barrier to participate	Barrier project
Surgeon Reinier de Graaf hospital	'I think we need to improve healthcare. We must make healthcare safer and more efficient, through the deployment and development of safe technology.'	'A driver is that you have a clear goal. And that has to be an improvement of patient care or efficiency. So, potentially you really need to have a strong product and make people see that.'	'Sometimes it takes you a lot of time while you actually have to operate a patient.'	'A barrier is work pressure'
	'I also do it to improve the work of people in healthcare, and to improve their quality of life. That they work more pleasant and safer. So I do it for the patients, but especially for the employees. You know, satisfied employees will also take better care of their patients.'	'The projects also just have to be paid and financed. Because it is not possible to have everything paid for by the hospital. So, good funds through which you can get the right people is also very important.'	'Malfunctioning of equipment'	'Legislation can also be a barrier. Such as the MDR and the AVG'

Table 11 Overview with an example of three interviewees and some of the coded drivers and barriers for projects that were mentioned in the interviews. The coloured blocks highlight drivers and barriers that were labelled with the same code.

Trauma surgeon Reinier de Graaf hospital	'A driver is that you have a clear goal. And that has to be an improvement of patient care or efficiency. So, potentially you really need to have a strong product and make people see that.'	Dpr_2	'A barrier is work pressure'	Bpr_7
	'The projects also just have to be paid and financed. Because it is not possible to have everything paid for by the hospital. So, good funds through which you can get the right people is also very important.'	Dpr_3	'Legislation can also be a barrier. Such as the MDR and the AVG'	Bpr_9
Executive partner Doublesense	'An innovation budget, something like that. Maybe that's there too. I don't know about Reinier. But in a general sense that can of course help. And then the money does not have to come from a specific department.'	Dpr_3	'But the OR is mainly busy, and that may sound a bit negative, with the things of today. They are not that concerned with innovation, that lies with other departments.'	Bpr_10
Innovation coordinator Reinier de Graaf hospital	'So you don't innovate to develop fun gadgets for surgeons, or fun gadgets for a dermatologist. But you really do it with a very strict goal. And that is increasing patient safety and making care affordable.'	Dpr_2	'It costs me a lot of effort to get out of the nursing departments where, for example, the TU can help them.'	Bpr_10

6.2.4 Ideal Living Lab Factors

After the clustering, the themes were named based on the contend of the drivers and barriers in them.
Table 12 shows an example of the theme's Dpa_2 and Bpa_10, and the drivers and barriers assigned to them. Themes that only included one driver or barrier have not been included in further analysis based on the argument of too little validation. The themes will be from this point on be referred to as the overall drivers and barriers.

The descriptions of the ideal Living Lab by the different participants have also been analysed and labelled for factors the ideal Living Lab should include. Table 13 shows a segment of one of the descriptions and the factors that have been abstracted from it. The factors that were abstracted have been labelled in Excel. Again, the factors within the same theme have been given the same code (Table 14, next page).

Table 12 Example of the Driver theme Dpr_2 and the Barrier theme Bpr_10, including the corresponding drivers and barriers.

Dpr_2 Have a clear goal	Bpr_10 There is little focus on innovation within the hospital
'A driver is that you have a clear goal. And that has to be an improvement of patient care or efficiency. So, potentially you really need to have a strong product and make people see that.'	'But the OR is mainly busy, and that may sound a bit negative, with the things of today. They are not that concerned with innovation, that lies with other departments.'
'So you don't innovate to develop fun gadgets for surgeons, or fun gadgets for a dermatologist. But you really do it with a very strict goal. And that is increasing patient safety and making care affordable.'	'It costs me a lot of effort to get out of the nursing departments where, for example, the TU can help them.'
'To have a clear goal and to make it as focussed as possible'	'What is missing is consistency in the projects'

Table 13 Example of a segment of one of the ideal Living Lab descriptions, and the three factors that have been abstracted from it.

Interviewee	Segment of ideal Living Lab description	Abstracted factors
Clinical physician Reinier de Graaf hospital	'The ideal Living Lab should be easily accessible. That means that you work with a relatively small team that determines what can and cannot be done. If we look at the legal part, a basic structure should be in place: this is the contract we work with and this is the compensation for all participants. Furthermore, there should be a very short line to the METC, so you can start the research much faster than in normal processes.'	Should be easily accessible, by the means of working in a small team that makes the decisions

Should have a basic structure for legislation

Should have a short line to the METC, so that projects start up quickly |

After the clustering, the themes were named based on the contend of the factors in them. Table 15 shows an example of the theme's F_4 and F_7, and the factors assigned to them.

Table 14 Overview with an example of three interviewees and some of the coded factors abstracted from descriptions of an ideal Living Lab that were given in the interviews. The coloured blocks highlight factors that were labelled with the same code.

Interviewee	Factor	Code
Clinical physician Reinier de Graaf hospital	Should be accessible, in the form of working in a small team that makes the decisions.	F_10
	Should have a basic structure for legislation	F_7
	Should have a short line to the METC, so that projects start up quickly	F_4
Surgeon Reinier de Graaf hospital	Should be a real work situation	F_6
	Should include people who have the single task to perform research	F_6
	Should be compliant with privacy legislation and the MDR	F_7
Innovation manager Medical Delta	Should give access to stakeholders that are relevant for the project	F_3
	The innovator should be supported in identifying the design requirements in an early stage	F_4
	Should get good ideas on the road quickly, and to help them in the right direction	F_4

Table 15 Example of the factor theme F_4 and the F_7, including the corresponding factors.

F_4 The ideal LL has efficient processes that allow for projects to both start and stop quickly	F_7 The ideal LL has a basic structure for legislation, and is compliant with privacy legislation and the MDR
The innovator should be supported in identifying the design requirements in an early stage	Should be compliant with privacy legislation and the MDR
Should get good ideas on the road quickly, and to help them in the right direction	Should have good working sensors that have been CE certified
Should steer project in the right direction in an early stage by the means of collaboration with the user	Should have a basic structure for legislation
Should have a short line to the METC, so that projects start up quickly	
Should make projects more efficient by creating short cycles in which it can be decided if a project should be continued or not.	
Projects that appear to be not such a good idea should be stopped, at low costs	

6.3 Results

Building on the drivers, barriers and theories found in literature the step to practice can be made, hereby answering the second research question: *What factors are important for the functioning of a Living Lab according to practice?* To this end, a case study has been conducted of a Living Lab called the ResearchOR.

6.3.1 Interviews

To validate the commandments identified in literature, seven interviews with stakeholders of the ResearchOR have been conducted. Besides validating, it was also the aim to prioritize commandments and to get indication for ways to implement them in practice. Table 16 gives an overview of the occupation of the interviewee and the company or organisation they are part of.

The interviews resulted in 11 drivers and 8 barriers for participating in the ResearchOR, and 10 drivers and 13 barriers for the functioning of the projects within the ResearchOR. Drivers and barriers for participating in the Living Lab are shown in Table 17. See Appendix 3 for the coded factors and themes the drivers and barriers are based on.

Table 16 Overview of the occupation of the interviewees and the company or organization they are part of.

	Occupation	Company/organisation
1	Surgeon	Reinier de Graaf Hospital/TU Delft
2	Innovation coordinator	Reinier de Graaf Hospital
3	Clinical physicist	Reinier de Graaf Hospital
4	Head OR	Reinier de Graaf Hospital
5	Innovation manager	Medical Delta
6	Living Lab coordinator	Medical Delta
7	Executive partner	Doublesense

Table 17 Overview of the drivers and barriers for participating in the ResearchOR based on interviews with stakeholders of this Living Lab.

	Drivers for participation		Barriers for participation
1	I was assigned to this project	1	Certain histories between stakeholders
2	It fits my background	2	Inexperience of people in the entrepreneur role
3	I like turning things to action	3	Legislation
4	I am interested in good implementation of healthcare innovation	4	Difficult to get finance
5	The management side of innovation in healthcare fascinates me	5	It takes time
6	I want to improve healthcare by the means of technology	6	Innovations do not always work when testing
7	I want to improve the working environment of people in healthcare	7	Projects are often not further developed
8	Other stakeholders come with new ideas	8	Overhead in organisation around the research in the Living Lab
9	Working in this Living Lab is beneficial for reputation and network		
10	It gives me the opportunity to be involved in interesting projects		
11	Testing innovations in practice has great value		

Drivers and barriers for the functioning of the projects are displayed in Table 18. On top of the drivers and barriers from practice, 10 factors have been identified the ideal Living Lab should include according to the stakeholders of the ResearchOR (Table 19).

Table 18 Overview of the drivers and barriers for the functioning of the projects of the ResearchOR based on interviews with stakeholders of this Living Lab.

| Drivers for Living Lab projects		Barriers for Living Lab projects	
1	The motivation of bringing innovations to the market	1	Driving and sustaining collaborations and finance are not always a top priority
2	Have a clear goal	2	Lack of cooperation
3	Money	3	Lack of focus
4	People with the right connections and influence	4	Too little time
5	Sufficient enthusiasm and support base amongst the people involved	5	Target group not involved enough
6	Living Lab projects fit in the current strategy or way of working of the stakeholder	6	It is extra work next to your regular job
7	A connection is created between science and practice	7	Too little money
8	The people in this world connect and involve each other	8	Legislation
9	Publicity about the projects	9	Sometimes hospitals tend to be scared to innovate
10	Synergy in the projects	10	There is little focus on innovation within the hospital
		11	There is a mismatch in where the innovation is beneficial and where the decisions are made
		12	Mismatch with the innovation and the general market (product is 'too customized')
		13	The research is not always of value for the hospital (financially)

Table 19 Ten overall factors the ideal Living Lab should include according to the stakeholders of the ResearchOR.

Code	Factor
F_1	The ideal LL has sufficient resources in the form of time, money and work space
F_2	The ideal LL has projects with a clear focus
F_3	The ideal LL gives access to the relevant stakeholders
F_4	The ideal LL has efficient processes that allow for projects to both start and stop quickly
F_5	The ideal LL is part of a real work situation
F_6	The ideal LL includes people whose single task is to perform research
F_7	The ideal LL has a basic structure for legislation, and is compliant with privacy legislation and the MDR
F_8	The ideal LL includes a mixture of small and larger companies
F_9	The ideal LL has only projects that are truly relevant for healthcare and the end user.
F_10	The ideal LL is easily accessible, and therefore has a small team to make decisions

The ideal ResearchOR is a real work situation, such as a real operation room, complete with research equipment in the form of sensors and cameras. The people who work on this operation room are trained and have their hands free to conduct research data during the operations. The ResearchOR has a clear goal and strong focus, in which improving patient safety and working conditions for the hospital staff is the central theme. This can be through improving the equipment the hospital staff works with, or by improving the processes and protocols.

The origin of projects should lie in problems that occur in the hospital. Because projects come from within the hospital, a certain level of involvement and commitment will be present. To make the goals become reality, the right stakeholders must have access to the ResearchOR. These stakeholders must bring something to the table in terms of knowledge or resources. In its turn, it must also be clear what value working in the ResearchOR will have for the stakeholder. Therefore a structure should be in place that captures legal matters such as IP and finance. The ideal ResearchOR has also the ability to start up projects and tests quickly, and to stop projects that appear not to work in an early stage and for little money. To start projects quickly, a clear legal structure and a close connection with the METC are required. Furthermore, to speed up decision making, a small group of people should be in charge of this matter.

There are also some contradicting elements participants mention a Living Lab should have. Some find that a Living Lab should be able to sustain itself, but that it's priority should be to produce knowledge. Others find it a pity that not more projects are further developed to market ready products. Some feel that the shortage of money and time are caused by a lack of management and organisation. Others perceive an (time consuming) overhead of organisation around the research.

6.4 Interpretation |PART 2
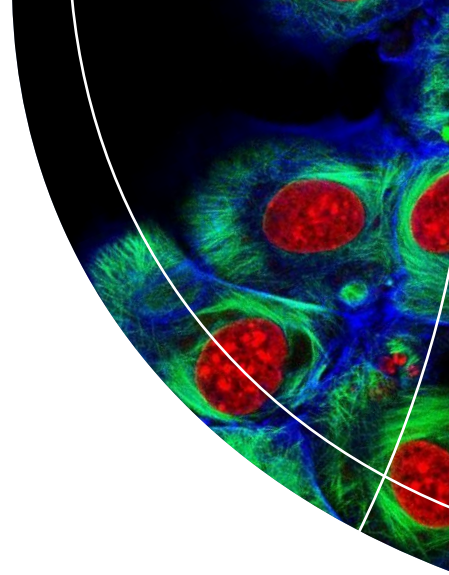
Similar to the method used for the drivers and barriers found in literature, the ones from the interviews too have been merged into 10 commandments. Table 20 shows the commandments and the drivers and barriers that form them. They will form the answer to the second sub question.

	Drivers and barriers for participation			Drivers and barriers for projects	
Cp1	D_pa1	I was assigned to this project	D_pr1		The motivation of bringing innovations to the market
	D_pa2	It fits my background	D_pr4		People with the right connections and influence
	D_pa3	I like turning things to action	D_pr5		Sufficient enthusiasm and support base amongst the people involved
	D_pa4	I am interested in implementation of healthcare innovation	D_pr6		Living Lab projects fit in the current strategy or way of working of the stakeholder
	D_pa5	The management side of innovation fascinates me	B_pr2		Lack of cooperation
	D_pa6	I want to improve healthcare by the means of technology	B_pr5		Target group not involved enough
	D_pa7	I want to improve the working environment of people in healthcare			
Cp2	D_p8	It is nice that other stakeholders come with new ideas	D_pr8		People in this world connect and involve each other
	D_pa9	Working in this Living Lab is beneficial for reputation and network	D_pr9		Publicity about the projects
	D_pa10	It gives the opportunity to be involved in interesting projects			
Cp3	D_pa11	Testing innovations in practice has great value	D_pr7		A connection is created between science and practice
	B_pa6	Innovations do not always work when testing			
Cp4	B_pa1	Certain histories between stakeholders			
Cp5	B_pa2	Inexperience of people in the entrepreneur role	B_pr1		Driving and sustaining collaborations and finance are not always a top priority
Cp6	B_pa3	Legislation	B_pr8		Legislation
Cp7	B_pa4	Difficult to get finance	D_pr3		Money
			B_pr7		Too little money
			B_pr13		The research is not always of value for the hospital (financially)
Cp8	B_pa5	It takes time	B_pr4		Too little time
	B_pa8	Overhead in organisation around the research in the Living Lab	B_pr6		It is extra work next to your regular job
Cp9	B_pa7	Projects are often not further developed	B_pr9		Sometimes hospitals tend to be scared to innovate
			B_pr10		There is little focus on innovation within the hospital
			B_pr11		There is a mismatch in where the innovation is beneficial and where the decisions are made
			B_pr12		Mismatch with the innovation and the general market (product is 'too customized')
Cp10			D_pr2		Have a clear goal
			D_pr10		Synergy in the projects
			B_pr4		Lack of focus

6.4.1 Answering the second sub question

The second sub research question was: ***What factors are important for the functioning of a Living Lab according to pracitce?*** As an answer the second set of 10 commandments gives an indication of how a Living Lab should be constructed and organized according to practice.

Practice commandment 1: The stakeholders in the Living Lab have to fit like a puzzle.

For Living Lab projects to function, the visions and motivations of the participants need to overlap. Drivers for participants to take part in in a Living Lab are that it fits their professional background and their style of working. They like turning things into action and are interested in the implementation of healthcare innovation. Some stakeholders are fascinated by the management side of innovation, others are driven to improve healthcare by the means of technology. There is also great interest in improving the working environment of the people that work in healthcare sector.

The participants also need to complement each other in terms resources. What drives the projects is the motivation of bringing innovations to the market and the involvement of people with the right connections and influence. That means that there is a need for sufficient enthusiasm and support base among the people connected to the project. It helps if Living Lab projects fit in the current strategy or workflow of the stakeholders. Insufficient overlap of visions and motivations or a lack of complementing each other's resources can lead to a lack of cooperation and a low involved target group.

Practice commandment 2: A Living Lab network has to complement the network of potential stakeholders.

Living Lab partners join the Living Lab because the other participants give them new ideas and because working in the Living Lab is beneficial for their reputation and network. It gives them the opportunity to be involved in interesting projects. Furthermore, the networks of Living Labs can be powerful. People in the world of Living Labs connect and involve each other.

Practice commandment 3: A Living Lab should give stakeholders access to research settings in practice.

The ability to test innovations in practice is of great value to Living Lab participants. A connection between science and practice is created. A barrier however, especially in healthcare, is that innovations do not always work when testing. This could create risks for patients.

Practice commandment 4: Social Capital between certain stakeholders should not lead to unequal collaboration (in terms of favouring one over the other).

History between stakeholders that now work together in the Living Lab can lead to unequal collaboration. It is important to be open about previous collaborations and social capital should be taken into account when selecting new stakeholders.

Practice commandment 5: Both the importance and the time and energy the management of a Living Lab takes should not be underestimated.

Driving and sustaining collaborations and finance are not always a top priority in Living Labs. The inexperience of most participants with the entrepreneur role can be a barrier for Living Lab projects.

Practice commandment 6: Legislation: be fair and square and have it ready before you need it.

Legislation is identified as a great barrier. Regulations in healthcare are strict and complex. Legislation for internal collaboration in the Living Lab also tend to be difficult. Setting up contracts for collaboration and sorting out matters such as IP can lead to problems.

Practice commandment 7: Living Labs need money.

It is difficult for Living Labs to get finance. Projects can be delayed or not start at all due to a lack of money. Furthermore, projects do not always pay of when completed. For example, the research is not always of value for the hospital (financially).

Practice commandment 8: A sweet spot must be found in the time and energy that is spend on regulation and on research.

Working in a Living Lab takes time, and that time can be hard to find for the participants. It is extra work next to their regular job. Due to this lack of time, some participants feel like there is an overhead in organization around the research in the Living Lab.

Practice commandment 9: Both in the start of the development of a medical innovation and its transition to the market, the hospital must see the benefits, benefit and be willing to participate.

Some participants experience the fact that projects are often not further developed as demotivating. There tends to be a mismatch with the innovation and the general market. In other words, the Living Lab products can be 'too customized'. Projects can also be slowed down by the somewhat limited focus of hospitals on innovation. Hospitals sometimes tend to be scared to innovate. There is also a mismatch in where the innovation is beneficial and where the decisions are made. Overall, for the ResearchOR specifically, it is crucial that the hospital is on board of the projects from the beginning to the end.

Practice commandment 10: Living Lab projects should have synergy and a clear goal.

A lack of focus in Living Lab projects can lead to inefficient processes and misunderstandings. Clear goals are therefore important, not only on project level but also on Living Lab level. That means a certain level of synergy between the projects should be present. This gives the overall Living Lab more focus and helps with expectation management amongst the stakeholders.

7. **PART 3** Perspectives in literature and practice

In this chapter, an analysis has been made of the different perspectives of the commandments from literature and practice, by placing them in the Living Lab perspective matrix.

7.1 Aim | PART 3

It was the aim of this analysis to get more grip on what the commandments in literature and practice mean, and on how they relate to each other. The commandments have therefore been placed in the perspective matrix with the goal to create an overview of their perspectives and to compare theory and practice.

7.2 Method | PART 3

The commandments have been placed in the perspective matrix based on my own judgement and the evaluation of three communication experts. When placing the commandments, I have looked back at the drivers and barriers they are based on. I have also revaluated the context in which the drivers and barriers were placed in literature or the interviews.

The evaluation of the placement of the commandments was performed in three separate sessions, so that the communication experts would not be influenced by each other's opinion. In the sessions, the participants were presented with the first draft of the matrix and the commandments. They were also provided with a table with an argumentation for the placement of each commandment in the matrix. Based on the feedback of the communication experts the placement of the commandments has been adjusted. There were no significant contradictions in the separate suggestions of the communication experts.

7.3 Results | PART 3

To place the 10 commandments of practice in perspective, we look back at the matrix used for the construction of the interview protocol. This time, the 10 Commandments of Practice have been plotted in the matrix (Figure 11). Commandment Cp7 (Living Labs need money) is applicable to all quadrants and has therefore been placed next to the matrix.

As can be seen from Figure 11, the functioning of the Living Lab network on a macro level is not a perspective the participants often choose. Especially the quadrants on the lower right are rather empty. The functioning and willingness of the entire Living Lab network to collaborate related to the functioning of the Living Lab as a whole might therefore not be on the top of their list. Collaboration on micro level however, both related to their own project and to the functioning of the total Living Lab, is a perspective that is chosen more frequent. This could explain the somewhat informal collaborations within the ResearchOR, and why personal preference for certain projects tend to be leading when deciding what direction the ResearchOR should take.
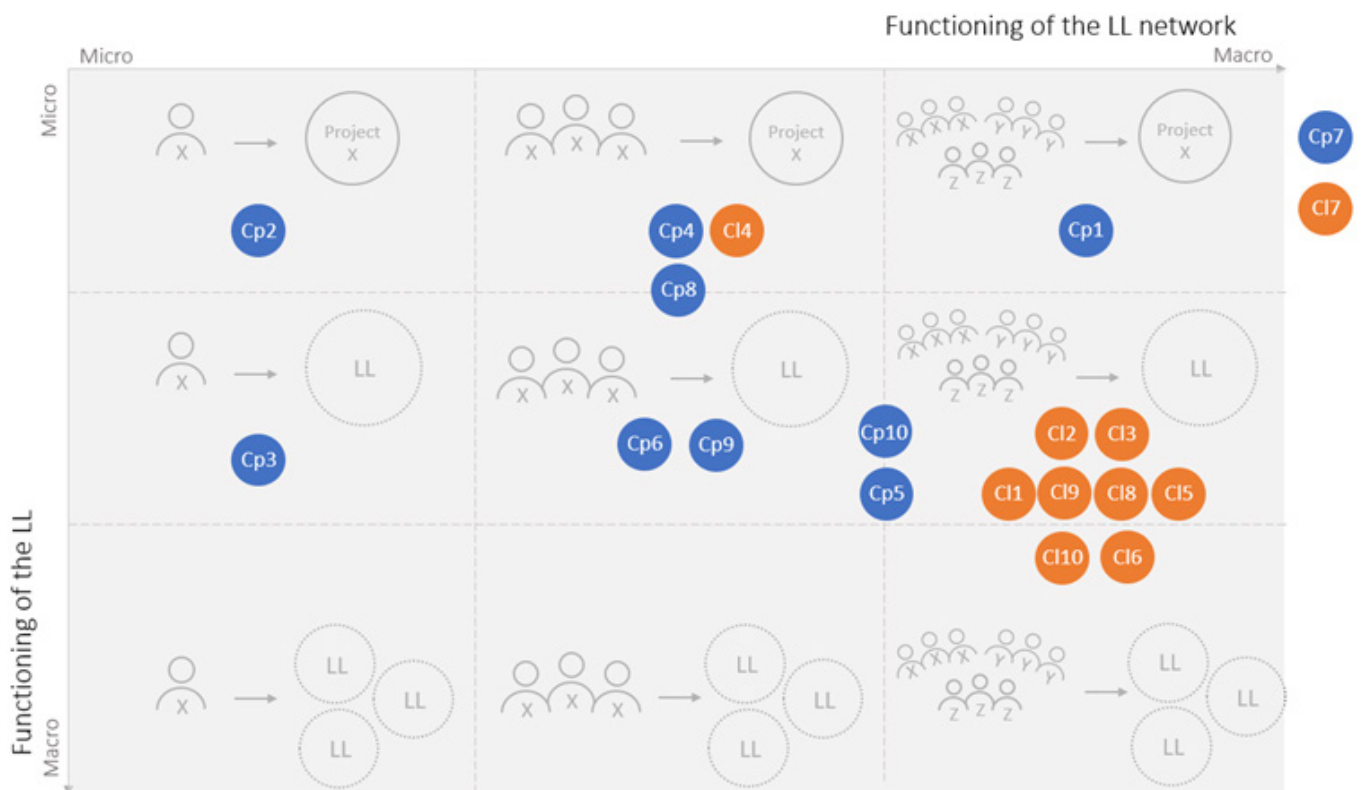
7.3.1 Comparison of the commandments of practice and commandments of literature

To compare the perspectives taken in literature and taken in practice, the Commandments of Literature have been plotted in the same Living Lab perspective matrix (Figure 12).
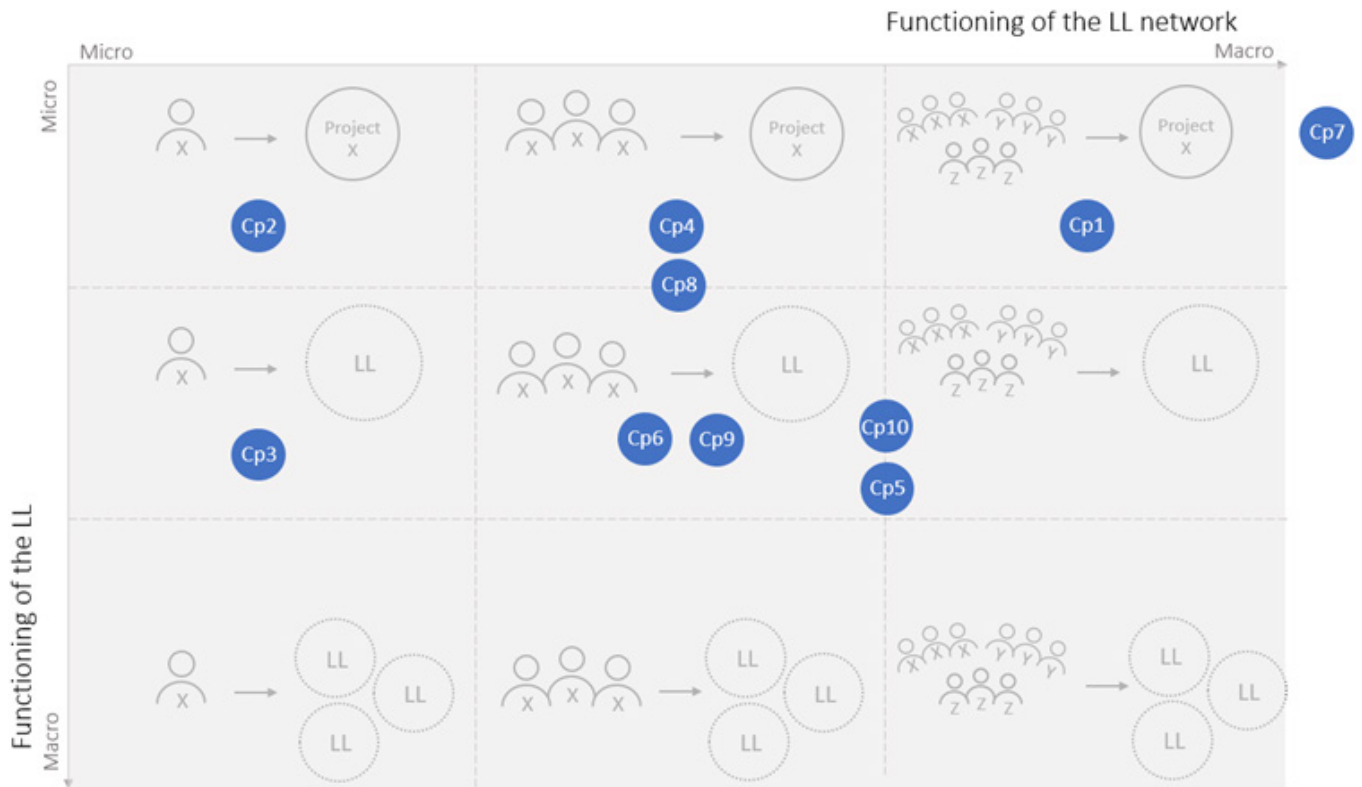
Figure 11 Living Lab perspective matrix with the 10 commandments of practice.

Cp1	The stakeholders in the Living Lab have to fit like a puzzle.
Cp2	A Living Lab network has to complement the network of potential stakeholders.
Cp3	A Living Lab should give stakeholders access to research settings in practice.
Cp4	Social Capital between certain stakeholders should not lead to unequal collaboration (in terms of favouring one over the other).
Cp5	Both the importance and the time and energy the management of a Living Lab takes should not be underestimated.
Cp6	Legislation: be fair and square and have it ready before you need it.
Cp7	Living Labs need money.
Cp8	A sweet spot must be found in the time and energy that is spend on regulation and on research.
Cp9	Both in the start of the development of a medical innovation and its transition to the market, the hospital must see the benefits, benefit and be willing to participate.
Cp10	Living Lab projects should have synergy and a clear goal.

Figure 12 Living Lab perspective matrix with the commandments of practice and literature.

The legend content:

Cp1 — The stakeholders in the Living Lab have to fit like a puzzle.

Cp2 — A Living Lab network has to complement the network of potential stakeholders.

Cp3 — A Living Lab should give stakeholders access to research settings in practice.

Cp4 — Social Capital between certain stakeholders should not lead to unequal collaboration

Cp5 — Both the importance and the time and energy the management of a Living Lab takes should not be underestimated.

Cp6 — Legislation: be fair and square and have it ready before you need it.

Cp7 — Living Labs need money.

Cp8 — A sweet spot must be found in the time and energy that is spend on regulation and on research.

Cp9 — Both in the start of the development of a medical innovation and its transition to the market, the hospital must see the benefits, benefit and be willing to participate.

Cp10 — Living Lab projects should have synergy and a clear goal.

Cl1 — A Living Lab must be managed

Cl2 — Living Lab participants should have diverse backgrounds and shared values

Cl3 — Living Lab participants must be equals

Cl4 — Users must be involved in Living Lab projects from the start

Cl5 — Living Labs must understand their position in their network and field of profession

Cl6 — Living Labs should invest in creating an attractive network

Cl7 — Living Labs need money.

Cl8 — Living Labs should exploit their role as facilitator of market transition

Cl9 — Living labs should display their successful projects and collaborations

Cl10 — Living Labs must be alert to conflict in their projects and network

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7.4 Interpretation PART 3

One could say that the commandments from literature take a perspective that is more on a macro level, and therefore focus on the Living Lab as a whole and its function in society. Consequently, there is less attention in literature for what happens on micro level in Living Labs, and how participants perceive the use and value of the collaboration.

8. **PART 4** Critical node and Problem statement

After investigating the perspectives of the commandments, the analysis in this chapter takes a step deeper and examines causalities between the drivers and barriers. Based on these causalities a critical node and problem statement were formulated.

8.1 Aim PART 4

It was the aim to formulate a problem statement by identifying a critical node in the causal diagram.

8.2 Method PART 4

After establishing an overall view on the perspectives taken in literature and practice, the layer beneath the commandments has been investigated: the drivers and barriers of both literature and practice. The first step of the design process is the setup of a causal diagram based on the drivers and barriers.

8.2.1 Drivers and barriers from literature in a causal diagram.

Figure 13 shows and example of how the causalities in the diagram have been established. The driver DL_9 is positively influenced by the driver DL_3, for openness and trust amongst stakeholders can be helpful when resolving conflicts in the network. The two drivers are therefore connected by a grey arrow. Driver DL_3 could be negatively influenced by the barrier BL_2 however, for it can be difficult to be open and trust one another when you are not treated equals. DL_3 and BL_2 are therefore connected by a red arrow.

8.2.2 Drivers and barriers practice added to the causal diagram

Not all drivers and barriers from practice have been included. For example, a driver to participate in the ResearchOR such as 'I was assigned to the subject' has little causality with the other drivers and barriers and was therefore excluded. The drivers and barriers from practice that were included often function as a more detailed explanation of the driver or barrier from literature. Figure 14 shows and example of how the causalities in the diagram have been established between practice and literature. The barriers BL_7 (from literature) and BP_1 (from practice) have been connected because BP_1 explains why the management in the setting of the ResearchOR sometimes proves to be difficult.
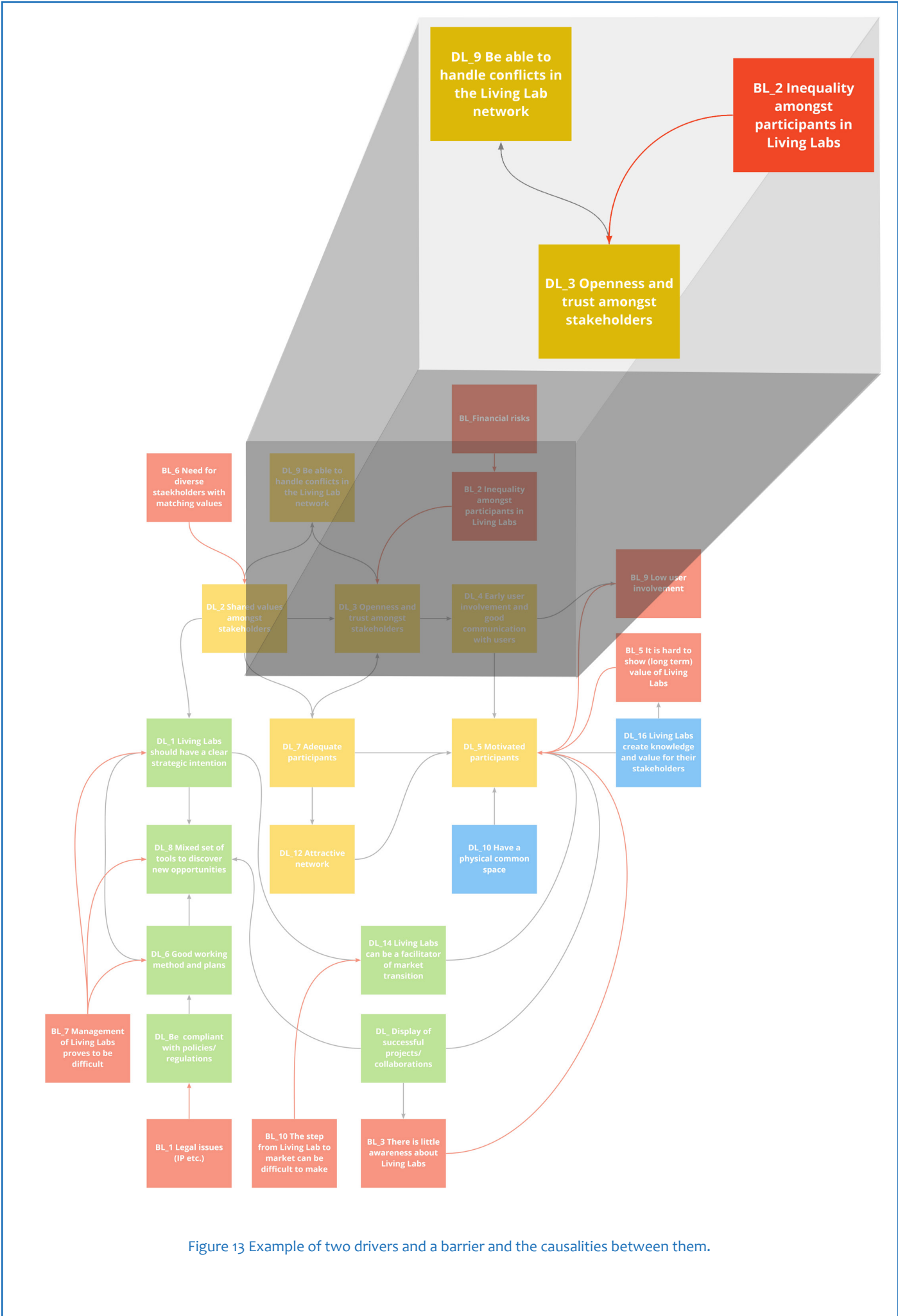
Figure 13 Example of two drivers and a barrier and the causalities between them.
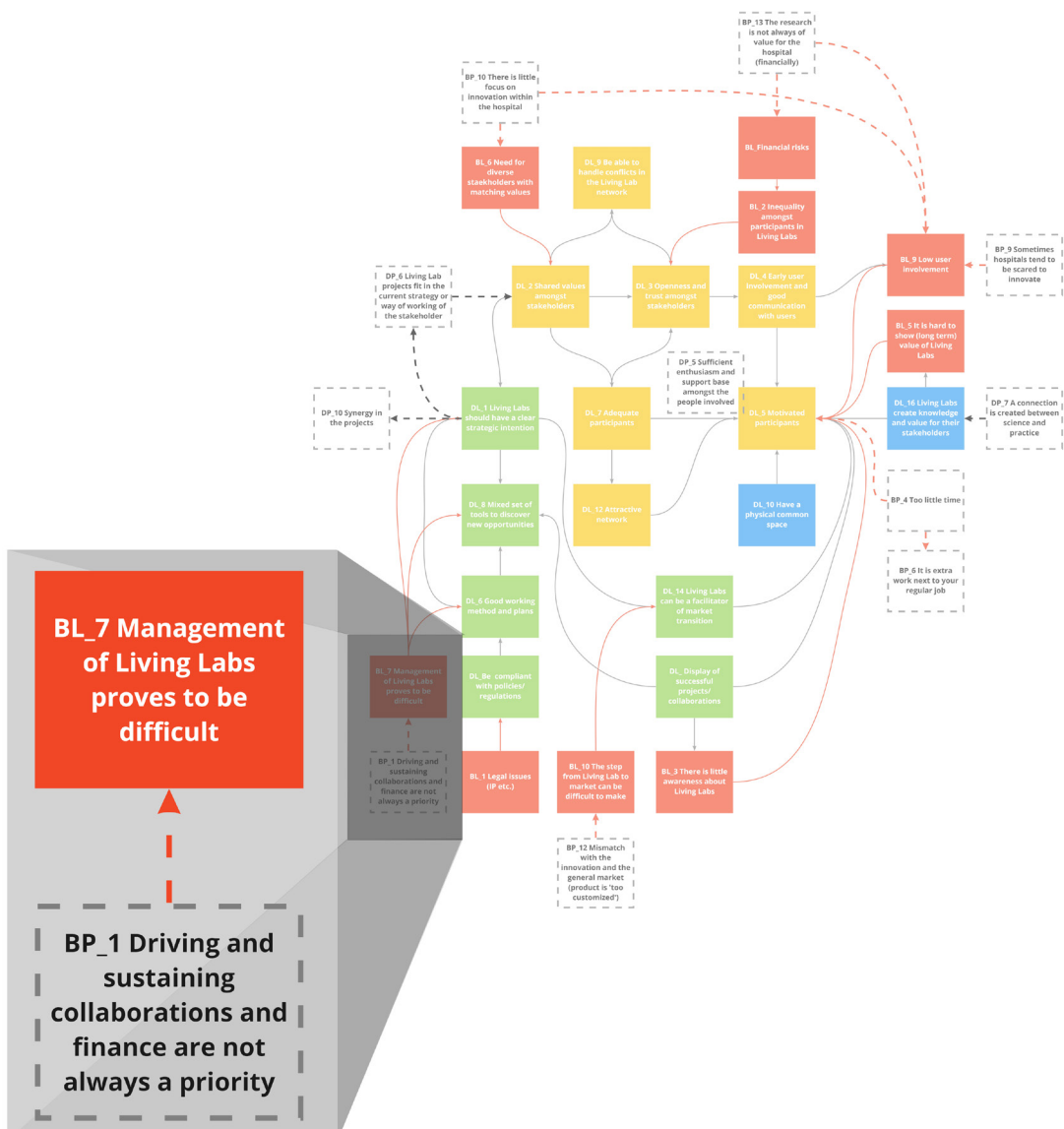
Figure 14 Example of a barrier from practice (BP_1) and a barrier from literature (BL_7) and their correlation.

8.2.3 Focus areas in the causal loop diagram

Based on the density of the arrows, two focus areas have been identified that have a relatively large impact on the total system. The focus areas are indicated by the two blue squares in Figure 15.

Figure 15 Two focus areas with a high density of arrows in the causal loop diagram

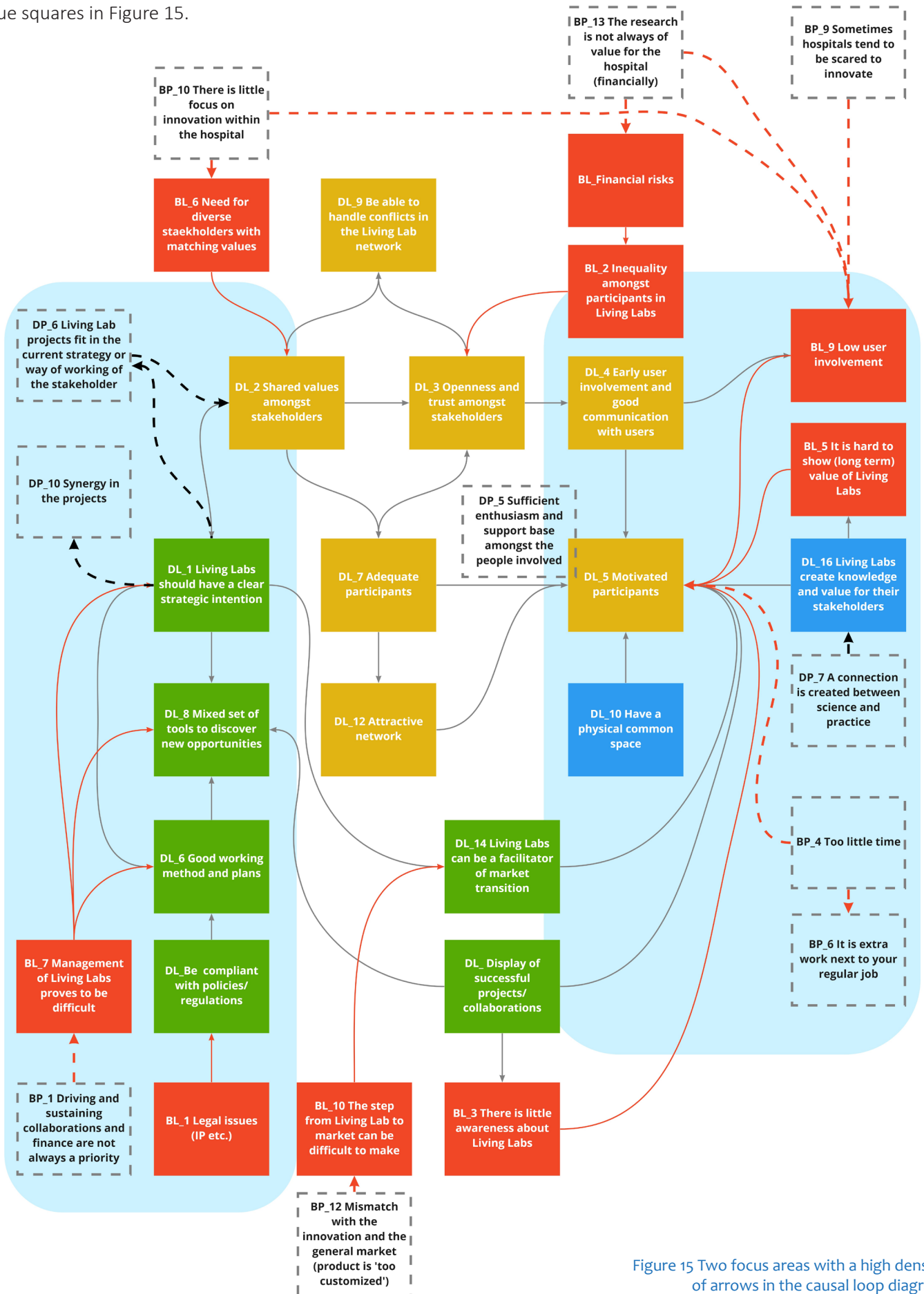When isolating these focus areas a new connection between the two appears to be possible. This connection is indicated by the large red arrow in Figure 16, and connects the barrier BP_6 and the barrier BP_1. Due to a lack of time, and the fact that stakeholders in the ResearchOR have to perform their Living Lab activities next to their regular job, tasks such as continuously driving and sustaining collaborations and finance could slip people's mind now and then.

8.2.4 Critical node and problem statement

The next step in the process is to identify the critical node and formulate the problem. The blocks with the greatest density of arrows in the focus areas of the causal diagram form the critical node. The explanation of the correlation between the blocks of the critical node forms the problem statement.
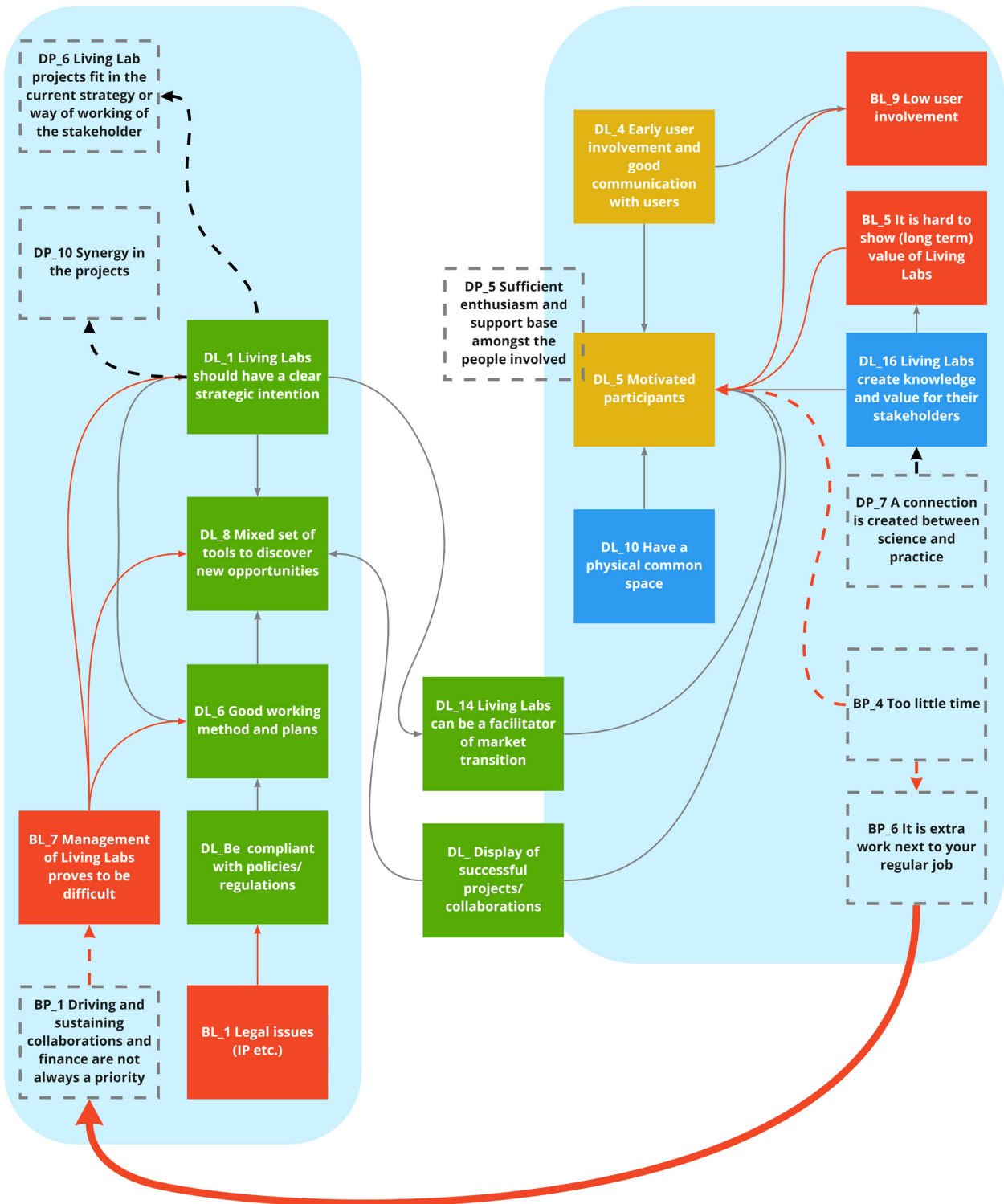
Figure 16 The isolated focus areas of the causal loop diagram. The large red arrow indicates a possible new connection between the focus areas.

8.3.1 Causality between the drivers and barriers of literature

In Figure 17, the drivers and barriers from *literature* have been combined in a causal loop diagram.

Figure 17 Causal loop diagram of the drivers and barriers from literature (RED block = barrier; GREEN block = driver (management/marketing orientated); YELLOW block = driver (people/network orientated); BLUE block = driver (general)).

8.3.2 Causality between drivers and barriers of both literature and practice

In Figure 18, drivers and barriers from *practice* have been added to the causal loop diagram.

Figure 18 Causal loop diagram with both drivers and barriers form literature and practice. (RED block = barrier; GREEN block = driver (management/marketing orientated); YELLOW block = driver (people/network orientated); BLUE block = driver (general) WHITE block = driver or barrier from practice).

8.4 Interpretation

Based on the analysis of the causal diagram a critical node and problem statement could be identified.
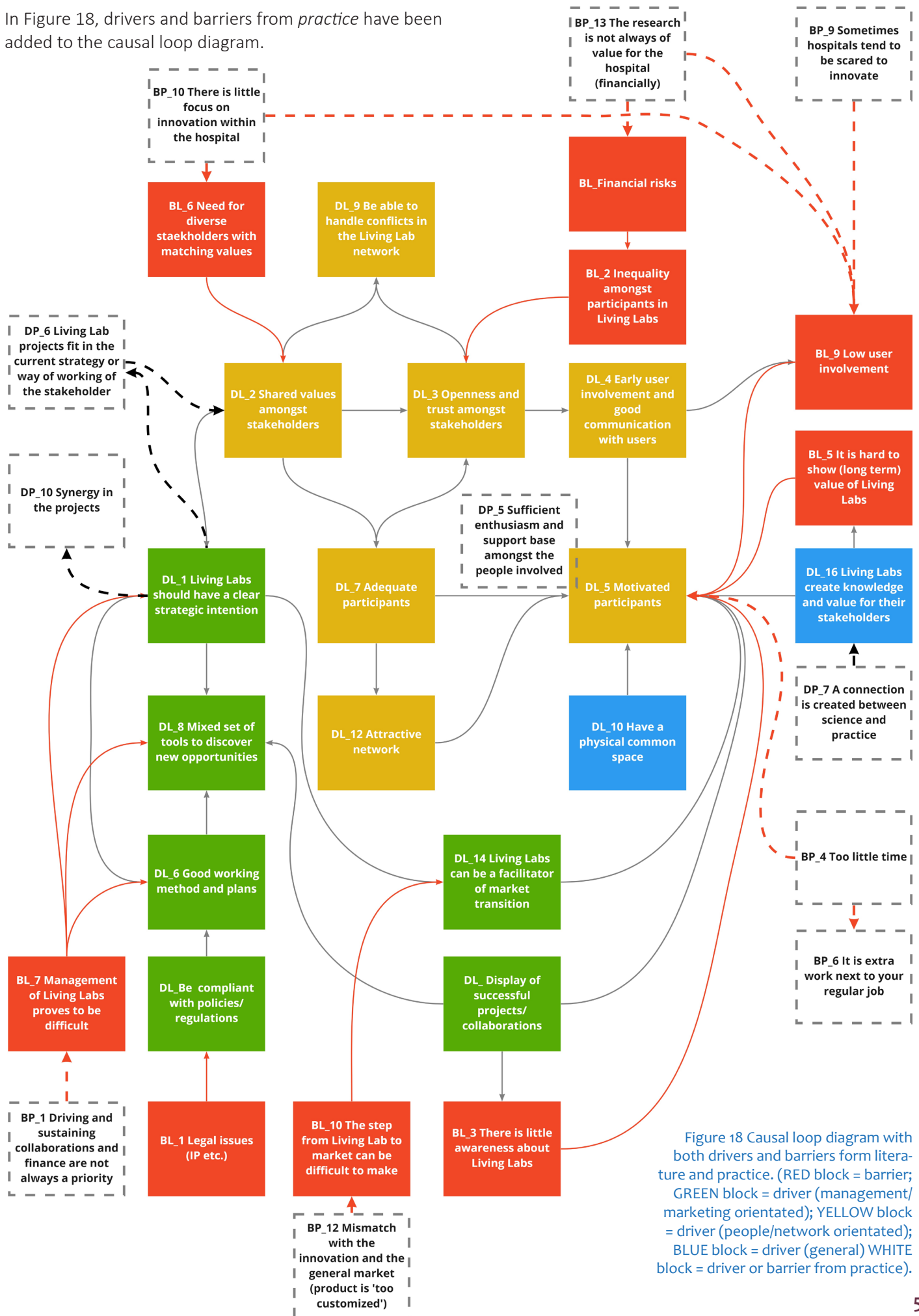
8.4.1 Critical node

The two blocks with the greatest density of arrows (BL_7 and DL_5), and the blocks connected to the causality between BP_1 and BP_6 (with the red arrow) have been isolated in Figure 19. The yellow and blue block (DL_5 and DL_16) present in the essence what a Living Lab ideally accomplishes: the Living Lab exists of motivated participants. In case of the ResearchOR that means sufficient enthusiasm and support base amongst the people involved. That clears the road for creating knowledge and value for the stakeholders of the Living Lab. For the ResearchOR that means useful and successful research into medical innovations, that could lead to real products, ready to use in the hospital.

However, due to a lack of time and the fact that participants of the ResearchOR have to perform their Living Lab activities next to their regular job, driving and sustaining collaborations and finance are not always a priority. That can make the management of the ResearchOR difficult.

8.4.2 Problem statement

A consequence of the rather limited focus on management amongst the people within the ResearchOR is that the overall structure, activities and vision is not always clear. Due to these unclarities, management might take even more time than necessary. That makes that the participants in the ResearchOR tend to have a preference to keep the whole collaboration low key. Otherwise it takes them simply too much time. However, valuable collaborations, research opportunities and funding might then be lost. This loop of events is illustrated by Figure 20.
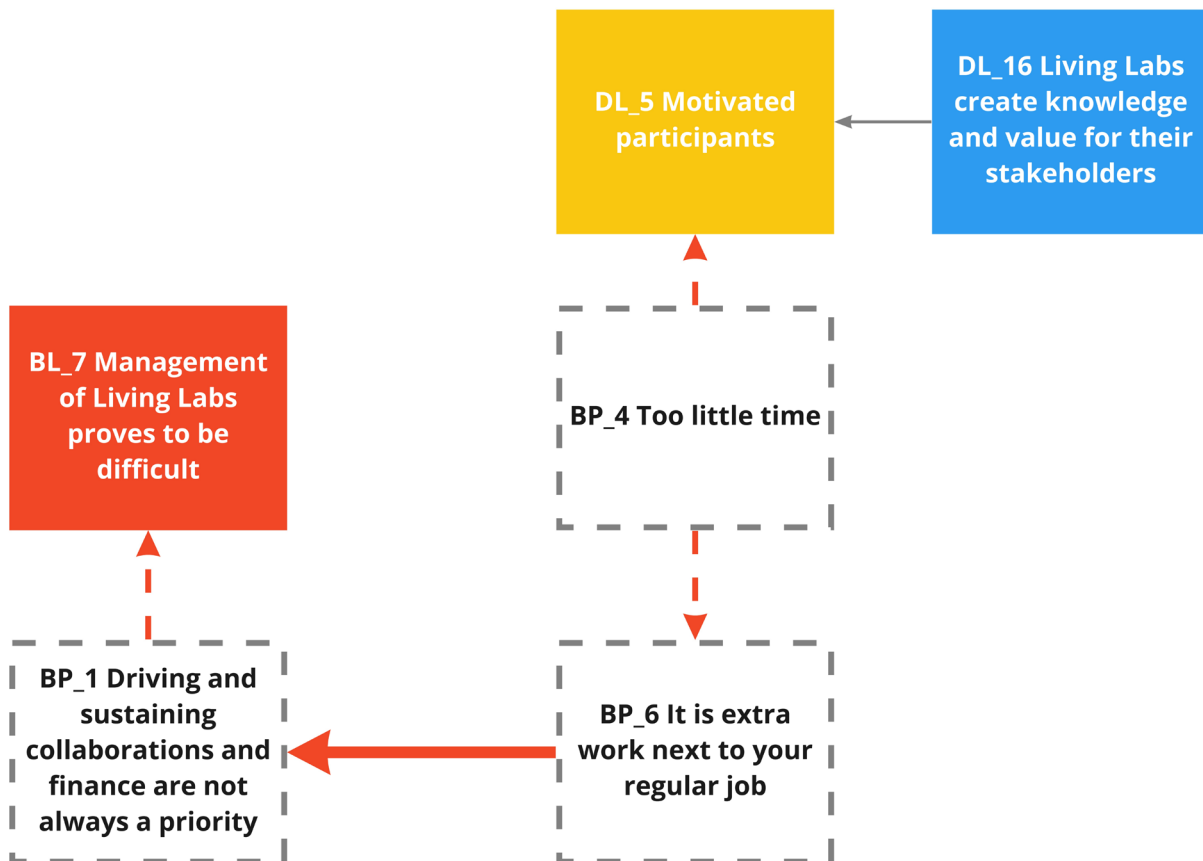

Figure 19 The critical node isolated from the causal loop diagram.

As an analogy, one could view the Living Lab and its stakeholders as a system of cells in which knowledge and resources are exchanged by diffusion (Figure 21). In facilitated diffusion, molecules move from the region of higher concentration to the region of lower concentration, assisted by a carrier. In the analogy, the molecules are knowledge and resources, and the carrier proteins are the stakeholders connected to the Living Lab. The stakeholders are present on the cell membrane of the Living Lab and carry molecules, change the confirmation of the molecules and release them to the other side of the membrane. For viable collaboration between the organizations that the stakeholders represent and the Living Lab, a certain equilibrium has to exist in the flow of resources that goes back and forth. That can be difficult, for there are external factors that affect the process of facilitated diffusion. Temperature influences the speed of the molecules, concentration influences the direction the molecules move,

diffusion distance and the size of the molecules influence how fast the molecules diffuse through the cell membrane. The carrier proteins are also affected by external factors such as temperature and saturation. Having to labour under the influences of all these external factors can be frustrating. Especially because Living Lab stakeholders have to perform their responsibilities next to their regular job. Unclarity about roles and responsibilities can then be problematic. If carrier proteins start pumping in the same molecules as their neighbours, the Living Lab will have a lack of other resources and that slows the processes in the cells down. It might then be extra work to pump in the right resources afterwards. A desire of the proteins/stakeholders to keep their diffusion activities low key is then understandable. However, that slows the overall development of the cells and their (innovation) processes down and brings the health of the Living Lab cell in danger.
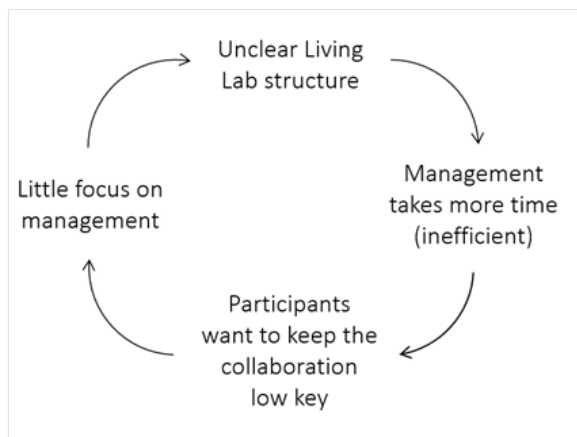

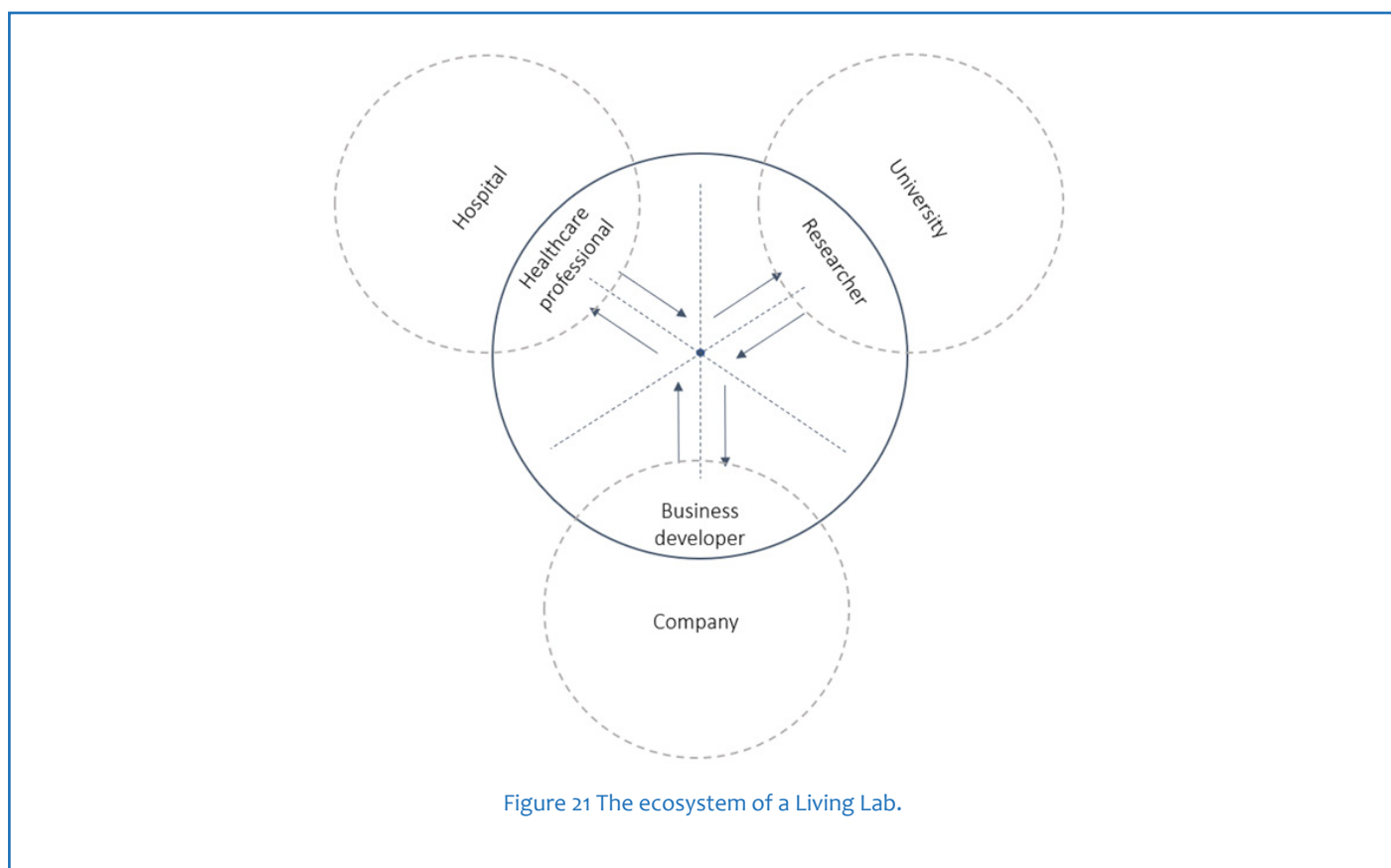
Figure 20 Problem statement loop.

Figure 21 The ecosystem of a Living Lab.

8.4.2 Problem statement

Based on the critical node and problem statement the design goal for this thesis can be formulated ⟶ **To design a guide that enables Living Lab coordinators to develop an organizational structure.**

9. **PART 5** Design criteria and morphological chart elements

In this chapter the design criteria for the tool are presented. The design criteria have been modified into morphological chart elements. The morphological chart elements form the answer to the third sub question.

9.1 Aim | **PART 5**

To answer the third sub question, *What communication elements could support the organizational structure of a Living Lab?*, it was the aim to identify factors that should be adressed in the tool in order to achieve the design goal: *To design a guide that enables Living Lab coordinators to develop an organizational structure.*

9.2 Method | **PART 5**

To further specify the design goal, design requirements have been formulated. The design requirements are composed of three elements: (1) Living Lab commandments related to the problem statement; (2) Ideal Living Lab factors related to the problem statement; (3) management literature (Figure 22). To select management literature, a systematic literature study has been conducted on the subject of management relevant to Living Labs. These views on management the selected commandments and the ideal Living Lab factors form the basis for the answer to sub question 3: *What communication elements could support the organizational structure of a Living Lab?* Furthermore, these three elements have been used to set up a morphological chart in order to create concepts that form possible answers to the design goal.
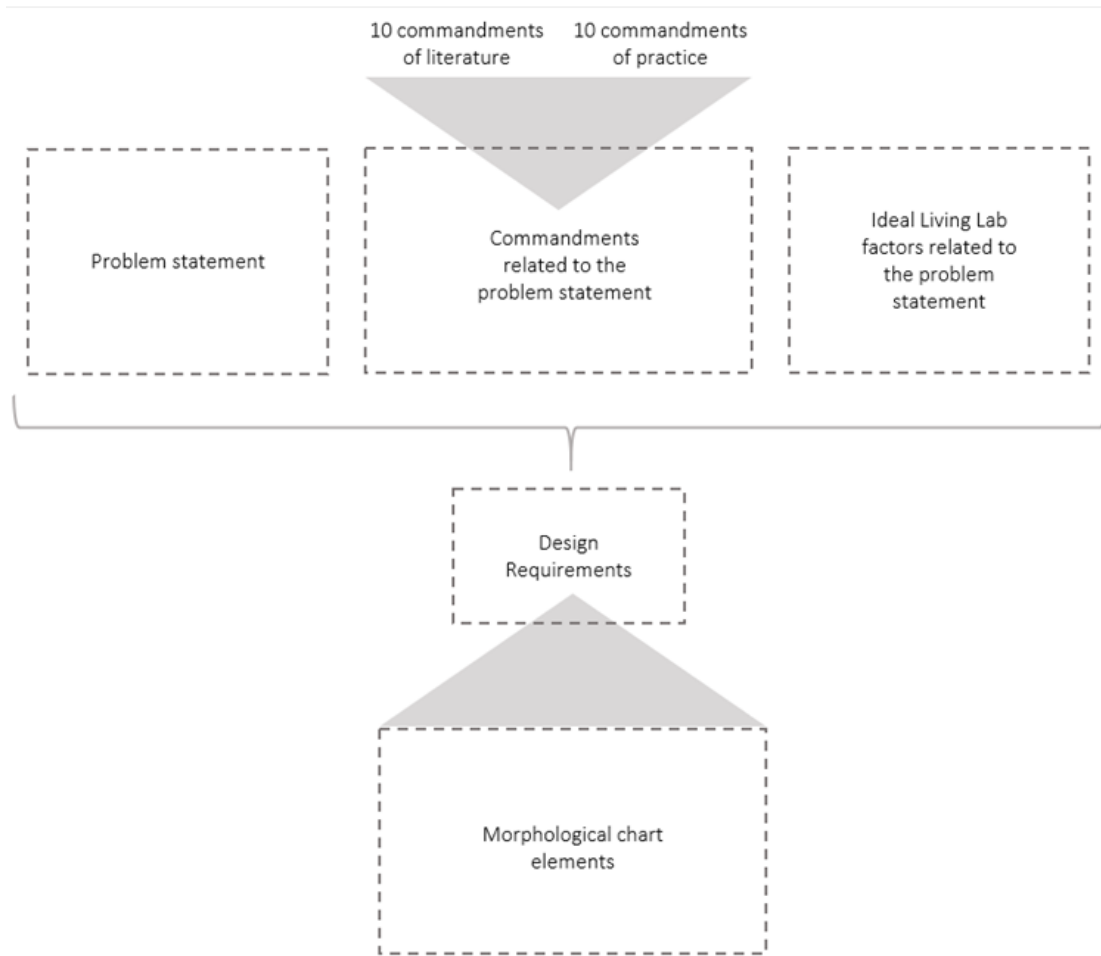

Figure 22 The composition of the design requirements.

9.2.1 Selecting the commandments of practice and literature related to the problem statement

The design criteria for the tool are based on the Commandments and the Ideal Living Lab Factors that have correlation with the problem statement. The following section explains how these commandments and Ideal Living Lab Factors have been identified.

To select the commandments relevant to the problem statement, the commandments of literature and practice that are similar or identical to each other have been placed in the same row in Table 21. Commandment sets identified as relevant to the problem statement have been placed in blue blocks. This selection has been verified by a fellow communication master student.

Table 21 Selected Commandments of Practice and Literature based on their connection with the problem statement.

set		Commandment of practice		Commandment of literature
1	Cp1	The stakeholders in the LL have to fit like a puzzle	Cl2	Living Lab participants should have diverse backgrounds and shared values
	Cp2	A Living Lab network has to complement the network of potential stakeholders	Cl6	Living Labs should invest in creating an attractive network
			Cl9	Living Labs should display their successful projects and collaborations
2	Cp3	A Living Lab should give stakeholders access to research settings in practice		
3	Cp4	Social Capital between certain stakeholders should not lead to unequal collaboration		
4	Cp5	Both the importance and the time and energy the management of a Living Lab takes should not be underestimated	Cl1	A Living Lab must be managed
5	Cp6	Legislation: be fair and square and have it ready before you need it		
6	Cp7	Living Labs need money	Cl7	Living Labs need money
7	Cp8	A sweet spot must be found between the time and energy that is spend on regulation and research		
8	Cp9	Both in the start of the development of a medical innovation and its transition to the market, the hospital must see the benefits, benefit and be willing to participate.	Cl4	Users must be involved in Living Lab projects from the start
9	Cp10	Living Lab projects should have synergy and a clear goal		
10			Cl5	Living Labs must understand their position in their network and field of profession
11			Cl8	Living Labs should exploit their role as facilitator of market transition
12			Cl10	Living Labs must be alert to conflict in their successful projects and collaborations

9.2.2 Selecting the ideal Living Lab factors related to the problem statement

As a criterium for selection a connection to the problem statement loop was chosen (Figure 23).

Ideal Living Lab factors identified as relevant to the problem statement have been placed in blue blocks (Table 22).
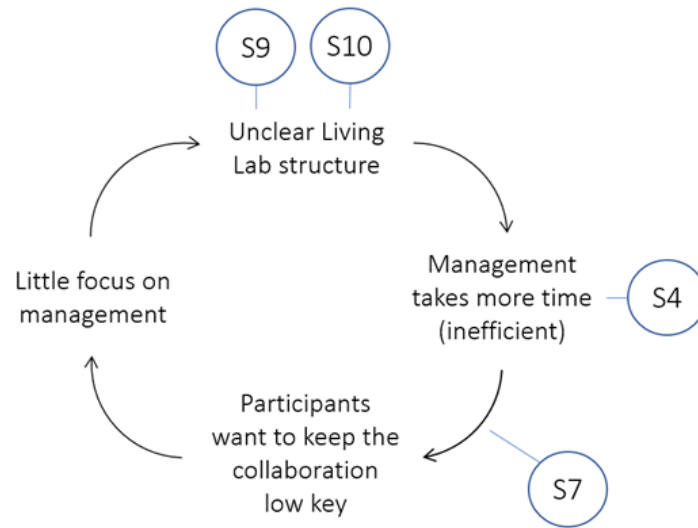
Figure 23 Validation for commandment set selection: the four chosen commandment sets (S4, S7, S9 and S10) and their connection to the problem statement loop.

Table 22 The ideal Living Lab factors; the factors identified as relevant to the problem statement have been placed in blue blocks (F_2)

Code	Factor
F_1	The ideal LL has sufficient resources in the form of time, money and work space
F_2	The ideal LL has projects with a clear focus
F_3	The ideal LL gives access to the relevant stakeholders
F_4	The ideal LL has efficient processes that allow for projects to both start and stop quickly
F_5	The ideal LL is part of a real work situation
F_6	The ideal LL includes people whose single task is to perform research
F_7	The ideal LL has a basic structure for legislation, and is compliant with privacy legislation and the MDR
F_8	The ideal LL includes a mixture of small and larger companies
F_9	The ideal LL has only projects that are truly relevant for healthcare and the end user.
F_10	The ideal LL is easily accessible, and therefore has a small team to make decisions

9.2.3 Transition from design criteria to morphological chart elements

Similar to the commandment selection, as a criterium for selection a connection to the problem statement loop was chosen (Figure 24).

To create more specific sub functions, the design criteria have been split up in morphological chart elements. These elements were filled in in the morphological chart. Table 23 shows an example of a design criterium and corresponding morphological chart elements.
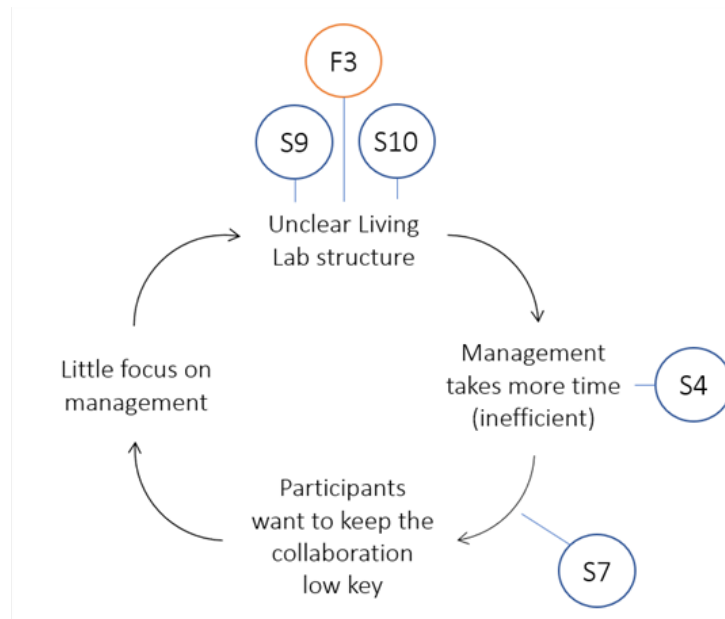
Figure 24 Validation for ideal Living Lab factor selection: the chosen factor (F2) and its connection to the problem statement loop.

Table 23 Example of how the design criteria have been split up in morphological chart elements.

Design criterium	Topic	Morphological chart function
Provide clear Living Lab structure	Structure Living Lab	Mapping the stakeholders and their roles and responsibilities
		Mapping the projects and the required and available resources
		Creating a mission and a vision for the total Living Lab

9.2.4 Literature study on views on management

To investigate the views of literature on (Living Lab) management structures, a systematic literature study was conducted around this subject. Table FIXME displays the used search terms, criteria and results used in this study. The starting point for these search terms were the morphological chart elements in from Table 24.

9.2.5 Morphological chart

In this step of the process the morphological chart is established. The morphological chart has been set up with the morphological chart elements. There was brainstormed for solutions based on management literature, interviews with ResearchOR stakeholders and my own intuition. The results in the morphological chart are based on six articles and four interviews with ResearchOR stakeholders. Table 25 shows an example of the first morphological chart function.

Table 24 Search terms, criteria and results used for the systematic literature study to answer the first part of the third sub question.

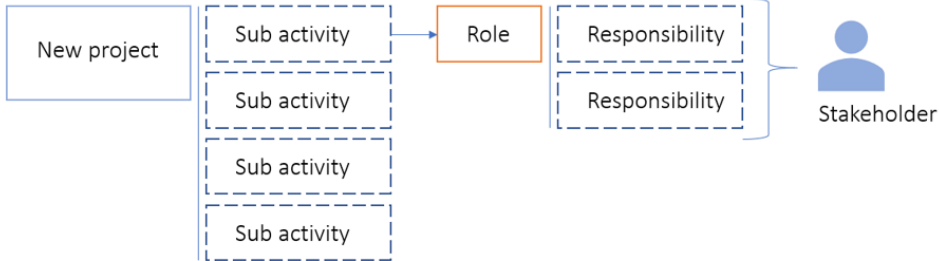| Search terms	Search engine	Results	Criteria	Filtered result	After reading abstracts removing duplicates	Result after reading the articles in full
Living Lab AND management	Scopus	372	Conference papers are excluded	114	9	3
Community AND bureaucracy AND management AND innovation	Scopus, Google scholar	37	Conference papers are excluded	29	15	3
						6

Table 25 Example of the morphological chart results.

Function	Mapping the stakeholders and their roles and responsibilities
Theory	The cognitive dimension of social capital enables collaborations from disparate teams. This leads to a more in-depth knowledge of team projects (Bartelt et al., 2020).
Practice	**WHAT**: start new project --> identify sub activities --> identify roles and responsibilities. This also makes it easier to see if there are stakeholders with the same role or if there are roles missing. **FORM**: checklist
Intuition	

A flowchart with the sub activities per new project and the roles and responsibilities that follow. This increases the shared understanding of the Living Lab as a whole through the cognitive dimension of social capital.

9.3.1 Design criteria

Based on the problem statement, the commandments and the ideal Living Lab factors, 5 design criteria for the tool have been formulated. Table 26 shows the criteria, their origin and related morphological chart element.

9.3.2 Views on management

The problem statement points out a lack of focus on Living Lab management. That raises the question to whether Living Lab management structures exist. And if so, what elements should they contain? In this chapter, different perspectives on the literature of management structures relevant to Living Labs are reviewed.

Bureaucracy versus community

In the article '*Learning to Balance Bureaucracy and Community as an Educational Administrator'* by Beairsto (1999) describes the delicate balance between being a bureaucracy and a community. Bureaucracy is what might be feared by the participants of the ResearchOR: the rules are the rules and what must be done must be done, hierarchy, strict management, little to no room for creativity and a focus on growth and productivity.

The description Beairsto gives of a community fits the current situation of the ResearchOR better: broad purposes, focus on people, creativity, preservation/sustainability, networking and inspirational leadership.

This holistic and humanistic approach is increasingly understood to be essential but is extremely difficult to operationalize and is, therefore, relatively rare. Throughout the years, the focus in academic writing has shifted towards the importance of inspirational leadership to such a degree that the efficient management component is ignored or denigrated. An unfortunate error, according to Beairsto. Leadership is important, but so is management. Ingen & Bennis describe management as doing things right, and leadership as doing the right things (Ingen & Bennis, 2007). Both are essential. Blending bureaucracy and community appears to be a solution, and would then lead to a '*high reliability learning community*'. According to Bearisto, an enormous challenge.

Table 26 Overview of the design criteria, their origin and related morphological chart element.

	Design criterium	Origin
1	Provide clear Living Lab structure	Problem statement
2	Increase focus of the Living Lab participants on management → provide insight in the importance and the time and energy the management of a Living Lab take	Problem statement Cp5
3	Help finding the sweet spot between the time and energy that is spend on regulation and research	Cp8
4	Help creating synergy and clear goals for the Living Lab projects	Cp10 F_2
5	Help the Living Lab understand their position in their network and field of profession	Cl5

A Living Lab performance assessment tool

The article 'Design and management of innovation laboratories: Towards a performance assessment tool '(Osorio et al., 2019) an assessment tool is proposed to assess the maturity degree of an innovation laboratory (Figure 25). Based on a literature study and the authors experience, criteria that are useful to examine when assessing a Living Lab are identified. For each of the five steps in the tool, four levels of maturity have been introduced. To identify at which level a Living Lab is, tables with a maturity grid are presented in the article. The tool has been tested in 15 Living Labs.

This tool can be interesting when looking at the ResearchOR and the identified problem statement. This tool can help the Living Lab coordinators to identify where the strengths and weaknesses lie in the current management style.

Nurse-led community care

Buurtzorg is an organization that exists of self-managed teams that provide home care to patients in their neighbourhoods. Autonomous teams work with primary care providers, community supports and family resources to give patients the optimal care. This way of organizing care has won awards and is based on trust, autonomy, creativity, simplicity and collaboration. A key element in this way of working is the almost complete absence of bureaucracy. Perhaps the ResearchOR can gain insight in how to perform management efficiently without having to become a bureaucratic institution.
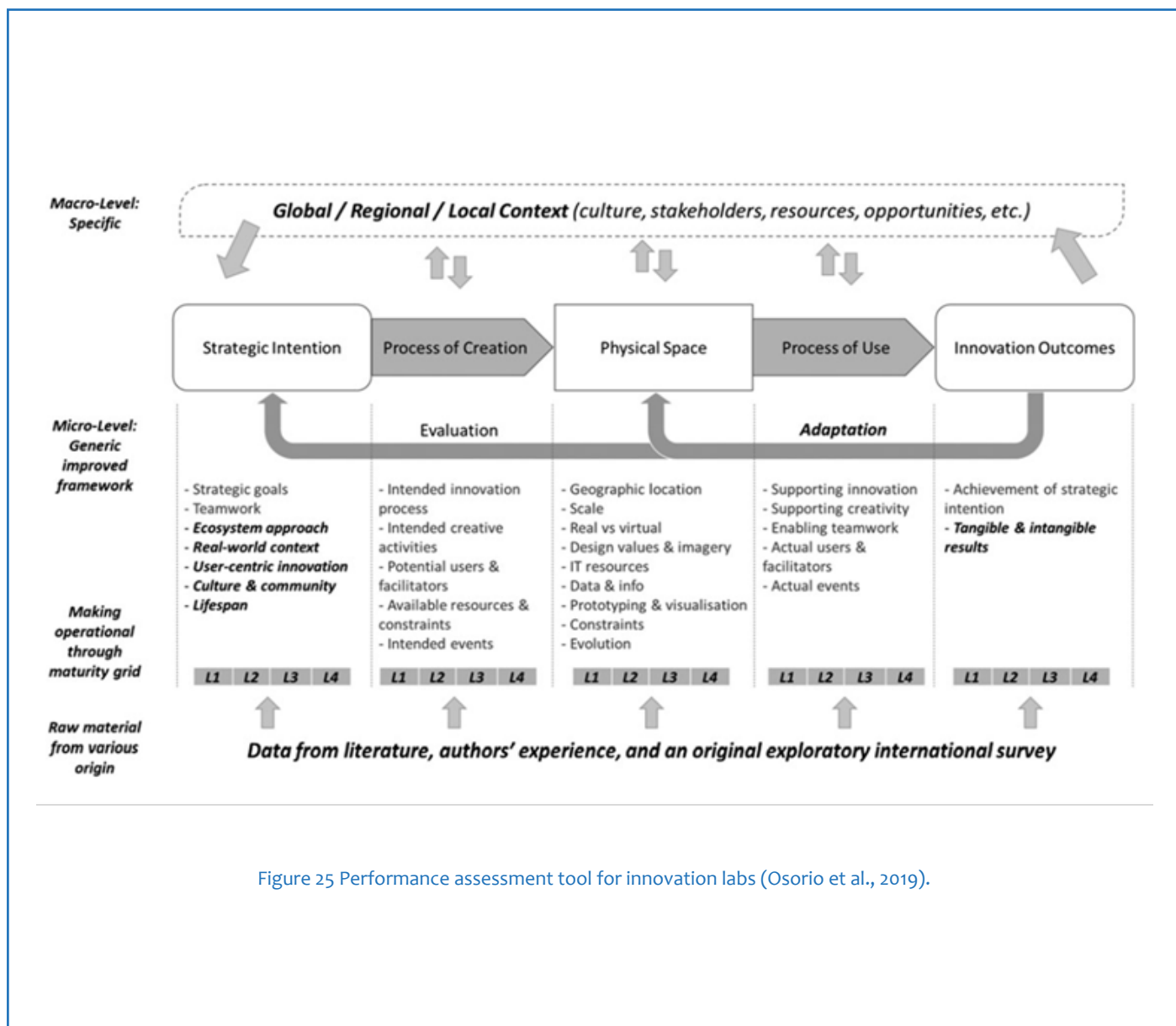

Figure 25 Performance assessment tool for innovation labs (Osorio et al., 2019).

Transition management as a model for managing processes of co-evolution

In the article 'Transition management as a model for managing processes of co-evolution towards sustainable development' Kemp, Loorbach, & Rotmans (2007) present a transition management model for managing processes of co-evolution. To manage transitions of societal systems, a form of multi-level governance is needed. Interaction between three levels is therefore introduced: a strategic, tactical and operational level (Figure 26).

Transition management aims to align these processes through a combination of network governance, self-organization and process management leading to modulation of ongoing dynamics. This way of management can be described as goal-oriented modulation: between planning and incrementalism (Figure 27). This perspective on management might provide the ResearchOR with insight in how to find the sweet spot between organisation and research.

Strategic level
Problem structuring, envisioning, long term goals

Tactical level
Agenda-building, negotiation, networking

Operational level
Experiments, projects, innovations, implementation
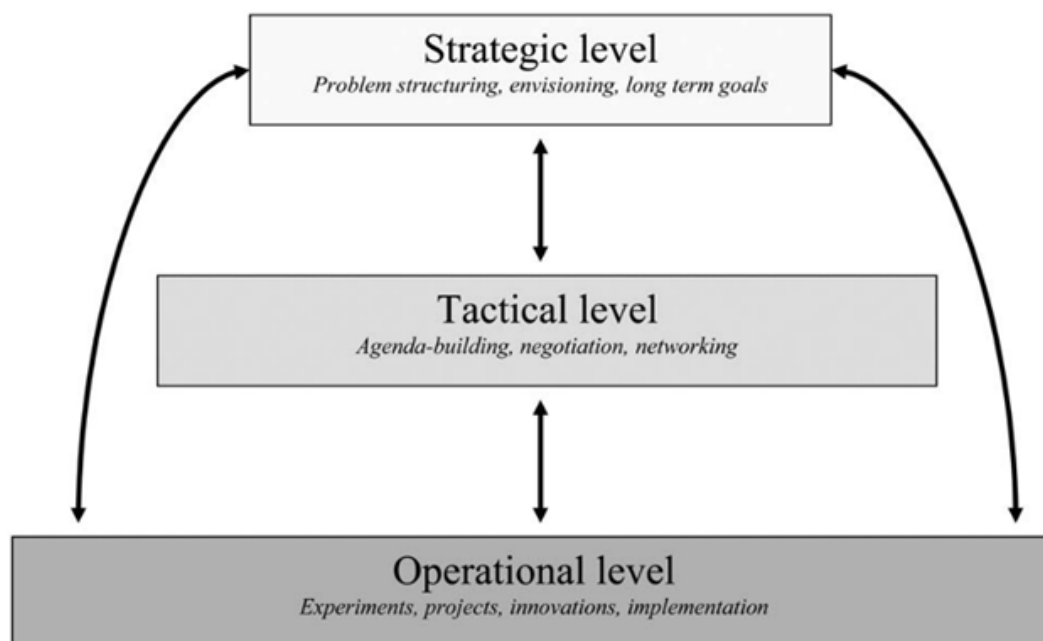
Figure 26 The different levels transition management aims to align (Kemp et al., 2007).

	Incrementalism	Goal-oriented modulation – of which transition management is an example	Planning
Key actors	Private and public actors	Private and public actors, experts	Bureaucrats and experts
Steering philosophy	Partisan mutual adaptation, learning-by-doing	Modulation of developments to collectively chosen goals, government is facilitator and mediator	Hierarchy
Role for anticipation	Limited (no long-term goals)	Dynamic, adaptive anticipation of desired futures as basis for interaction	Future is analysed and implemented through blueprint plans

Figure 27 Transition management as goal-oriented modulation, between planning and incrementalism (Kemp et al., 2007).

Managing open innovation

In the article '*Managing the challenges of becoming an open innovation company: experiences from Living Labs*' Westerlund & Leminen (2011) examine the steps and managerial challenges firms face when becoming open innovation companies. Based on experiences with Living Labs, four steps have been identified (Figure 28). These steps describe the different levels of user involvement a company encounters when becoming more open in their innovation.

When going through these steps, a transition in management style should take place. Westerlund & Leminen note that there is a difference between conventional project-based innovation development and the open innovation model. Management needs to pay special attention to these differences in order to be able to guide the company through the four steps. Westerlund & Leminen describe six main differences. Presenting the differences between traditional innovation and 'Living Lab innovation' can help the ReserachOR to give management a relevance and a style that fits them:

1. **Objective:** Traditional innovation projects work with pre-defined goals, and managers can evaluate the success of the project by comparing the project outcomes with the original project plan. Living Labs tend to work with undefined objectives and use loose guidelines to initiate and promote collaboration. The results can comprise several different outcomes which were not targeted at the beginning.

2. **Control points:** Project management control points are often located at the completion of defined tasks within the overall project plan. Open innovation in Living Labs is self-organizing and the goals of innovation management change by the users' activity and involvement.

3. **Project manager's role:** In the conventional model, the project manager manages and controls the resources and organizes schedules according to the project plan. However, Living Lab participants cannot be managed as though they were personnel. Their participation is often compelled by hedonic motives instead of economic ones. Managers therefore need to learn how to manage Living Lab participants. This is challenging and resource intensive.

4. **User's role:** In conventional innovation development users are objects of study. In Living Labs the users are equal to the other participants.

5. **Resources:** In traditional projects innovation recourses include those of the firm, and they are spend according to the project plan. In a Living Lab, goals might change radically over time. This can lead to a need of resources that was not anticipated for. A key managerial challenge is to facilitate user communities to generate sufficient support and resources.

6. **Management tools:** In order to manage a conventional project, a company can choose from an assortment of standard management methods and tools such as the stage gate model. In Living Labs collective decisions are made about future directions and control and coordination is often self-organized. Living Labs therefore need to use diverse facilitative methods, work group tools and relevant groupware.
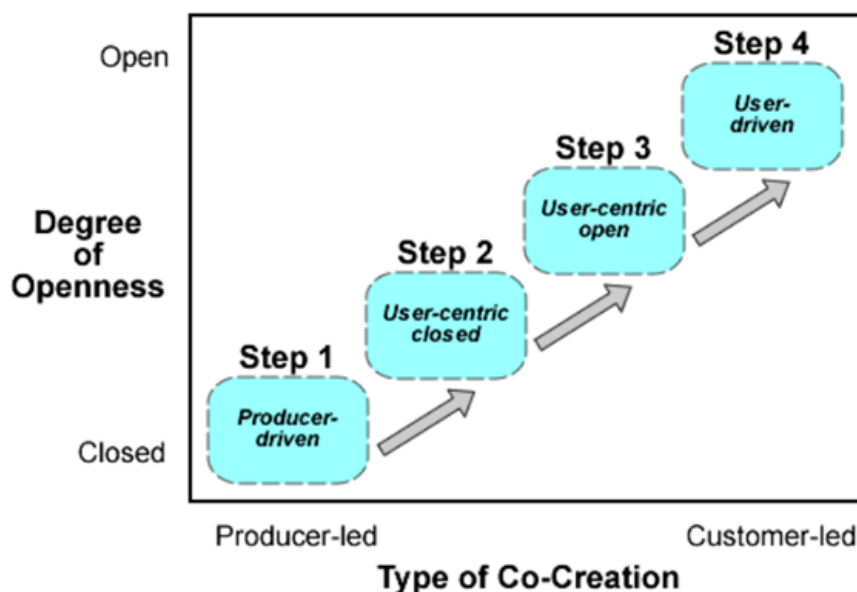

Figure 28 Four steps towards open innovation (Westerlund & Leminen, 2011).

In the article '*Enabling collaboration and innovation in Denver's smart city through a Living Lab: a social capital perspective*' Bartelt et al. (2020) state that the cognitive dimension of social capital enables collaborations from disparate teams. This leads to a more in-depth knowledge of team projects. As a result, there are more efficient project development strategies. An example is the concept of failing fast. A methodology or project is aborted as soon as it appears to not be succeeding.

Project abandoning can be done more quickly in a Living Lab environment because the teams are composed of experts who jointly and rapidly agree on whether the outcome will be a success or a failure. Thus, shared understanding through the cognitive dimension of social capital in Living Lab teams stimulates the 'fail-fast' approach. This might support the ResearchOR in their desire to start and stop their projects more rapidly.

10. **PART 6** Concept development and selection

In this chapter a morphological chart is set up. Based on the chart, three concepts were formulated. At the end of the chapter, one concept is chosen based on the design requirements to be further developed as the final design.

10.1 Aim | PART 6

The aim of this part of the design process was to co-design a concept that could be further developed as the final tool.

10.2 Method | PART 6

Based on the morphological chart an overall draft of the tool has been setup. The three concepts are formed by three possible levels of management in the tool (Figure 28). Concept selection was done by the means of a Harris profile.

Fully self-organized — Concept 1

Concept 2

Project manager — Concept 3

Figure 29 Three levels of management possible in the tool. These three levels are the three possible concepts.

10.3.1 Morphological chart functions

The design criteria have been transformed into morpho-logical chart functions (Table 27). These functions have been filled in in the morphological chart in Table 28.

10.3.2 Morphological chart

Possible solutions are based on the management litera-ture (theory), interviews with the ReseachOR participants (practice) and my own common sense (intuition). Diverg-ing takes place throughout these three columns . The theory provides a first window to look at a function. Input from practice then leads to more specific actions that could be undertaken. Based on my own intuition, these actions are translated into possible methods for in the tool. The results in the morphological chart are based on six articles and four interviews with ResearchOR stake-holders (Appendix 5).

Table 27 The design criteria, there themes and morphological chart functions.

Design criterium	Topic	Morphological chart function
Provide clear Living Lab structure	Structure Living Lab	Mapping the stakeholders and their roles and responsibilities
		Mapping the projects and the required and available resources
		Creating a mission and a vision for the total Living Lab
Increase focus of the Living Lab participants on management → provide insight in the importance and the time and energy the management of a Living Lab take	Awareness of Living Lab management	Mapping the current management structure (including roles and responsibilities)
		Evaluating the current management structure
Help finding the sweet spot between the time and energy that is spend on regulation and research	Balance focus between management and research in Living Lab	Balancing the time, energy and money spend on management and research
Help creating synergy and clear goals for the Living Lab projects	Synergy and clear goals Living Lab projects	Creating clear goals for Living Lab projects
		Creating synergy between the different Living Lab projects
Help the Living Lab understand their position in their network and field of profession	Strategic position Living Lab	Determining the position of the Living Lab in the network of participating stakeholders
		Determining the position of the Living lab in its field of profession

Figure 28 Morphological chart, to generate solutions based on theory, practice and my own intuition.

Functions	Solutions		
	Theory	Practice	Own intuition
Mapping the stakeholders and their roles and responsibilities			
Mapping the projects and the required and available resources			
Creating a mission and a vision for the total Living Lab			
Mapping the current management structure (including roles and responsibilities)			
Evaluating the current management structure			
Balancing the time, energy and money spend on management and research			
Creating clear goals for Living Lab projects			
Creating synergy between the different Living Lab projects			
Determining the position of the Living Lab in the network of participating stakeholders			
Determining the position of the Living lab in its field of profession			

Converging
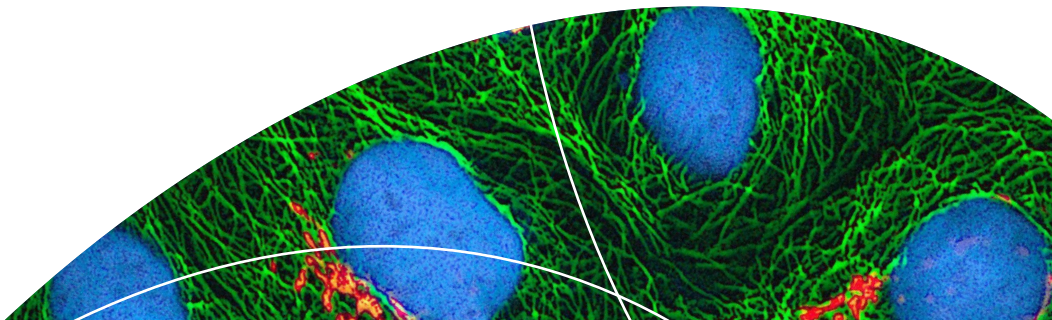
10.3.3 Development of concepts

An overall structure for the tool was established based on the morphological chart (Figure 30). The design of this tool can be carried out on three management levels. These three levels form the three concepts.

Overall tool structure

The tool starts by developing a profile for the ReserachOR. This includes determining the strategic position of the Living Lab in its field. This will help later on with the identification of new suitable stakeholders for the Living Lab. This follows the philosophy of landscapes of practice by Wenger: 'One could in fact define a responsible practitioner as someone whose experience in providing a service reflects the current competence of a community' (Wenger-trayner & Hutchinson, 2014). A vision and mission emerge from the strategic position, and form the second part of the Living Lab profile. Once the Living Lab profile is established, a standard procedure for the start of new projects follows. In this procedure a project goal and corresponding activities are determined. Based on this information roles, responsibilities and fitting stakeholders can be identified. By following this procedure, the Living Lab can avoid collaborations with stakeholders with unclear contributions to the project, or competition between stakeholders who offer the same resources. It makes it also easier to defend to current partners why a new partnership with another party is started.

The third phase of the tool leaves the course of the project open. Important in this phase are the moments of evaluation of the goal and management of the project. As described by Westerlund & Leminen (2011), in contrast to traditional innovation, the project goals of Living Labs can change during the process to initiate and promote collaboration. It is however crucial that all concerned stakeholders are aware of the development of the project goal over time. The same goes for management. Westerlund and Leminen state that standard management methods do not hold in a Living Lab. In Living Labs control and coordination is often self-organized. Evaluation of how this self-organized management is executed is therefore important. This information can be used at the start of new projects.

Note that, by creating an overall Living Lab profile and standard project start procedure but a self-organized project execution, this tool aims to establish the balance between management and research. At the core of this tool lies the idea that self-organized project execution and an overall Living Lab structure do not rule each other out.
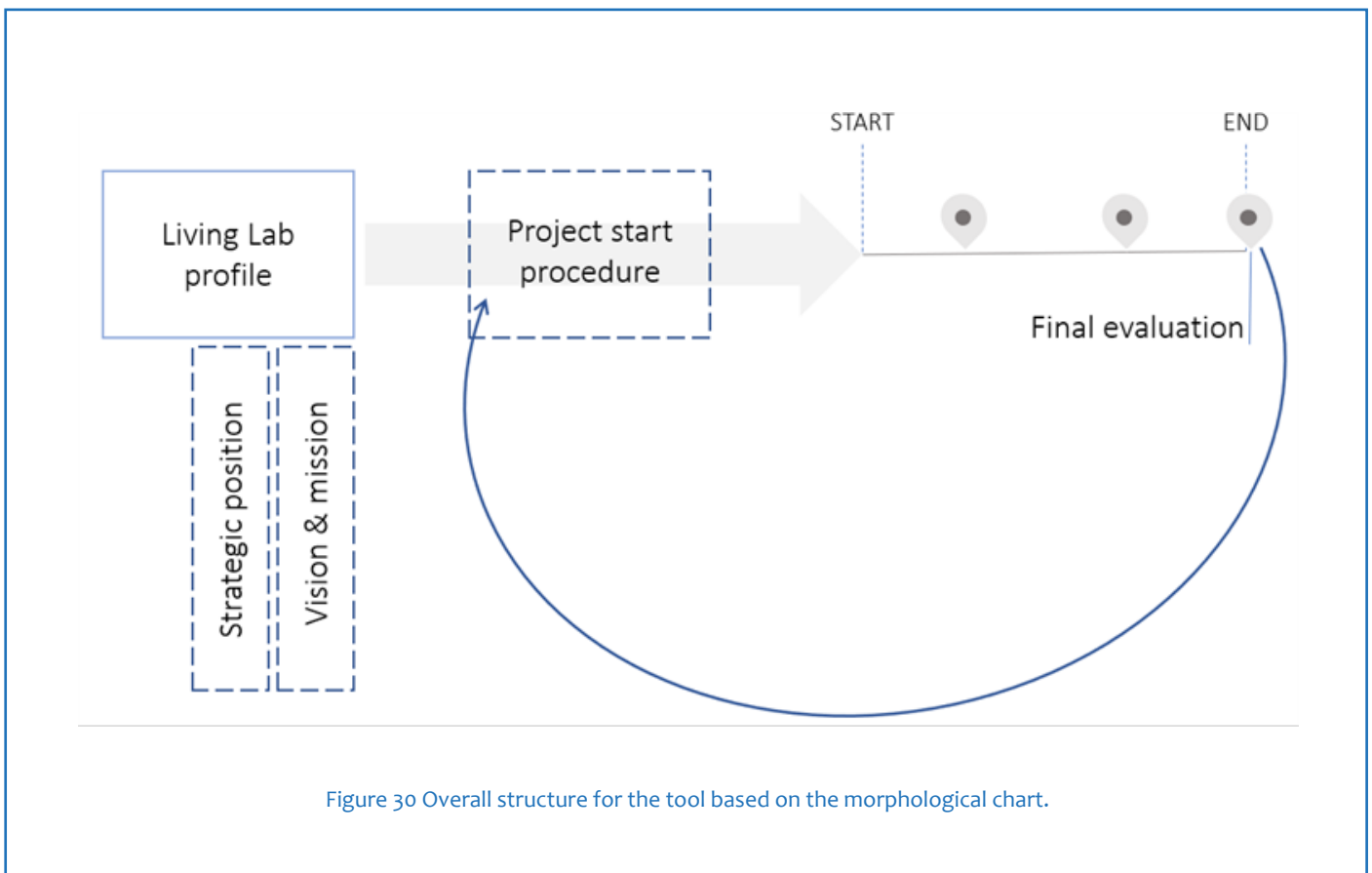

Figure 30 Overall structure for the tool based on the morphological chart.

Three concepts

The three concepts all have a different management level for carrying out the tool (Figure FIXME). The scale of the management levels goes from fully self-organized Living Lab teams to a situation where the teams are supported by a project manager. Note that by using this scale there is searched for a balance in being a community (with little reliability) and a bureaucracy (with little freedom).

Concept 1
Self-organization of the Living Lab teams leads to maximum involvement of the stakeholders. It gives them independence and freedom. Furthermore, the costs of this management style are low. However, this also means that there is little control over the teams from the Living Lab as a whole. This might lead to less synergy between the different projects. The quality of the project fully depends on the ability and motivation of the stakeholders to collaborate.

Concept 2
The risk's as described in concept 1 are less present in concept 2 due to the organizing and monitoring role of the Living Lab coordinators. Because there is more control over the projects from the Living Lab as a whole, it is easier to secure synergy between the different projects. Furthermore, the monitoring of the projects is now also performed by the Living Lab coordinators.

This could increase the quality of the monitoring and therefore lead to better solving of the problems that are detected. Overall, this could result in more successful projects and more control at a limited cost. Disadvantages of this approach are that it takes the Living Lab coordinators more time and that the involvement of the stakeholders might be less than the scenario in concept 1.

Concept 3
Hiring a project manager gives the Living Lab a lot of control over the projects. Furthermore, it will save both the stakeholders and the Living Lab coordinators a lot of time that would otherwise be spend on management and organization. This scenario requires some expenses however. The stakeholders might also feel less ownership over their project and become therefore less involved and motivated. Another risk of hiring a manager could be that management become a goal in itself. One of the great advantages of a Living Lab is that the free and uncontrolled way of working leads to surprizing innovations that fit the situation in practice. Great investments in management by funding could lead to external demands on how the management is executed. In this scenario, a very clear description for the supporting role of a manager in a Living Lab is therefore crucial.
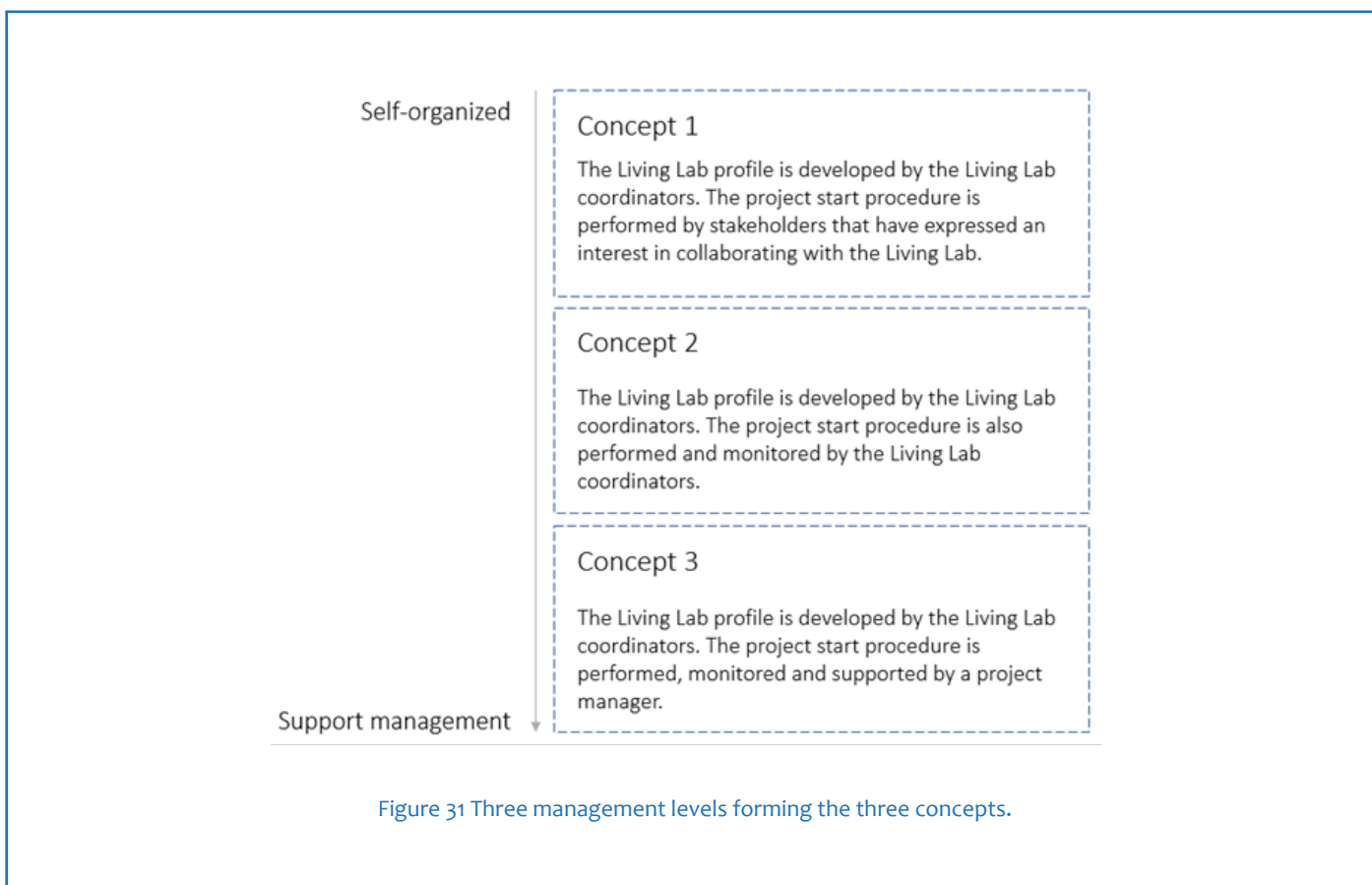
Figure 31 Three management levels forming the three concepts.

For the selection of a concept the design criteria have been placed in Harris Profiles (Table 29). The design criteria have been ranked, and a Harris Profile was filled in for each concept. On a scale of-2 to 2 the concepts have been scored for each design criterium. This resulted in the black 'block towers' as shown in Table 29. The concept with the tower that has the best chance to 'fall' to the right wins. In this case, that would be concept 2. Concept 2 has therefore been selected to be further developed as the final tool.

10.4.1 Answering the third sub question

The third sub question, *Which (communication) functions could support the organizational structure of a Living Lab?*, can be answered with the morphological chart functions in Table 30.

Table 29 Harris Profiles with ranked design criteria for concept selection. Concept 2 was selected for further development.

Table 30 Morphological chart elements that are communication functions that could support the organizational structure of a Living Lab.

1	Mapping the stakeholders and their roles and responsibilities
2	Mapping the projects and the required and available resources
3	Creating a mission and a vision for the total Living Lab
4	Mapping the current management structure (including roles and responsibilities)
5	Evaluating the current management structure
6	Balancing the time, energy and money spend on management and research
7	Creating clear goals for Living Lab projects
8	Creating synergy between the different Living Lab projects
9	Determining the position of the Living Lab in the network of participating stakeholders
10	Determining the position of the Living lab in its field of profession

To avoid getting to abstract and lose touch with the practical application of the morphological chart functions, a sketch of their role in the communication tool has been made (Figure 32). The first step is to determine the strategic position of the Living Lab in both its network and in their field of profession. This will help creating a Living Lab structure: the Living Lab knows what it means to its stakeholders and what role it would like to play. Determining internal stakeholder roles and responsibilities is accommodated by this knowledge. Furthermore, mapping previous, current and future projects can reveal trends the Living Lab was unaware of and support the creation of a shared Living Lab mission and vision.

The mission and vision form the basis for the creation of synergy and clear goals in future Living Lab projects. The Living Lab structure also supports the mapping and evaluation of the Living Lab management, since it provides clarity in where the management should lead to. There is an evaluation loop between the search for balance between management and research in the Living Lab, and the mapping of the current management structure.

Figure 32 The role of the morphological chart functions (per topic) in the communication tool.
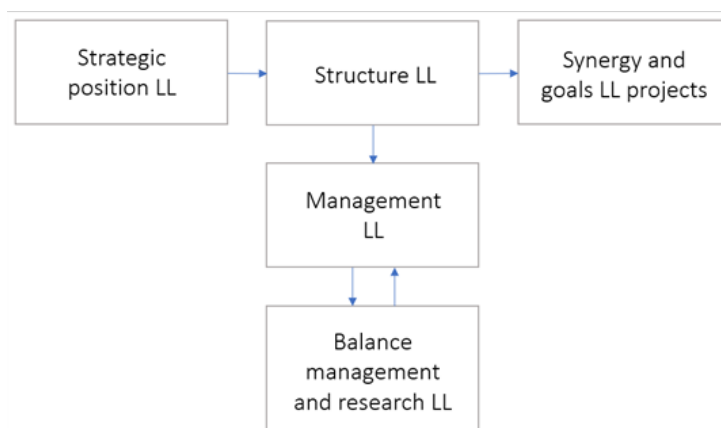
11. **PART 7** Final design

In this chapter the first draft of the tool is further developed on the management level of concept 2 into a final design for a guide that enables Living Lab coordinators to develop and maintain an organizational Living Lab structure.

11.1 Aim | **PART 7**

It was the aim to achieve the design goal: *to design a guide that enables Living Lab coordinators to develop an organizational structure.*

11.2 Method | **PART 7**

In the morphological chart sub solutions were generated by participants of the ResearchOR. Together with theory and my own intuition, these sub solutions have been connected in the final tool. The way the sub solutions have been connected is inspired by the Living Lab performance assessment tool of Osorio et al., 2019 (Figure 25).

11.3 Results | **PART 7**

11.3.1 Time line and form of the tool

Before explaining the separate elements of the tool in detail, it is important to show how the timeline of the tool is intended. The first part of the tool (creating a Living Lab profile) is a one-time event that should be evaluated and updated now and then. The Project start procedure and monitoring happens every time a new project is started. Furthermore, at the end of each project a final evaluation takes place. The output of this evaluation can then be used as possible input for improvement of new project start procedures and, on a higher level, the vision and mission of the Living Lab (Figure 33).

The physical tool will exist of two parts:
1. *Booklet* with overview of the tool and design for the Living Lab profile sessions, project kick-off and project evaluation.
2. *Digital tool* for the Living Lab coordinators to fill in the project start procedure and evaluation outcomes.

Figure 33 At the end of each project a final evaluation takes place. Output of this evaluation can be used for improvements of new project start procedures.
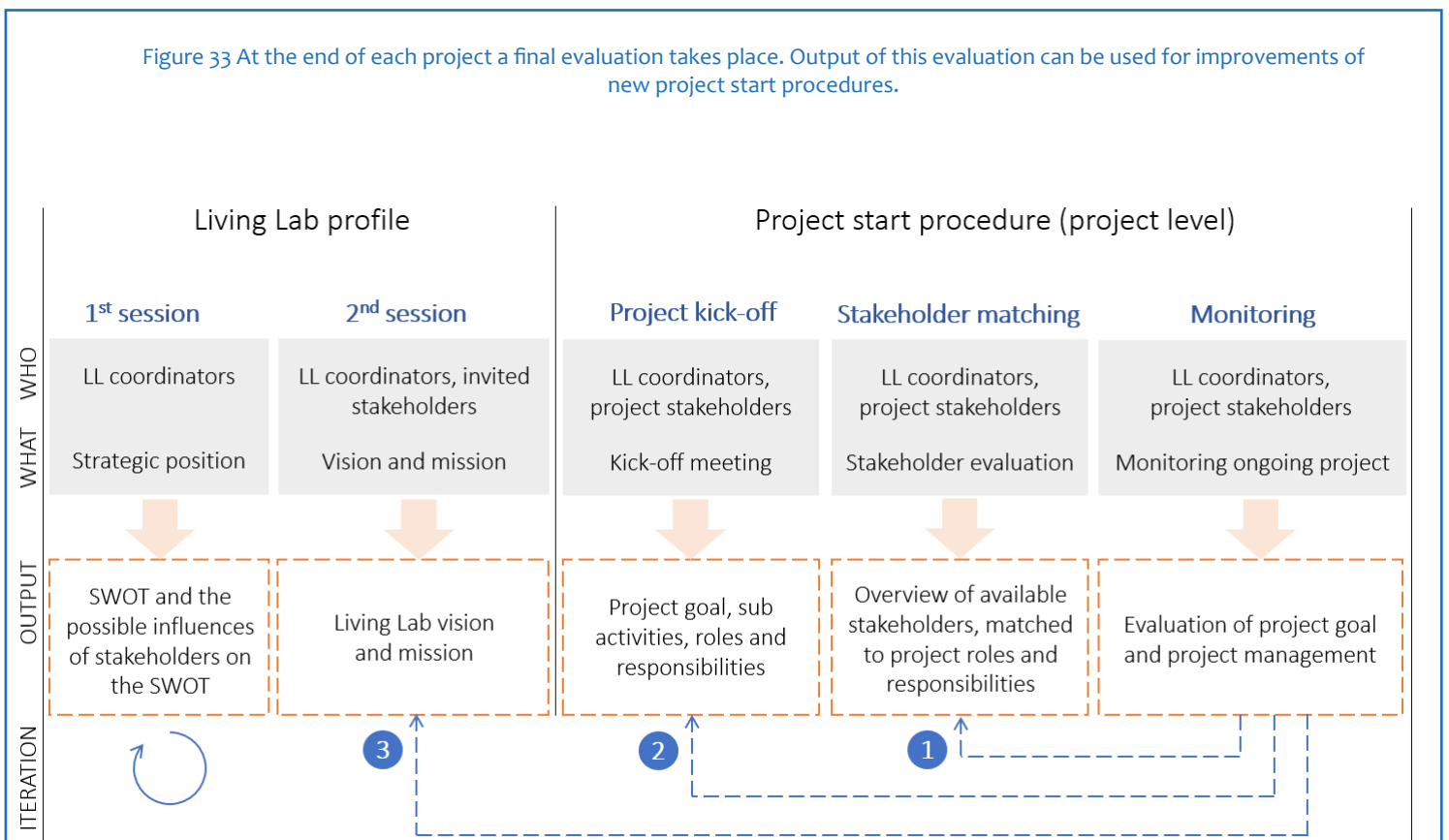
11.3.2 Living Lab profile

In this section the first part of the tool is illustrated: the development of a Living Lab profile.

Strategic position

Living Labs are strongly dependent on their stakeholders. The constantly changing composition of the stakeholders makes the collaborations in Living Lab complex. It is therefore crucial to have a clear strategic direction, to know which stakeholders they need to achieve their goals and, consequently, to know what they can offer their stakeholders in return. Identifying which role your Lab plays in the landscape it operates in is therefore important. The tool therefore starts with identifying the strategic position of the Living Lab by conducting a SWOT analysis (Figure 34).

INTERNAL	EXTERNAL
Strengths	Opportunities
Weaknesses	Threats

Table 31 Overview of SWOT scheme.

The Living Lab coordinators start by making an environmental scan. An inventory of relevant trends for the Living Lab is made by making use of the PEST method (onStrategy, 2020). By using this method there is systematically brainstormed for trends in four categories: political (such as legal and regulatory), economic, social and technological.

The next step is to perform a competitive analysis. The Living Lab coordinators make a list of organizations similar to their Living Lab and make an estimation of the strengths and weaknesses of these organizations. Good questions to ask yourself here are if these organizations form opportunities or threats for the Living Lab, and if there are competitive advantages. By looking at the trends and competitors in the landscape of the Living Lab, a SWOT analysis can be performed in the third step. The Living Lab coordinators identify the strengths, weaknesses, opportunities and threats of their Living Lab (Table 31).

At the end of this step it is important to think about what the outcomes of the SWOT mean for the network of the Living Lab. Which stakeholders could be attracted by your strengths? Which stakeholders could reduce the risks of threats for your Living Lab? The SWOT scheme should be kept up to date by iterating on it every now and then. Are the trends still relevant? Should new trends be added?

Figure 34 At the end of each project a final evaluation takes place. Output of this evaluation can be used for improvements of new project start procedures.

	Environmental scan	Competitive analysis	SWOT
WHO	Living Lab coordinators	Living Lab coordinators	Living Lab coordinators
WHAT	Make an inventory of relevant trends for your Living Lab (PEST method) Political / Economic / Social / Technological	Make list of organizations similar to the Living Lab and their strengths and weaknesses Do they form opportunities or threats? Are there competitive advantages for the Living Lab?	Based on the previous steps, identify strengths, weaknesses, opportunities and threats for your Living Lab
OUTPUT	Overview of key trends in your operating environment	Overview of competitors	Overview of strengths, weaknesses, opportunities and threats

Vision and mission

For the development of the vision the scheme in Figure 35 was developed. The Living Lab coordinators organize a meeting with stakeholders that are stable partners and have a long term interest in the Living Lab. In the session a vision is formulated, based on statements about how they would like the Living Lab to look like in 5 or 10 years.

After the formulation of the vision, the mission of the Living Lab can be established (Figure 36). In the same session as the vision, a mission is created by brainstorming about *why* the Living Lab exists.
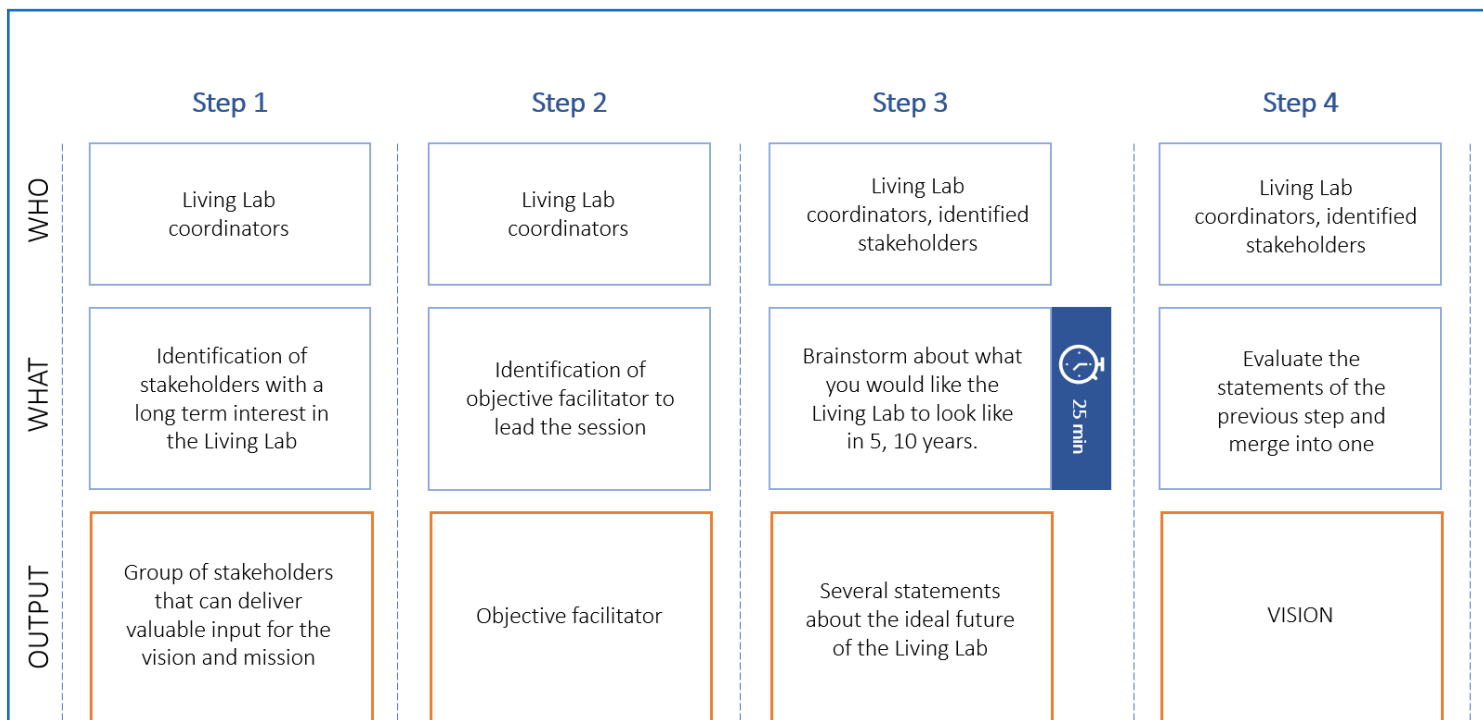
Figure 35 Scheme from the tool for the development of a Living Lab vision.
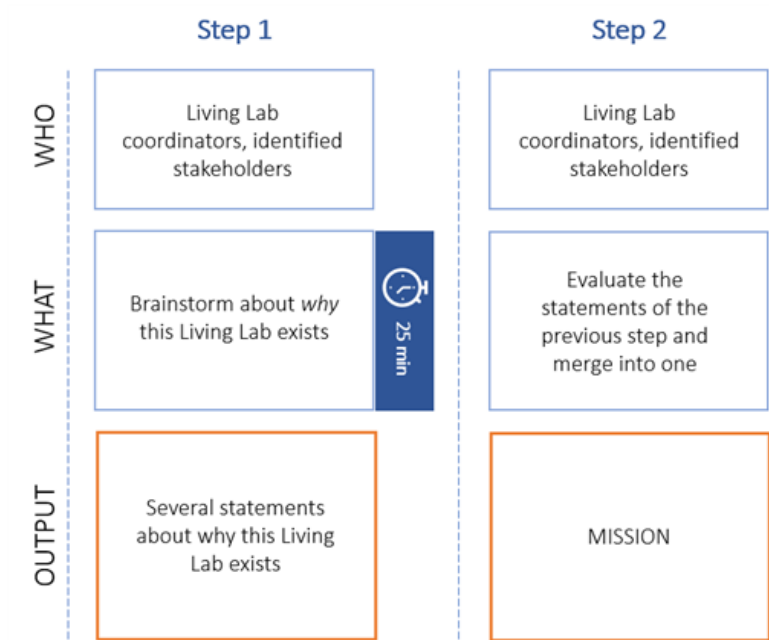
Figure 36 Scheme from the tool for the development of a Living Lab mission.

11.3.3 Project start procedure

In this section the second part of the tool is illustrated: the project start procedure.

Project kick-off

New projects in Living Labs often start with conversations about possible collaborations with stakeholders who have an idea that fits the Living Lab philosophy. In a first kick-off meeting with possible stakeholders the vision and mission of the Living Lab are presented by the Living Lab coordinators. A project goal can be established in this meeting, or perhaps in meetings later on. This depends on the type of stakeholders and the nature of the collaboration. This is up to the Living Lab coordinators.

Once a project goal has been established, sub activities required to fulfilled this goal can be identified. For this purpose the tool includes a digital scheme in which the sub activities can be listed (Figure 37). From these sub activities, stakeholder roles and corresponding responsibilities can be identified. These components are added to the scheme in the tool.

Stakeholder matching

After the identification of the required stakeholder roles and responsibilities, the tool advises to make an inventory of possible stakeholders and their resources, expertise and available hours. This step is performed by the Living Lab coordinators and the other initiative takers of the new project. The result of this inventory can be listed in an overview in the tool (Figure 38).

Figure 38 Digital component of the tool to make an inventory of possible stakeholders for the project.
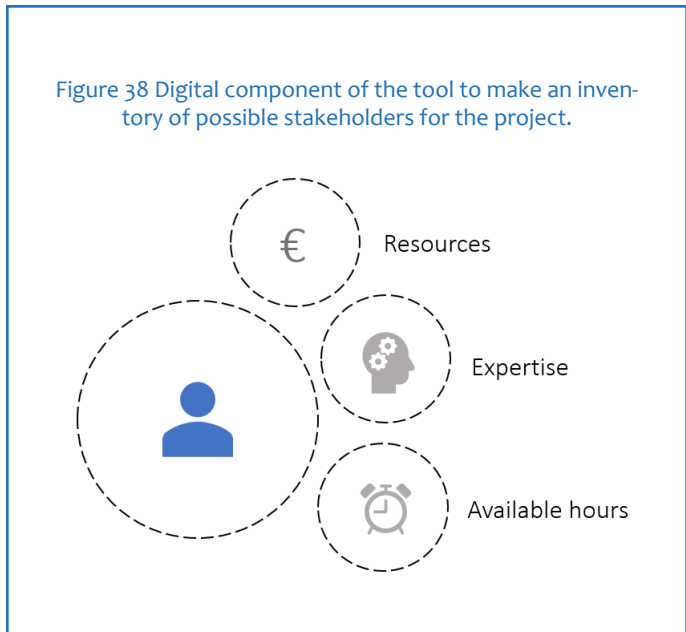
Based on this evaluation, stakeholders can now be matched to certain responsibilities based on their capabilities (Figure 37). Take a look back at the SWOT and think of which stakeholders you need to counter threats. The most important stakeholders to match are of course the initiative takers. When it appears that other stakeholders are required for certain responsibilities, they can be invited to the project. This way of selecting and matching stakeholders creates very clear goals and responsibilities for all parties involved. It can be used as support to defend why a certain external party was invited to collaborate, or as a base for contracts between Living Lab partners. The tool is also meant to help the project group to avoid collaborations with stakeholders who will have the tendency to take the same role. When stakeholders share expertise they might start acting like competitors instead of partners.

Figure 37 Digital component of the tool in which the sub activities and corresponding stakeholder roles and responsibilities can be listed.
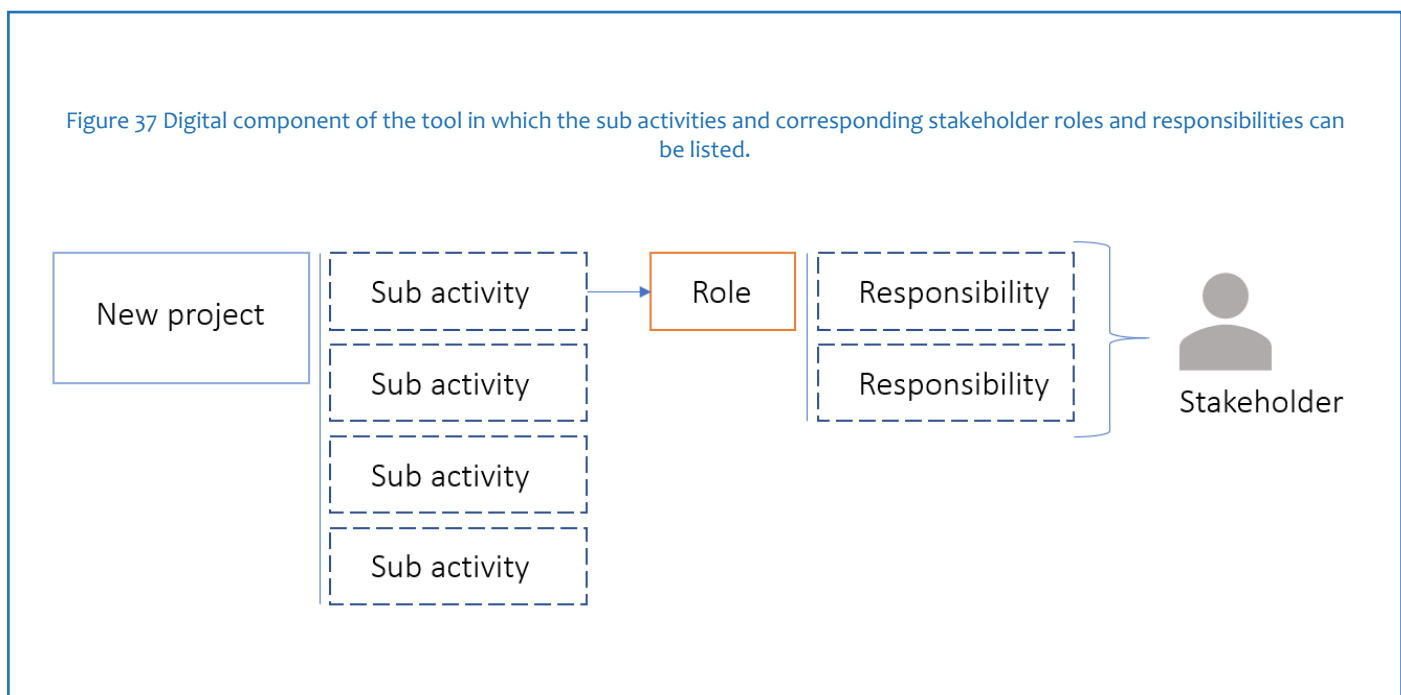
Once the project goal, responsibilities and stakeholders are identified and on board, the project activities can start. While the project is ongoing, the tool advises to have an evaluation session every few weeks. The frequency of the evaluations depend on the project size and duration. It is up to the Living Lab coordinators and project participants to determine these evaluation moments.

During the evaluation session the current project goal and management are evaluated.

Questions the participants could ask themselves while evaluating the project goal:

1. Does the goal still satisfy all the stakeholders?
2. Based on where you are now in the project, is this goal still useful for the user?
3. Should the goal be adjusted bases on the knowledge you now have?

Questions the participants could ask themselves while evaluating the project management:

1. Is everything in the collaboration clear?
2. Is there a good balance in time you spend on management and time you spend on research? And if not, how could this balance be restored?

At the end of a project, a final evaluation takes place.

Questions the participants could ask themselves in the final evaluation:

1. Was the project goal reached?
2. How could the collaboration have been improved?
3. What are learnings to take with you for future collaborations?

The Living Lab coordinators can register the learnings from the final evaluation in the tool. These learnings can be used for the improvement of the setup of new projects, the current vision and mission and the strategic position of the Living Lab.

11.3.4 Validation of the tool

To validate if the tool addresses the identified barriers we look back at the commandments relevant to the problem statement. These commandments state that driving and sustaining collaborations and finance are not always a priority in Living Labs and that the inexperience of participants with the entrepreneur role can be a barrier for Living Lab projects. Another barrier is that a lack of focus in Living Lab projects can lead to inefficient processes and misunderstandings. Clear goals are therefore important on both project and Living Lab level. That also means there should be a certain synergy between the projects.

Furthermore, working in a Living Lab takes time. This can be problematic for participants, since it is extra work next to their regular job. Therefore some participants feel like there is an overhead in organization around the research in the Living Lab. A sweet spot must therefore be found between regulation and research. It is also important that Living Labs understand their position in their network and field of profession.

The tool starts with the setup of a SWOT analysis. This helps the Living Lab coordinators think about the position of the Living Lab in the network and what position they would like to have. The next step in the tool is establishing a vision and a mission. This involves thinking about strategy and therefore involves an entrepreneurial way of thinking. Following the mission and vision also supports creating synergy between the different Living Lab projects. The Project Start Procedure in the tool addresses the need for clear project goals. Tracking stakeholders and their resources has the function of creating overview and structure without an overhead of organization around the research. Another way of looking for the sweet spot between regulation and research are the evaluation steps at the end of each project.

RIGHT: Figure 38 Living Lab perspective matrix, with extra focus on the shift in perspective that takes place when a stakeholder moves to the second row.

Discussion

It was the aim of this project to design a tool that supports coordinators of Living Labs by means of communication, hereby enabling the coordinators to realize successful innovations on the healthcare market. Complementary to the aim of the project, the main research question was formulated as follows:

How can communication help the ResearchOR to work in a structured way without loosing its adaptivity?

To this end a matrix containing different perspectives of a Living Lab was constructed. In this matrix, a connection is made between the functioning of the Living Lab in terms of successful projects and the functioning of the network between those projects. This connection can be examined on different levels in a Living Lab, from a single stakeholder in a project to the entire Living Lab network and the Living Lab as a whole. It is crucial for Living Labs to be aware of this connection because it can have great impact on the sustainability of the organization. One of the reasons is that by looking at the Living Lab from different perspectives, a distinction is created in Living Lab project success and Living Lab success. What makes a Living Lab successful? Separate successful projects? Or should the projects serve the greater good, namely the Living Lab as a whole?

The former might be true for a beginning Living Lab. But when the jurisdiction of the Living Lab grows, and the network improves, the latter perspective might become necessary to secure the long term establishment of your Living Lab.

The hypothesis that there is a shift in perspective when a Living Lab develops itself further implies that stakeholders move through the matrix. This could be an interesting thought to further explore. New stakeholders start in the top left corner (Figure 38). When both the stakeholder and the Living Lab develop, the stakeholder moves through the matrix towards the lower right quadrant. One can also imagine that when new stakeholder joins a further developed Living Lab, he might start in the upper left corner but on a 'higher level' because the projects and other stakeholders already share higher perspectives. The same goes for an experienced Living Lab stakeholder that comes from the lower right corner but starts a brand new project. In other words: the lower right quadrant is not the end of the road. It seems that stakeholders will keep moving through the matrix, but in an upward spiral in which they reach more advanced levels of Living Lab collaboration (Figure 39). In that sense, the value of the Community of Practice increases each level.
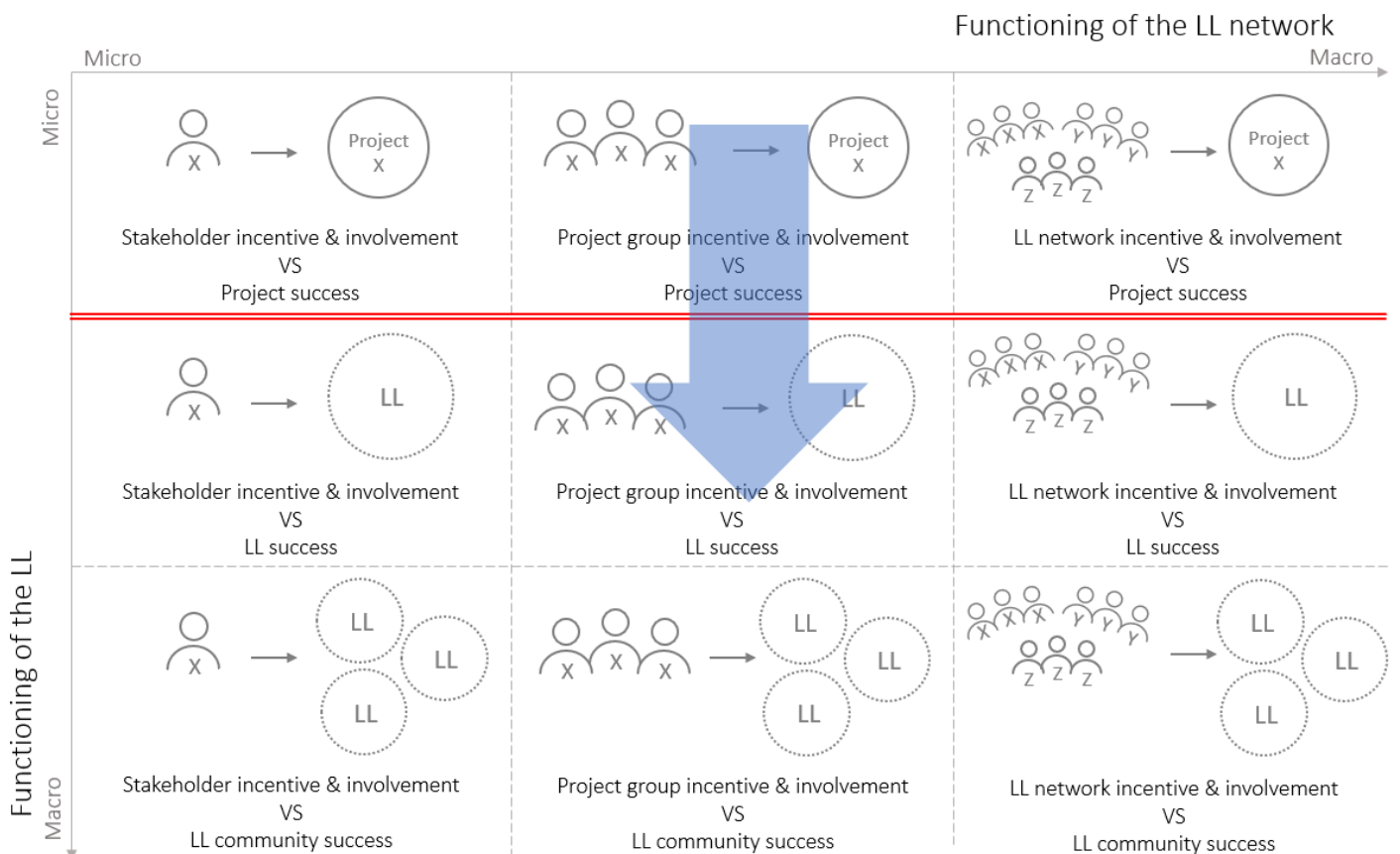
When moving through the matrix, the transition from the first row to the second is a crucial and difficult step (Figure 38). A change in perspective then takes place from a single project to the functioning of the Living Lab as a whole. In some aspects, the stakeholders of the ResearchOR have made this transition, in other aspects, not yet. An important factor for making the transition is trust: trust in the people you work with, and trust in the Living Lab as an organization. Sometimes you have to let go and trust other stakeholders with responsibilities. You also have to trust that the Living Lab will be worth your investments.

The tool developed in this thesis also plays a role in this transition. It creates an overview of the overall goal of the Living Lab and maps the roles and responsibilities of the people involved. That means that the stakeholders have a better understanding of the organization and strategy of the Living Lab. This could support the shifting of perspective from single project to the Living Lab as a whole.

Figure 39 Moving through the matrix multiple times could lead to an upward spiral with more advanced Living Lab collaboration.

Literature also recognizes this need for trust. However, mostly in the form of displaying valuable Living Lab results to attract and convince new partners. The development of trust based on (long term) experiences in the Living Lab is still overlooked. As can be seen when plotting the commandments in the matrix, literature focusses more on the lower right of the matrix. However, it takes time to reach that point and perspective of collaboration. Just as Wenger states about Communities of Practice, it is important for Living Labs to be aware of their role and position in the landscape. However, it takes time to grow into a landscape and to leave the past behind. It is important to look at human measures when investigating Living Labs. That means the upper left part of the matrix and the road towards the lower right should also be taken into account. In future research, it would be valuable to investigate which factors are important for the transition from one quadrant in the matrix to the next. For example, more interviews could be held in which drivers and barriers for the specific transitions are identified.

Still, the management of Living Labs proves to be difficult and should therefore be addressed with care. It is important that the participants in Living Labs have diverse backgrounds while having shared values. Being alert to conflict between the projects and network should therefore not be overlooked.

For optimal collaboration, equality amongst the participants should be present. The Living Lab organization should understand the position of the Living Lab in their field of profession and invest in creating an attractive network. That is crucial for bringing in funding for the Living Lab. Other ways for the establishing funding and strengthening the Living Lab position is to exploit its role as facilitator of market transition and by displaying successful projects and collaborations.

Next to shared values, Living Lab participants should have a way of working that fits the other stakeholders. The Living Lab network should complement the network of potential stakeholders and give stakeholders access to research settings in practice. When a new stakeholder enters the Living Lab network, disbalance in social capital between this stakeholder and the others should not lead to unequal collaborations. Living Lab participants tend to have a limited focus on management. The importance of the time and energy the management of a Living Lab takes should therefore not be underestimated. This also means that a sweet spot should be found between time and energy spend on regulation and on research.

Other organizational related commandments are Living Lab projects should have synergy and a clear goal, and legislation should be sorted out before starting a project. A commandment specific for the ResearchOR is correlated with the important role of the hospital in this Living Lab: the hospital must see the benefits of a project and must be willing to participate. This should be the case at the start of the development up to the market transition.

Based on the commandments of literature and practice, elements that should provide a Living Lab structure were identified. The organizational structure of al Living Lab should include a clear strategic position by determining the position of the Living Lab in the network of participating stakeholders and in its field of profession. A more clear structure of the Living Lab itself should be established by mapping the stakeholders and their roles and responsibilities, mapping the projects and required resources, and creating a mission and vision. Awareness of Living Lab management amongst the participants should be created by mapping and evaluating the management of the Living Lab in the project groups.
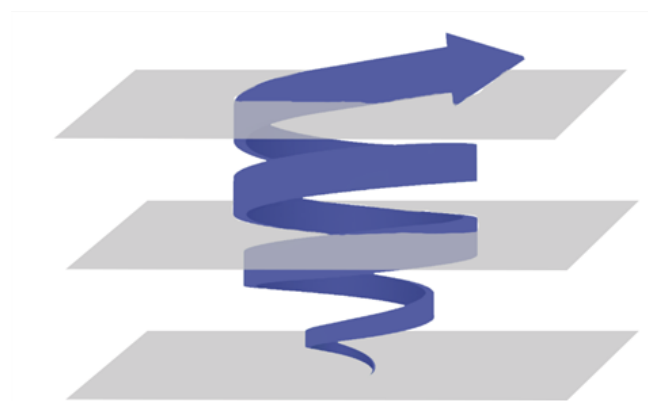
Furthermore, a balance should be found in focus between management and research and clear goals in the living Lab projects should be established.

As most literature has concluded, Living Labs are just getting started. They are increasingly recognized as valuable collaborations. That creates possibilities for growth, and with that, more mature and stable Living Labs. The tool developed in this thesis can support Living Labs in becoming more stable undertakings. However, despite the fact that this tool was codesigned with the participants from the ResearchOR, it has not been tested in practice yet. To validate the tool, it should be tested- first, in the ResearchOR, and later on in other Living Labs. In these tests it is important to establish if the tool creates a balance between a both structured and adaptive way of working. Furthermore, it is important to assess if the Living Lab coordinators do not experience too much workload. Other limitations lie in the fact that this tool has been developed based on just one case study. Developing such a tool in collaboration with multiple Living Labs, Living Labs from different fields even, will lead to better validation.

Overall, collaborations in a Living Lab on micro level are still a bit underexposed in literature. Investigating these interactions in more detail might help to create more unity between the different stakeholders in Living Labs. This could improve the stability of the collaborations, and therefore, the sustainability of the Living Lab as a whole. The step from a starting Living Lab to a more mature Living Lab could then be made. For that is what healthcare needs: the creation of medical innovations that are truly of value in practice. That means innovations that improve patient safety and improve the working conditions of the medical staff. Such innovations can only be created through close collaboration with all involved stakeholders. That makes the concept of a Living Lab powerful but complex.

Due to this complexity people can get tangled up in the collaboration. Unclear working structures and responsibilities then cause a decrease in the power of the Living Lab. Finding the balance between adaptivity and clear standard procedures is the million dollar question in many collaborations, not just Living Labs. How to make your work innovative and customized without having to reinvent the wheel every time? This is something that takes time and practice. With new people and new ingredients you follow a certain recipe that has standardized steps. People have to learn to follow the recipe, have to be educated in the Living Lab methodology. This way, stakeholders can move through the matrix and develop themselves into professional Living Lab stakeholders. Partners with powerful collaboration and innovation skills, and with a vision that focusses on creating valuable innovations that can be directly implemented in practice.

Conclusion

Healthcare systems are under increasing pressure. I believe that Living Labs can play an important role in the future by creating medical innovations that both solve problems from practice and fit in the workflow of the user. An important factor is the determination and open-mindedness of Living Lab participants. These are ingredients that can move mountains. One of the interviewees made a comparison with the vast medical developments around the corona pandemic. When determination and open-mindedness are present, great things are possible in a short time.

Still, implementing medical innovations in healthcare is extremely complex. Collaboration between healthcare professionals, engineers, the industry and the government is crucial. Bridging between other parties that have views that are so very different from your own, however, is difficult. It is necessary to let some of your own habits go to be able to come to a mutual understanding of the innovation you are working on. This is precisely what happens in Living Labs. This does not mean, however, that the complex dynamics from the world of healthcare are not present in the Living Labs. The people in Living Labs tend to be very openminded and driven for the cause of the Living Lab. However, with different Living Lab projects come different stakeholders. That means that the network of a Living Lab is always changing. This has great impact on the functioning of the Living Lab, for the network brings the required expertise and resources.

Connected to the different levels of collaboration and the dynamic network is the problem statement of this thesis. The Living Lab method is relatively new, and Living Lab participants are rarely entrepreneurs. The result tends to be an unclear Living Lab structure with little focus on management. Creating structure in Living Lab collaborations can save participants lots of time and frustration. It is crucial however, to maintain the free and open way of collaborating, which is characteristic for Living Labs. The key in finding the sweet spot between working like a community and a bureaucracy might be systematically tracking of involved Living Lab stakeholders. Much of the Living Lab structure and organization will be dependent on local circumstances. And that is both the strength and the curse of the Living Lab. But, being able to systematically track your stakeholders, their responsibilities and contributions by the means of a protocol could save many Living Labs a lot of time and unpleasant surprises.

In this thesis, it was concluded that participants in Living Labs tend to have a limited focus on management. A consequence is that the overall structure, activities and vision are not always clear. Due to these unclarities, management might take more time than necessary. That makes that the participants in this case study tend to have a preference to keep the whole collaboration low key. However, valuable collaborations, research opportunities and funding might be lost.

To conclude, the answer to the main research question (*How can communication help the ResearchOR to work in a structured way without loosing its adaptivity?*) might lie in mapping the vast changing composition of stakeholders Living Labs have to cope with. By clearly communicating who is involved and why, structure can be provided without turning the Living Lab into a static bureaucratic organization.
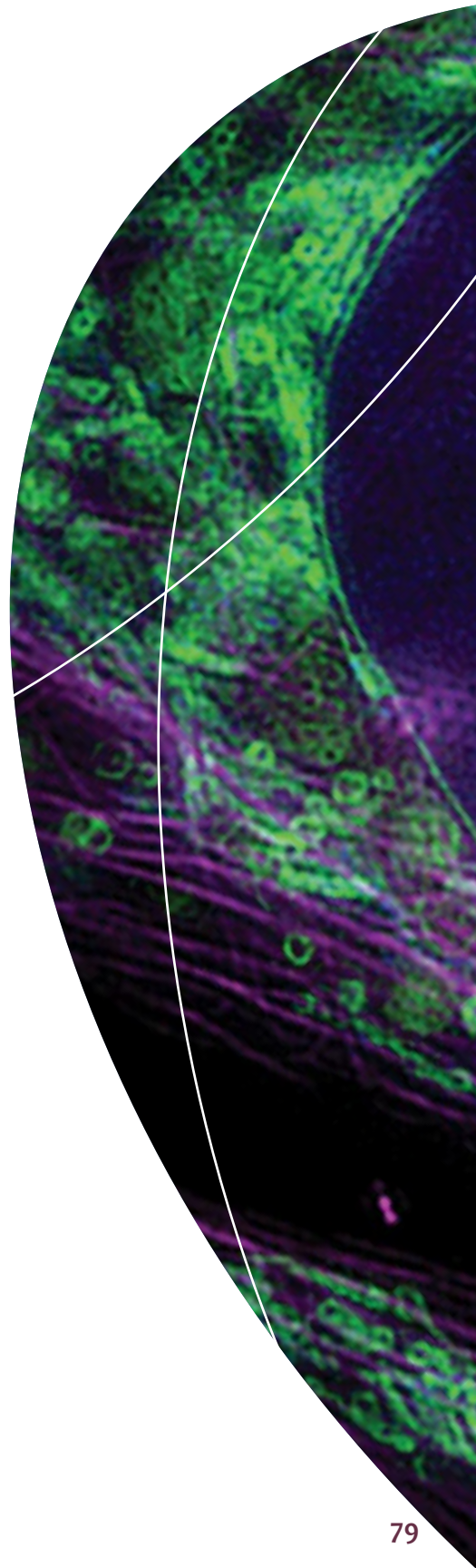
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Appendices

Appendix 1 Drivers and Barriers from literature clustered in themes

Appendix 1.1 Drivers per theme

Appendix 1.2 Barriers per theme

Appendix 2 Description of Drivers and Barriers from literature

Appendix 2.1 Description of the drivers in literature

Appendix 2.2 Description of the barriers in literature

Appendix 3 Drivers and Barriers from practice clustered in themes

Appendix 3.1 Drivers for participating from practice clustered in themes

Appendix 3.2 Drivers for projects from practice clustered in themes

Appendix 3.3 Barriers for participating from practice clustered in themes

Appendix 3.4 Barriers for projects from practice clustered in themes

Appendix 4 Drivers and Barriers from literature labelled per article

Appendix 5 Morphological chart

Appendix 1 Drivers and Barriers from literature clustered in themes

Appendix 1.1 Drivers per theme

D_1 CLEAR STRATEGIC IINTENTION	D_2 SHARED VALUES AMONGST STAKEHOLDERS	D_3 OPENNESS AND TRUST AMONGST STAKEHOLDERS
Develop a working plan (intended results, budgets) and plan for continuous evaluation at start, incl. participatory nature, major boundary spanning issues, etc.	User-values: trust, privacy, cultural identity, wishes of self-determination, cultural 'distance' to ICT, transparency in decision-making	the 'human factor' including particular interaction and management features like trust and willingness to take risk and being passionate as decision makers
Transparent project selection and decision, eventually, design of business models	Values among managers: commitment, passion, risk-taking	Transition and evolution of knowledge in the network
Give attention to upscaling, financial investment, regulators, contractors, etc.	Societal values, like sustainability and responsibility	Defining open innovation policy and guidelines
Has quick and efficient work networking processes or clear focus areas.	Living Lab's area of industry is appealing, current or unique	A minimum level of openness
Good understanding of policy issues expressed in ability to secure public project funding	Secondly, sufficient trust and alignment between the partners involved such as the medical faculty, supplying faculties, academic hospital and non-academic hospitals, multinationals and smaller firms, etc., avoiding that 'one goes its own way', but also a partner composition that guarantees a sufficient access to multiple disciplines.	
To profoundly tackle care fragmentation, more targeted interventions are necessary. A more integrated care delivery can be attained by bundling activities in multidisciplinary care teams (Körner et al., 2016) or inter- organizational care networks (Sheaff and Schofield, 2016).	Common learning process	
Introducing the territorial dimension to regional innovation policy Funded measures grounded in existing programmes can introduce mechanisms that encourage partnerships to reach out to other actors and expressions of need.	Thus, the living lab not only allows for experimentation and data collection on various aspects of the connection between mobility and energy by using ICT but also sets the stage for the competition between differing frames and views of the field. The development of interdependent interests is a necessary condition for the emergence of a new SAF, but this interdependence does not bring about a shared understanding.	

D_1 CLEAR STRATEGIC IINTENTION	D_2 SHARED VALUES AMONGST STAKEHOLDERS	D_3 OPENNESS AND TRUST AMONGST STAKEHOLDERS
Funding innovation through procurement, linking it to concrete needs Instead of considering innovation as an abstract exercise to be carried out by universities and industry, specific regional spending needs can become innovation opportunities through open calls for ideas. This approach, called Pre-Commercial Procurement (PCP),	Involve stakeholders early in the process, before projects are clearly formulated.	
Focusing on long-term goals, knowledge and expertise when participating in the chain of projects	Work together on joint articulation of aspirations and concerns as a starting point.	
Assure different levels of impact, both in terms of the direction of political decision-making and significance for other communities represented by influential participants.	Use alignment to achieve match-making and accelerated buy-in	
A clear strategic intention	common or compatible long-term goals	
	A minimum of shared value creation and sharing among all stakeholders	

D_4 EARLY USER INVOLVEMENT AND GOOD COMMUNICATION WITH USERS	D_5 MOTIVATED PARTICIPANTS	D_6 GOOD WORKING METHOD AND PLAN
Early involvement of users	motivation of actors to participate	An adequate use of business models, referring to dividing tasks and distributing costs and benefits over the participants.
Sufficient gaining and absorption of end-user feed back	Users and other actors of Living Lab are actively participating in the R&D projects	Third, business models that divide tasks and distribute costs/benefits, yet allow for openness, and value chains that are fully integrated to enable economic success; also, after some years, a critical evaluation of the leading concept, eventually followed by shifts to stronger commerce and international operations.
Different kind of users or user groups are available for R&D projects	Lead users are described as both, well-motivated to actively participate in innovative collaboration and qualified as they are a source of anticipative needs that can (only) be satisfied by innovative solutions. The integration of lead users in the early stages of the innovation process provides insight into tacit and latent needs and possible solutions.	Good understanding of collaborative working environment methods, processes and tools
The involvement of users, particularly the need for close and intensive interaction.		a structured innovation process based on a funnel or a network model in starting open processes which gradually become more tight with on the operational level a clear go/no-go and an easy access
A sufficient involvement of technology, referring to ICT – use in monitoring and analysis of user response to inventions.		dealing with practical requirements, mainly management issues like the model of management, e.g., balancing interests between different partners
First, an appropriate selection of users, such as patients, risk groups and hospital personnel, regarding their needs, motivation, capabilities, representativeness, social influence, loyalty, etc.		
Fifth, attention for technology as a means for monitoring of patients and risk groups at home and for analysis of user-response to the inventions, but avoiding dominance of technology and the rise of barriers, such as with 'soft' aspects in health care.		

D_4 EARLY USER INVOLVEMENT AND GOOD COMMUNICATION WITH USERS	D_5 MOTIVATED PARTICIPANTS	D_6 GOOD WORKING METHOD AND PLAN
important to attract a varied group of participants		
the project illustrates that it is not the quantity of user involvement that determines the categorization, but rather the influence that is wielded by the users.		
Building a strong, ongoing relationship with users was crucial, since their involvement required a considerable time commitment on their part as well as psychological involvement.		
particular network features like covering all parties involved and allowing sufficient critical mass as well as access to multidisciplinary knowledge		
Treating users as equal co-creators instead of research objects		
Paying regard to users (motivation, rewards and fun) and their relevance for innovation		
there is a clear need to enhance user involvement and user support in experimental research related to the Future Internet.		
Based on academic literature on field trials, user engagement and the technology acceptance model, the authors argue that several factors play a role in the participation of users in field trials. An influential factor that emerged is the functional maturity of the innovation, the extent to which a prototype resembles the functionalities and the processes of the final, go-to-market product at the moment of the field trial		

D_4 EARLY USER INVOLVEMENT AND GOOD COMMUNICATION WITH USERS	D_5 MOTIVATED PARTICIPANTS	D_6 GOOD WORKING METHOD AND PLAN
participation and user involvement		
Fun		
Participation/empowerment		
user involvement in the beginning of service design process		
thorough involvement of the user within the innovation process, resulting in a two-way street with advantages for the user as well as for companies		
A minimum set of users and establish a strong communication		

D_7 ADEQUATE PARTICIPANTS	D_8 MIXED SET OF TOOLS TO DISCOVER NEW OPPORTUNITIES	D_9
Adequate capabilities/skills of actors to perform roles and interact	Multiple approaches and collaboration tools	Ability to deal with unpredictability
The composition of stakeholders and the required functionalities of the networks, in view of creation of vertical cooperation in the value chain.	Arranging workshops and seminars to identify development needs in the Living Labs model in different contexts	
Community members are willing to contribute resources to the development of the rural Living Labs	A mixed set of living lab tools to discover new opportunities	

B_1	B_2 LEGAL ISSUES	B_3 UNEQUALITY AMONGST PARTICIPANTS IN LIVING LAB
Hence, the care living labs projects seem to affect mainly care fragmentation by improving coordination and communication, rather than aiming at the underlying cause by reshuffling existing care inter- and intra-organizational boundaries.	Legal issues, like liability, IP issues, data ownership and access	Avoid large numbers of actors, powerful/dominant actors and strong interdependency; avoid actors that do not comply with living lab values
	Sixth, dealing with potentially disturbing legal issues, such as intellectual ownership protection and legal liability issues following from the collaborative nature of living labs and the involvement of human health.	
	Some of the Living Labs are operated by networks without the status of a legal entity	
	Distinction between the openly shared and internally held company issues	
	Promoting trust and transparency	

B_4	B_5 FINANCIAL RISKS	B_6 LITTLE AWARENES ABOUT LIVING LABS
Settle issues concerning access to places, and implementation of new infrastructure (timing, responding to willingness-to-pay)	Improve financial factors and reduce financial risks	There is no widespread understanding of the living lab concept, making it difficult to implement benchmarking initiatives at research and practitioner levels.
	Due to the economic situation, there is a lack of public funding, and other successful business models that could serve as examples are not properly reported in the literature.	As already mentioned, there still exists confusion regarding the exact interpretation of the Living Lab-concept and there is a lack of empirical studies regarding research parameters, appropriateness of underlying business models and effectiveness of Living Labs as a system for innovation
	Creating a living lab requires long-term funding. This may necessitate non-traditional models to fund innovation, such as crowdfunding or the implementation of joint ventures to sell products and services created in collaboration with end users and software companies.	
	Weak funding base; Living Labs heavily relying on public funded projects	
	Public project funding may shift focus in a way that is not beneficial for rural Living Labs	
	Ensuring exploration and exploitation for resources	
	Monitoring and managing the collaboration took up much time and financial efforts. The study revealed that a sustainable implementation of any coordination between innovation agents strongly depends on public funding again.	
	the requirement of a lot of time and budget to set up a Living Lab-approach is a general weakness for the Living Lab-approach	
	The most prominent threat for Living Labs is the need for substantial financial support, mostly external funding, to establish them	

B_7 HARD TO SHOW (LONG TERM) VALUE OF LIVING LAB	B_8 NEED FOR DIVERSE STAKEHHOLDERS WITH MATCHING VALUES	B_9 MANAGEMENT OF LIVING LABS PROVES TO BE DIFFICULT
Speed and effectiveness of valorisation	The effectiveness of a living lab depends on the involvement of lead users and a relevant set of early adopters in the innovation process. If the user groups participating in the innovation processes are not appropriate in terms of profile and scale, this could lead to unfinished or failed innovation initiatives or the creation of products or services that do not have an appropriate target market.	There is a lack of dedicated personnel who have the required competencies and skills to manage living lab innovation projects and initiatives.
It is difficult to demonstrate the long-term value of a living lab for businesses, user communities, and territories.	Living labs operations appear to be based on individuals as opposed to being deeply embedded into the member organization functions and structures, which leads to sustainability risk	The management of the user groups have issues and processes yet to be resolved or further developed as some current management methods are not scalable
a tension between lab-like open-ended experimentation and pressures to demonstrate success;	Shifting and combining individual objectives with those of the network	the limits of controlled experimentation due to messy social responses and co-creation activity;
Transition from a single project to a chain of projects	Balancing differing motives and expectations	Further formulation and development of a standardised (multiple) Living Labs model
Ensuring continuous participation and expressing relevant experiences	Our perspective suggests that engaging people in a network is an on-going process. Where situations and context shift over time, so too will peoples' understandings and interests.	Engaging the Living Labs network in the long-term strategic goal development

Depicting benefits of the Living Labs network	In many cases Living Lab innovations require not only technological but also socio-political and institutional changes to be made in order for them to be adopted. The need of socio- political and institutional changes becomes especially visible in cases where Living Lab participants attempt to propose innovative solutions for domains that are highly regulated. The reason for that is that in such cases, often the existing legal requirement would need to be adjusted first, in order to create grounds for the further adoption of the innovation.	Ensuring flexibility and continuation of the project
Tying parties to long-term objectives	Policy implications: With more and more countries aiming to increase the share of renewable energies to their national energy supply and the growing diffusion of electric vehicles, the ties between mobility and energy will become even stronger in the future. The foundations of how these ties are going to look are laid out in living labs like the innovation campus we studied. Therefore, it is crucial not only for scholars but also for businesses and policy makers to pay close attention to the developments in these arenas. The living lab of today might become be the new strategic action field of tomorrow – with all kinds of path-dependencies.	Monitoring and managing the collaboration took up much time and financial efforts. The study revealed that a sustainable implementation of any coordination between innovation agents strongly depends on public funding again.
Instability/non-functionality of the prototype --> not attractive to users	The stakeholder-model for Living Labs assumes the symbiotic nature of the stakeholder roles. However, as the primary focus of the developer is his/her own market and business opportunities, in practice, a symbiotic cooperation is not very evident.	
	Differences in values, etc. between university and industry	

B_10 STICT REGULATIONS IN HEALTHCARE	B_11	B_12 LOW USER INVOLVEMENT	B_13 STEP FROM LIVING LAB TO MARKET CAN BE DIFFICULT TO MAKE
Information about the patients' health status and the patients' personal data must be handled with utmost care along the whole procedure.	Only high performing Living Labs can be differentiated from other organizations with inexplicit organization and activities and gain a sustainable position in an open innovation market	A recurring challenge within PD concerns how to communicate the needs of users in such a way that developers can understand them while developers need to be able to feed back their understanding of system requirements in a manner such that the users can make sense of it.	the link between successful design and successful implementation may be weak, non-existent, or irrelevant
The methodology of the experiment within the Living Lab must be authorized by a regulatory organization.		The level of end user involvement is lower than what can be expected considering that the Living lab movement endorses the user focus.	the opposing needs of local socio-cultural specificity and scalability, i.e. the inherent promise of test bed outcomes being generalizable or transferrable because the tested "model society" is presumed to represent a future society at large.
		The major weaknesses of the present study were, as mentioned before, the absence of compelling, mobile specific content, and of an iterative research approach	lead users and technology providers do not generally have adequate resources and incentives to bring these solutions to market.
		Language and versatility of approaches may be a barrier in the way of living lab-to-living lab collaboration	Another disadvantage, especially in Living Lab-settings with smaller amounts of users, is the difficulty to ascertain whether the findings can be extrapolated to the market. This can be seen as the problem of outliers

Appendix 2 Description of Drivers and Barriers from literature

Appendix 2.1 Description of the drivers in literature

D_1 Living Labs should have a clear strategic intention

Successful Living Labs tend to have efficient networking processes and clear focus areas (Heikura & Schaffers, 2010). When formulating these focus areas it is important to look at on long-term goals, knowledge and expertise (Leminen & Westerlund, 2012). Living Labs should therefore develop a working plan which includes intended results and budgets. Furthermore, a plan for continuous evaluation is relevant. This could contain elements such as the participatory nature of stakeholders and boundary spanning issues. Next to clear a planning and evaluation, Living Labs should have transparent project selection and decision making. Eventually, this can evolve into Living Lab business models, where attention is paid to upscaling, financial investment, regulators and contractors (Mäkäräinen-suni, 2008). If you choose your strategic direction wisely, strong political support at all levels for this kind of open innovation initiatives is possible (Guzmán et al., 2016). Therefore it is wise to assure different levels of impact in terms of the direction of political decision-making and the significance for other communities represented by stakeholders (Paskaleva, Cooper, Linde, Peterson, & Götz, 2015). Furthermore, good understanding of policy issues can result in the ability to secure public project funding (Heikura & Schaffers, 2010).

It is important to realize that funded projects embedded in existing programmes can introduce mechanisms that encourage partnerships to reach out to other stakeholders and resources (Garcia, Marsh, Trejo, & Switters, 2010). Living Labs can, due to their often limited scale and specific technological focus, act as a trust catalyst between their stakeholders (Baltes & Gard, 2006). This could lead to unique collaborations.

D_2 Shared values amongst stakeholders

Values reported by users in Living Labs according to literature are trust, privacy, cultural identity, wishes of self-determination and transparency in decision-making. Important values for managers in Living Labs are commitment, passion and risk-taking. Important for all participants literature reports societal values, such as sustainability and responsibility (Mäkäräinen-suni, 2008). Certain common values attract more people than others. Living Lab's therefore often operate in areas of industry that are appealing, current or unique (Van Geenhuizen, 2018).

Sufficient trust and alignment between stakeholders in Living Labs is crucial. It avoids that 'one goes its own way' (Van Geenhuizen & Guldemond, 2013) and is necessary for a common learning process (Leminen & Westerlund, 2012).

A common learning process means that Living Labs do not only make experimentation and data collection possible, but also sets the stage for competition between different frames and views of the field. Development of interdependent interests as a binding factor between the stakeholders is then a necessity (Canzler, Engels, Rogge, Simon, & Wentland, 2017). To create interdependent interests, stakeholders should be involved early in the process, before projects are clearly formulated. Working together on shared ambitions and concerns are then the starting point (Paskaleva et al., 2015). This should then evolve in common or compatible long-term goals (Schuurman, Baccarne, De Marez, Veeckman, & Ballon, 2016)

D_3 Openness and trust amongst stakeholders

Openness and flexibility are important factors for the functioning of a Living Lab. One should therefore shape an inviting arena where improvisations and knowledge can be shared and inventions created and validated (Mäkäräinen-suni, 2008). Defining open innovation policies and guidelines can be helpful (Leminen & Westerlund, 2012). Hereby, the human factor should be central, including interaction and management features such as trust, a willingness to take risks and being passionate as decision makers (Van Geenhuizen, 2014). This way, openness and trust could act as a catalyst for transition and evaluation of knowledge in the Living Lab network (Leminen & Westerlund, 2012).

D_4 Early user involvement and good communication with users

Early user involvement is seen as a crucial factor for Living Labs. Especially because of the need for close interaction with them (Van Geenhuizen, 2018). In Living Labs it appears not to be the quantity of user involvement that determines design choices, but rather the influence that is wielded by the users (Bergvall-kåreborn et al., 2010). It is therefore important to threat users as equal co-creators instead of research objects (Leminen & Westerlund, 2012). Another factor that can influence the engagement of users is the functional maturity of the innovation, the extent to which a prototype resembles the functionalities and the processes of the final product at the moment of the field trial (Georges, Schuurman, Baccarne, Coorevits, & Georges, 2015).

To keep users motivated and committed to the Living Lab, good communication with them is a must. Also think of paying regard to users (rewards, fun) and their relevance in the innovation process (Leminen & Westerlund, 2012). User engagement could be improved by gaining and absorbing sufficient end-user feedback (Mäkäräinen-suni, 2008). Overall, this should lead to a two-way street with advantages for both the user and the involved companies (Schuurman, Moor, Marez, & Evens, 2011).

D_5 Motivated participants

All stakeholders in the Living Lab should have motivation to participate (Mäkäräinen-suni, 2008).

D_6 Good working method and plan

Innovations that involve multiple regimes need a systematic approach to avoid the 'chicken and egg' problem (Joller & Varblane, 2016). A Living Lab should therefore make adequate use of business models who include dividing tasks and distributing costs and benefits over the stakeholders. At the same time they should allow for openness and processes that are fully integrated to enable economic success (Van Geenhuizen & Guldemond, 2013). For successful integration a good understanding of collaborative working environment methods, processes and tools is required (Heikura & Schaffers, 2010). Furthermore, documentation and conceptualization of the development activities, tasks and accumulated knowledge should take place (Leminen & Westerlund, 2012). After some years and a critical evaluation of the leading concept, a shift can take place to stronger commerce and international operations (Van Geenhuizen & Guldemond, 2013). Part of the evaluation could be an impact assessment the projects (Garcia et al., 2010).

D_7 Adequate participants

A Living Lab needs adequate capabilities/ skills of participants to perform roles and interact with each other (Mäkäräinen-suni, 2008). The composition and required functionalities of the networks should be made with the goal to realize vertical cooperation in a chain of value (Van Geenhuizen & Guldemond, 2013).

D_8 Mixed set of opportunities to discover new opportunities

A Living Lab should use multiple approaches to seek new opportunities and multiple collaboration tools to keep the network strong. Hereby it is important to develop embeddedness with focus groups, communities of practice and supportive policies (in region or sector) (Mäkäräinen-suni, 2008). Living Labs could also develop new business models that facilitate the development of new ideas and opportunities that come from different types of stakeholders (Guzmán et al., 2016). Another approach would be jumping outside of the traditional innovation policy sectors. Living Labs are then supported in a regional policy arena outside of the technology research domain (Garcia et al., 2010). Other options are arranging workshops and seminars to identify development needs in different contexts (Leminen & Westerlund, 2012)

D_9 Be able to handle conflicts in the Living Lab network

Living Labs must be able to handle conflict and work with intermediaries (Mäkäräinen-suni, 2008). They should not only be sensitive to possible sources of conflict within the Living Lab, but also outside the network with important (future) stakeholders (Paskaleva et al., 2015).

D_10 Have a physical common space

With the kind of collaborations that take place in a Living Lab, a good infrastructure is required (Baltes & Gard, 2006). This could be in the form of a physical space where different actors can meet and share ideas (Van Geenhuizen, 2018). Furthermore, experiments can take place here with the prototypes provided by the technology providers of the Living Lab. This way, fast feedback loops can be created and it allows users to gain experiential knowledge and researchers to turn this tacit experiential knowledge into valuable solutions (Baltes & Gard, 2006).

D_11 Be compliant with policies and regulations

It is important to have policies for practical matters such as ethical issues and intellectual ownership, balancing interests of stakeholders, and issues concerning safety and legal liability (Van Geenhuizen & Guldemond, 2013). Furthermore, for fast market uptake of radical innovations the active role of the government is crucial (Joller & Varblane, 2016). This also includes being aware of the relevant policies.

D_12 Attractive network

Good performing Living Labs have very attractive networks with partners who support the collaboration of stakeholders, such as the ENoLL (European Network of Living Labs) (Guzmán et al., 2016). Furthermore, Living Lab networks cover all parties involved and allow sufficient critical mass as well as access to multidisciplinary knowledge (Van Geenhuizen, 2014). These kinds of networks can also provide access to the various resources crucial for successful commercialization of the innovations. They also create more awareness of Living Labs. This could lead to positive changes in innovation policies (Schuurman et al., 2011). An important condition however is that Living Labs have to maintain their extended networks of stakeholders (Baltes & Gard, 2006). The dynamic adaptation, efficiency and geographical embeddedness of the network are then factors that should be paid attention to (Leminen & Westerlund, 2012; Voytenko, Mccormick, Evans, & Schliwa, 2016). Also beneficial for the network is cooperation between Living Labs. They are then able to benefit from each other's experiences (Schuurman et al., 2011).

D_13 Money

Well performing Living Labs are good at securing project funding for their projects, often from more than one type of funding organization (Heikura & Schaffers, 2010). A strategy to achieve this could be to link funding innovation to concrete needs. So, instead of considering innovation as an abstract exercise of universities and the industry, certain regional spending needs could become innovation opportunities through open calls for ideas. This strategy is also called Pre-Commercial Procurement (PCP) (Garcia et al., 2010). Living Labs can be an attractive option for these kinds of initiatives because they can be cost-effective: they avoid making costly changes at a later innovation state (Schuurman et al., 2011).

D_14 Living Labs can be a facilitator of market transition

Living Labs can make the adaptability of a legal concept or status easier. For example from a public-private network to a company (Van Geenhuizen, 2014). Entrepreneurs play therefore a vital role in the process of Living Lab implementation (Baltes & Gard, 2006). It also makes Living Labs attractive if they offer support for future projects and activities in retail process development (Leminen & Westerlund, 2012).

D_15 Display of successful projects/collaborations

It is beneficial to be able to show you have experience with the Living Lab innovation method. Communication about the potential of commitment to the Living Lab network can lead to new opportunities (Leminen & Westerlund, 2012). Identify and work therefore upon what participants can gain from taking part. Active engagement of stakeholders rests upon how beneficial the Living Lab proved to be for each individual participant (Paskaleva et al., 2015). A portfolio with successful projects could also lead to new business models in terms of funding (Turgut & Katzy, 2012).

D_16 Living Labs create knowledge and value for their stakeholders

There is an increasing need for easy and context-specific access to common technical and non-technical resources and capabilities that can be shared for complex experimentation and innovation projects (Schaffers, Sällström, Pallot, & Hernández-muñoz, 2011). Good performing Living Labs accumulate and develop new knowledge, tools and competences. Training and learning could therefore be seen as a part of Living Labs projects (Leminen & Westerlund, 2012). Thus, engage stakeholders with different backgrounds and agendas and stress how they will be able to complement each other through their collaboration (Paskaleva et al., 2015).

D_17 Living Labs allow for more freedom to make mistakes

Living Labs create an environment with experimentation that allows actors involved to move into the unknown and use failures as a basis for learning, without immediately facing market pressure (Canzler et al., 2017).

Appendix 2.2 Description of the barriers in literature

B_1 Legal issues (IP etc.)

Living Labs can encounter difficulties when it comes to legal issues, such as liability, IP, data ownership and access (Mäkäräinen-suni, 2008). When these issues are not resolved, promoting trust and transparency becomes difficult (Leminen & Westerlund, 2012).

B_2 Inequality amongst participants in Living Labs

Living Labs should avoid large numbers of participants, very powerful or dominant participants, strong interdependency and participants who do not comply with the Living Lab values (Mäkäräinen-suni, 2008). What can especially be difficult are differences in values between universities and the industry (Van Geenhuizen & Guldemond, 2013).

B_3 Financial risks

Many Living Labs rely heavily on public funding (Heikura & Schaffers, 2010). Often they encounter a lack of public funding, and other successful business models that could serve as an example for Living Labs or not yet properly reported in literature. Creating a Living Lab requires long-term funding however. Monitoring and managing Living Lab collaborations requires a lot of time and financial effort (Turgut & Katzy, 2012). Living Labs might therefore be forced to seek for other ways to obtain funding, such as crowdfunding or the implementation of joint ventures to sell products and services (Guzmán et al., 2016). Having multiple ways to gain finance can be beneficial for Living Labs, since public project funding might shift focus in a way that is not desirable for Living Labs (Heikura & Schaffers, 2010).

Overall it can be stated that the need for a lot of time and money to set up a Living Lab is a general weakness of the concept. The most important threat is the heavy reliance on external funding (Schuurman et al., 2011).

B_4 There is little awareness about Living Labs

There is no widespread understanding of the Living Lab methodology. This makes it difficult to benchmark initiatives to researchers and practitioners (Guzmán et al., 2016). A cause might be the lack of empirical studies regarding research parameters, appropriateness of business models and the effectiveness of Living Labs as a system for innovation (Schuurman et al., 2011).

B_5 It is hard to show the (long term) value of Living Labs

It is hard to demonstrate the long-term value of Living Labs for businesses, users and territories (Guzmán et al., 2016). Furthermore, the speed and effectiveness of the valorisation of a Living Lab proves to be a difficult point (Van Geenhuizen & Guldemond, 2013). This creates a tension between the 'Living Lab-like' open-ended experimentation and the pressure to demonstrate success (Engels, Wentland, & Pfotenhauer, 2019). To make the transition from a single project to a chain of projects, continuous participation must be ensured and positive experiences expressed. It is therefore important that stakeholders are tied to long-term objectives of the Living Lab (Leminen & Westerlund, 2012).

B_6 The need for diverse stakeholders with matching values

Often, Living Lab innovations do not only require technological but also socio-political and institutional changes in order to be adopted. Especially in domains that are highly regulated (such as healthcare) existing legal requirements would need to be adjusted before an innovation can enter the market or even be tested (Van Stijn, Rukanova, Wensley, & Tan, 2009). Having the right stakeholders on board is then crucial.

Living Labs often exist of stakeholders who are deeply embedded in other organization functions and structures. This can lead to sustainability risks (Heikura & Schaffers, 2010). The stakeholders will have to shift and combine individual objectives with those of the Living Lab. It can be a difficult task for Living Labs to balance differing motives and expectations (Leminen & Westerlund, 2012). If participants in a Living Lab are not appropriate in terms of profile and scale, this could lead to unfinished or failed projects or the creation of products that do not have a target market (Guzmán et al., 2016). Tying the right people to the Living Lab network is therefore an ongoing process. Situations and context will shift over time, and so will peoples' understandings and interests (Van Stijn et al., 2009).

B_7 The management of Living Lab proves to be difficult

Management of Living Labs frequently has issues and process yet to be resolved or further developed because the current management methods are not scalable (Heikura & Schaffers, 2010). This can result in limits of controlled experimentation due to messy social responses and co-creation activity (Engels et al., 2019). This asks for further formulation and development of a standardized (multiple) Living Lab model with long term strategic goal development. Hereby, flexibility and continuity of the projects should be ensured (Leminen & Westerlund, 2012). A complicating factor is the lack of dedicated personnel who have the required competencies and skills to manage a Living Lab (Guzmán et al., 2016).

B_8 Strict regulations in healthcare

A barrier specifically for Living Labs in healthcare is that information about a patients' health status and personal data must be handled with the utmost care along the whole process. Getting access to certain information can be very difficult. Furthermore, the methodology of the experiments must be authorized by a regulatory organization (Kuba et al., 2009).

B_9 Low user involvement

Despite their user focus, Living Labs can experience low user involvement (Heikura & Schaffers, 2010). Users can have the tendency to drop out of a Living Lab project if they do not feel relevant or important enough. Connected to this is the challenge of how to communicate the needs of users in such a way that other stakeholders such as technicians can understand them. This is a two way street. Technicians must be able to communicate their understanding of the product requirements in such a way that users can make sense of it too (Bergvall-kåreborn et al., 2010). Another factor that can make users less engaged is instability or non-functionality of the prototype (Habibipour, Padyab, Bergvall-Kåreborn, & Ståhlbröst, 2017).

B_10 The step from Living Lab to market can be difficult to make

A successful design does under no circumstance guarantee successful implementation on the market (Bergvall-kåreborn et al., 2010). Good marketing and smart networking are required. The lead users and technology providers in Living Labs often lack adequate resources and incentives to undertake these steps and bring innovations to the market (Baltes & Gard, 2006). Furthermore, the promise of test bed outcomes being generalizable or transferrable to the target market can be questionable due to limited sample sizes in the experiments (Engels et al., 2019). This can be defined as the problem of outliers (Schuurman et al., 2011).

Appendix 3 Drivers and Barriers from practice clustered in themes

Appendix 3.1 Drivers for participating from practice clustered in themes

Toegewezen gekregen	Past bij mijn achtergrond	Inhoud in daden omzetten
D_part_1	D_part_2	D_part_3
Nou ten eerste dat ik binnen MD dat onderwerp toebedeeld kreeg haha.	Maar het is ook wel logisch want ik heb een achtergrond in zorginnovatie en eHealth dus dat ligt heel erg dicht bij me	Ik ben ook wel echt iemand die heel erg houd van dingen doen. Ik houd van inhoud, maar het moet ook wel altijd gekoppeld zijn aan een doel om dat uiteindelijk in daden om te zetten. Nou LL zij iets waarbij dat heel erg plaats vindt.
Het is binnen het Reinier de Graaf besloten, en ik denk dat Maarten daar ook veel aan gedaan heeft, om uiteindelijk die samenwerking aan te gaan en is aan mij gevraagd of ik af en toe wat dingen wil organiseren en faciliteren. Dus dat is vanzelf gegaan.	Business development gebaseerd op nieuwe technologie is de rode draad in mijn loopbaan.	
Nou toen ik met deze functie begon toen was dat al in bedrijf.	Maar nu zie ik daar heel erg een koppeling in met wat ik doe. Dus als ik startups uitnodig om een pitch te komen doen of met hun praat dan denk ik ook altijd wat kunnen we daar testen zo meteen. Dus als ik dan chirurgen dan aanschrijf met ik heb hier een startup die een bepaald product aanbied of een bepaald product wil ontwikkelen dan heb ik ook gelijk in mijn achterhoofd dit is echt een heel goed product voor deze chirurg of deze orthopeed om op de ResearchOR uit te proberen.	
Nou dat is, als ik naar onze vakgroep kijk, heb ik drie poten. Een poot is beleid rondom medische technologie, andere poot is stralingsbescherming, en de derde poot is innovatie. En bij die innovatie poot horen die Living Labs ook.		

Interesse in goede implementatie	Interesse in management	De zorg verbeteren
D_part_4	D_part_5	D_part_6
En een persoonlijke driver voor mij is ook wel de vraag hoe implementeer je nou zorginnovatie en zorg technologie op een goede en toekomst bestendige manier.	Maar het is in de werkelijkheid een veel groter probleem, of uitdaging: je moet daadwerkelijk processen veranderen, je moet stakeholders mee krijgen, je moet eHealth veranderen. De management kundige kant daarvan is me steeds meer gaan fascineren.	Nou ik denk dat we de zorg moeten verbeteren. De zorg moeten we veiliger maken en efficiënter, door middel van de inzet en het ontwikkelen van veilige technologie. Dus we moeten de zorg veiliger en efficiënter maken door het ontwikkelen en de inzet van veilige technologie. Want de zorgmedewerker is schaars, de populatie vergrijsd en we zullen dus technologie nodig hebben om de zorg te kunnen leveren. Want we moeten voor steeds meer oudere mensen zorgen met minder jonge mensen. En technologie kan daarbij helpen.

Werk zorgverleners verbeteren	Mensen komen met dingen waar je zelf nog niet aan gedacht had	Reputatie
D_part_7	D_part_8	D_part_9
Dus ik doe het ook wel om het werken van de mensen in de zorg te verbeteren, en hun kwaliteit van leven te verbeteren snap je. Dat ze prettiger en veiliger werken. Dus ik doe het voor de patiënten maar daarnaast ook vooral voor de medewerkers. Want tevreden medewerkers die zorgen ook beter voor hun patiënten weet je wel.	Maar ik vind het heel leuk. Ik vind het heel leuk om te zien met wat voor ideeën mensen komen. Nou het is goed om te zien dat als je mensen van buiten betrekt dat ze soms met hele nieuwe ideeën komen. Dingen waar je zelf nog niet aan gedacht hebt.	En het heeft ons geholpen. Het heeft ons een naam gegeven binnen de ziekenhuiswereld. En om die reden weten veel ziekenhuizen ons ook nog te vinden, voor andere werkzaamheden

Je komt makkelijker het ziekenhuis binnen	Leuk dat je overal bij betrokken wordt	Testen in de praktijk heeft meerwaarde
D_part_10	D_part_11	D_part_12
Als Living Lab kun je daar natuurlijk wel een invulling aan geven. want dan heb je natuurlijk automatisch mensen om tafel van verschillende disciplines. Dus dat kan wel werken. Dan heb je al een paraplu. Maar als je gewoon als je gewoon als een bedrijf zoals het mijne aankomt met een idee, los van de structuur van zo'n Living Lab, dan is dat toch lastig. Dat heb ik ook wel bij het verkopen van Dora ondervonden. Je komt toch een organisatie binnen op een bepaalde plek he.	ik word er heel erg enthousiast van. En met name ook omdat Maarten van der Elst en John van den Dobbelsteen, dat is jouw begeleider he, die betrekt me overal bij.	Ik heb ook in een werkgroep een tijd gezeten voor om robotica in de zorg te versterken, ook voor Medical Delta. En dan merk je dat er aan de ene kant een heleboel kan, maar aan de andere kant als je dat in de praktijk gaat brengen dat er zoveel hobbels in de praktijk voorbij komen die zo'n project kunnen laten ontsporen. Ja dat laat dus zien dat het echt heel belangrijk is om in een reële praktische situatie te testen. En dan hebben die Living Labs meerwaarde.
	Dus het snijdt van twee kanten. En dat vind ik hele leuke dingen om te doen. Om die cultuuromslag te maken. En om die verbinding tussen de praktische zorg en de wetenschappelijke wereld, om die aan elkaar te verbinden.	
	Kijk, als ik ga kijken naar een Living Lab voor robotica dan zeg ik ja ik kom daar mensen tegen die ik normaal niet tegen kom.	

Motivatie om innovaties naar de markt brengen	Duidelijk doel	Geld
D_project_1	D_project_2	D_project_3
Ik denk toch wel de wens om innovaties naar de markt te brengen.	En om die zo toegespitst mogelijk te maken.	En daarnaast moet het ook gewoon betaald worden en gefinancierd worden. Want alles door het ziekenhuis laten betalen dat kan ook niet. Dus goeie fondsen waardoor je goede mensen kan krijgen is ook wel heel belangrijk.
	Nou als driver is dat je een duidelijk doel hebt. Dat moet dus een verbetering zijn van de patiënten zorg of efficiency. Dus potentieel moet je echt een sterk product hebben wat mensen er ook in zien.	Nou, kijk bij het Reinier de Graaf is het gestart als een innovatief project. Er waren ook geen kosten mee gemoeid voor hen. Of minimale kosten moet ik dan zeggen. In ieder geval voor de pilot. En toen ze eenmaal met die pilot in de weer waren geweest toen dachten ze nou dit is wel een heel interessant product. Dus dat willen we eigenlijk in de nieuwbouw wel hebben. Dus die beslissing was voor hen een stuk makkelijker toen.
	Dus je innoveert niet om leuke gadgets voor chirurgen te ontwikkelen, of leuke gadgets voor een dermatoloog of wie dan ook. Of een leuk appje ofzo. Maar je doet het echt met een heel strak doel. En dat is de patiëntveiligheid verhogen, en de zorg betaalbaar maken.	Ja, een innovatie budget, zoiets he. Misschien is dat er ook wel hoor. Bij Reinier dat weet ik niet. Maar in algemene zin kan dat natuurlijk wel helpen. En dan hoeft het geld niet van een specifieke afdeling te komen. Die hebben dan zoiets van ja dan heb je wel de lasten en maar een deel van de lusten.
		Tweede ding is dat je dus een organisatie nodig hebt die wel wil investeren in ja, alles wat daar bij komt kijken. En dat zit hem met name in de OK organisatie en ook in de technische ondersteunende organisatie. Want wat een manager of wat een medisch specialist niet doet is inderdaad in die sessies gaan zitten van hoe moet dit nou gaan werken. Als ik op die knop druk wat moet er dan gaan gebeuren etc. Je hebt dus die buy-in nodig van mensen mogen hier mee bezig zijn en we willen dit graag

Goede mensen	Enthousiasme/ draagvlak	Past in huidig proces
D_project_4	D_project_5	D_project_6
Goeie PhD-ers en goeie studenten zijn wel heel belangrijk ook	En iedereen was daar enthousiast over en wilde daaraan werken. Dus die samenwerking is eigenlijk uitstekend verlopen.	Nou, kijk bij het Reinier de Graaf is het gestart als een innovatief project. Er waren ook geen kosten mee gemoeid voor hen. Of minimale kosten moet ik dan zeggen. In ieder geval voor de pilot. En toen ze eenmaal met die pilot in de weer waren geweest toen dachten ze nou dit is wel een heel interessant product. Dus dat willen we eigenlijk in de nieuwbouw wel hebben. Dus die beslissing was voor hen een stuk makkelijker toen.
Nou ik denk het enthousiasme van de studenten. Of iemand die promoveert, die is natuurlijk helemaal gedreven. En medewerking van de collega's hier. Soms wordt er ook wel gewoon wat van de medewerkers hier gevraagd. We hebben ook een vast aanspreekpunt voor innovatie. Dat is een operatie assistent hier. En die is ook heel enthousiast en die zorgt ook voor draagvlak.	Tweede ding is dat je dus een organisatie nodig hebt die wel wil investeren in ja, alles wat daar bij komt kijken. En dat zit hem met name in de OK organisatie en ook in de technische ondersteunende organisatie. Want wat een manager of wat een medisch specialist niet doet is inderdaad in die sessies gaan zitten van hoe moet dit nou gaan werken. Als ik op die knop druk wat moet er dan gaan gebeuren etc. Je hebt dus die buy-in nodig van mensen mogen hier mee bezig zijn en we willen dit graag	Maar hoe het eigenlijk begonnen is, wij waren dus opzoek naar toepassingen van die sensor techniek in ziekenhuismarkt. Het is dus een techniek die in andere branches wordt gebruikt maar wij zagen zelf mogelijkheden in de zienhuis branche. Dus dat was de belangrijkste drijfveer, zo zijn we begonnen.
dat heeft te maken met de buy-in. Je hebt dus zo iemand als Maarten op de OK nodig, of iemand die daar wat te vertellen heeft, die mensen kan enthousiasmeren, ja die dat project wil trekken. Die daar dus echt enthousiast over is.	Je hebt aan de andere kan op lager niveau heb je dus enthousiasme nodig dan mensen hier ook aan bij willen dragen. En inderdaad gewoon heel veel tijd en energie van leveranciers en onderzoekers om daar telkens maar weer aandacht voor te vragen. Of dat mensen naast al die dingen die als maar op hen af komen vliegen ook hier tijd en aandacht voor hebben.	
Het heeft niet met een bepaalde achtergrond te maken, maar het heeft met een type persoonlijkheid te maken dat moet gaan matchen met de ziekenhuismentaliteit. Maar daar toch ook ver genoeg vanaf moet staan om zich daar niet door op te laten slokken. Dus je moet een beetje een outsider blijven maar je moet wel relationeel dichtbij genoeg staan dat mensen iets voor je willen gaan doen.	En op het moment dat je op de lange termijn ontwikkelingen wilt gaan faciliteren, dan moeten daar dus mensen zijn die daar telkens aandacht voor vragen en telkens daar aan blijven trekken. Tegen alle frustratie in.	

Koppeling wetenschap en praktijk	Mensen haken elkaar aan	Publiceren over projecten	Synergie in de projecten
D_project_7	D_project_8	D_project_9	D_project_10
Nou dat komt dus door de samenwerking van de wetenschappelijke wereld, van de TU, die zijn structuur al heeft en op een bepaalde manier aankijkt tegen onderzoek. En daarnaast praktische invulling in het ziekenhuis, die de wegen weten in het ziekenhuis.	Ja, omdat dus de mensen die zich in dat wereldje bewegen van innovatie die haken mekaar continu aan	En aan de andere kant kan je dan de cirkel rond maken door er vervolgens over te gaan schrijven. En dat wetenschappelijk onderzoek goed af te ronden. En dan heb je de universiteit weer nodig. Want daar zijn zij weer meer thuis in.	En dan helpt het als je dus een PhD student hebt die met meerdere studenten of met meerdere artsen samenhangende projecten gaat doen en daar een lijn in bewaart. Zodat je ook wat synergie voordeel tussen die projecten kan hebben.
En dat is ook de reden dat er van ziekenhuizen steeds meer gevraagd wordt, van neem nou in je teams ook hoogleraren aan die al werken in het ziekenhuis omdat je dan nog strakker die verbinding krijgt met wetenschap en praktisch onderzoek			

Appendix 3.3 Barriers for participating from practice clustered in themes

Voorgeschiedenis tussen partijen	Onrijpheid ondernemers	Wetgeving	Geld
B_part_1	B_part_2	B_part_3	B_part_4
Nou, ja, maar dat is ook persoonlijk, dat partijen heel vaak een voorgeschiedenis hebben met elkaar dus er zijn dan vaak nogal wat verborgen agenda's in samenwerking. Dat ik denk, joh, doe niet zo ingewikkeld en ga het gewoon doen! Maar dan blijkt dat er in het verleden iets geweest is of dat ze ook nog met de mond belijden en dat men heel graag wil samenwerken maar dat het eigenlijk "conculega's" zijn. Wat het ingewikkeld maakt omdat binnen een project iedereen dat een beetje zijn eigen positie moet claimen en dat kan nog wel een botsen.	Ja, wat ik zie is toch de onrijpheid van de ondernemers. Er zijn veel start ups die met zo'n Living Lab samen willen werken. Ja en soms zijn ze gewoon niet rijp genoeg. Dan zijn ze te naïef. Ze denken ook dat andere partijen wel even met geld komen.	Daarbij komt natuurlijk dat de regelgeving gaat toenemen en strenger wordt. De METC gaat daarmee toch ook weer veranderen. Dus het wordt er allemaal niet makkelijker op.	Het is gewoon lastig, voor iedereen, dat het zo moeilijk is om aan financiering te komen.

Kost tijd	Storing (nieuwe) apparatuur	Projecten worden niet doorontwikkeld	Overhead in organisatie rondom innovatie
B_part_5	B_part_6	B_part_7	B_part_8
Nou, ja kijk soms is het zo dat het heel veel tijd kost terwijl je eigenlijk patiënten moet opereren	Of je hebt een stroring in de apparatuur ofzo	Soms hebben we hier een project gehad, van een minor of noem het maar op. En dan het vervolg zou misschien wat professioneler aangepakt kunnen worden. Snap je wat ik bedoel? Dus vaak hebben we hele goeie ideeën maar doen we er niet zo heel veel mee.	dat is dat een pijnpunt van deze structuren is dat de overhead op een gegeven moment best wel groot wordt. Je krijgt dus een organisatie, en die organisatie gaat zich bezig houden met het organiseren van. Maar, nou zijn wij eigenlijk ook al niet de onderzoekers. Wij zijn ook al mensen die faciliteren. Dus wij als mensen die onderzoek faciliteren zijn aan het praten met mensen die onderzoek faciliteren. En op een gegeven moment heb je heel veel lagen van mensen aan het werk die zelf niks van de kerntaak uitvoeren.

Appendix 3.4 Barriers for projects from practice clustered in themes

Onderhouden/ aanjagen samenwerking en financiering niet op netvlies	Onvoldoende medewerking	Onvoldoende focus
B_project_1	B_project_2	B_project_3
Iedereen die vanuit zijn eigen werk of expertise samenwerking zoekt maar ook het onderhouden van die samenwerking en het aanjagen daarvan en het op zoek gaan naar financieringsmogelijkheden en dergelijke kost veel tijd en is ook eigenlijk een functie op zich die partners in een LL niet op het netvlies hebben staan.	onvoldoende medewerking	onvoldoende focus
Maar, het is heel tijdrovend om een goed plan te ontwikkelen. De slaagkans van een onderzoeksproject is gewoon heel laag.	Maar toch ook met een onduidelijke verdeling van verantwoordelijkheden. Want bij wie moet dit initiatief liggen? Bij de OK? Want die hebben het voordeel hiervan. Maar de OK is vooral bezig, en dat klinkt misschien wat negatief, met de dingen van vandaag. Die zijn niet zo met innovatie bezig, dat ligt toch bij andere afdelingen.	Maar, het is heel tijdrovend om een goed plan te ontwikkelen. De slaagkans van een onderzoeksproject is gewoon heel laag.
En ik denk aan die kant dat we nog wel wat marketing kunnen doen. In de zin van wat bekendheid daaraan geven. Dan heb je dus ook nog een niet ontgonnen stuk als we commercieel onderzoek zouden willen doen voor de ResearchOR, dan zit je op het punt dat je een structuur moet maken waarbinnen je dat kunt doen. Dan je ook kunt zeggen daar heeft het ziekenhuis ook wat aan, zij het financieel, zij het in de samenwerking met bedrijven. En daar hebben wij nog helemaal geen uitwerking aan gegeven.		

Onvoldoende tijd	Doelgroep onvoldoende meegenomen	Extra werk naast normale baan	Werkdruk
B_project_4	B_project_5	B_project_6	B_project_7
onvoldoende tijd om in het project te kunnen steken	misschien toch het nog niet voldoende meegenomen hebben van de doelgroep in de ontwikkeling. Dus niet vanaf een heel vroeg stadium, dat in een LL naar voren komt dat er toch onvoldoende aansluiting is	En iedereen moet het er eigenlijk iedere keer maar gewoon weer bij doen.	Barrières is werkdruk. Dus dat mensen het heel druk hebben.
Maar, het is heel tijdrovend om een goed plan te ontwikkelen. De slaagkans van een onderzoeksproject is gewoon heel laag.			
Want het is niet voor elk onderzoek van je gooit de OK open en je gaat even wat doen. Dat vergt toch altijd een hoop voorbereiding en ook tijd om dat veilig te doen.			

Geld	Wetgeving	Onvoldoende vervolg projecten	Ziekenhuis durft niet te innoveren
B_project_8	B_project_9	B_project_10	B_project_11
Barrières is geld	En barrières is ook wel de wetgeving, de MDR. En de AVG.	Het is zo jammer dat er dan iets wordt gemaakt of bedacht en daar zit dan weinig vervolg aan vast. Eigenlijk zou je nog een derde partij moeten hebben zoals een firma zoals dat bij Dora gebeurd is. Dat je het dan ook door kunt ontwikkelen. En dat mis ik wel een beetje.	Ik denk dat het belangrijkste is, ze zien track and trace als een interessante ontwikkeling. Ook om aan hun processen toe te voegen om in algemene zin te organiseren. Dus waar een bed staat, om informatie van allerlei sensoren te krijgen. Nou daar moet een infrastructuur voor komen. Wij kwamen met een product voor een hele specifieke toepassing, namelijk Ok's. En nu hebben ziekenhuizen dat niet durven realiseren omdat men verwachtte dat op termijn er een hele andere infrastructuur zou komen. Ja dus ze hebben het uitgesteld om dit te doen omdat ze denken dat op de termijn er een andere infrastructuur komt. En daar hebben wij last van gehad. Dat is de belangrijkste reden.
			Wat wij gemerkt hebben is dat er gewoon medische afdelingen zijn die dit een beetje buiten de deur willen houden. En dat ze bang zijn voor automatisering, en ook hun eigen rol in het proces
			In de eerste plaats is het technische materie die ziekenhuizen niet eigen is. En ze zijn bang om zo'n beslissing te maken omdat ze denken dat dat een soort schaduw vooruit werpt voor andere track and trace oplossingen.

Geen focus op innovatie	Mismatch in plaats waar innovatie voordeel bied en waar het besluit genomen wordt	Evenwicht verdeling van organisatie rondom onderzoek en het onderzoek zelf is moeilijk te vinden
B_project_12	B_project_13	B_project_14
Maar toch ook met een onduidelijke verdeling van verantwoordelijkheden. Want bij wie moet dit initiatief liggen? Bij de OK? Want die hebben het voordeel hiervan. Maar de OK is vooral bezig, en dat klinkt misschien wat negatief, met de dingen van vandaag. Die zijn niet zo met innovatie bezig, dat ligt toch bij andere afdelingen.	Maar, er kan een mismatch zijn tussen de plek waar de innovatie het meeste voordeel biedt, in dit geval op de OKs, het zou de OK medewerkers heel veel werk besparen, en het onderdeel van de organisatie die zoiets kan trekken en organiseren. Ja, daar schort het hier aan.	Als je dan gaat naar een keer per maand moet er vergaderd worden over trajecten die lopen, dan denk ik ja dat is misschien weer net te veel. Want in een maand gebeurt er in een onderzoeks- of wetenschapssetting niet zoveel. En als we dan ook weer specifiek een symposium moeten gaan doen voor robotica in de zorg, ja is dat nu niet een stapje te ver. Zijn we niet teveel dingen bij elkaar aan het trekken nu. En zijn we niet teveel uren aan het verbranden nu in de omgeving van de ontwikkeling, en niet in de ontwikkeling zelf. Maar het is en blijft heel moeilijk om het goede efficiency punt daarin te raken
Het kost mij ook heel erg veel moeite om bij de verpleegafdelingen los te krijgen waar bijvoorbeeld de TU hen mee kan helpen.		
Ja, kijk, wat soms mist in dit soort trajecten is gewoon lijn. Lijn in opeenvolgende trajecten.		

Mismatch met de markt (product is te veel toegespitst op de situatie waarin het getest is)	Onderzoek levert het ziekenhuis niet altijd wat op (financieel)
B_project_15	B_project_16
Aan de andere kant is het ook wel zo dat de leverancier daarvan, dat is toch een beetje waar je dan het succes vanaf moet meten, de leverancier daarvan heeft heel veel moeite om dat specifieke product aan de man te brengen. Dus waarvan wij denken, dit is het product waar wij iets mee kunnen en dit vinden we heel prettig, is het aan de andere kant iets wat ze niet makkelijk aan de man gebracht krijgen voor andere locaties.	Nou ja wat steeds meer gaat spelen, we zitten een beetje in een transitie dat steeds meer ziekenhuizen steeds meer kennisinstellingen worden. Dus het ziekenhuis wordt zich er steeds meer van bewust dat wij bijzondere unieke kennis hebben waarmee we kunnen bijdragen aan zo'n project. En als je gaat kijken naar bijvoorbeeld Dora, dan zeg je van ja dat is heel opmerkelijk, maar aan de ene kant heeft de TU een PhD student erin gezet, wij hebben toegang tot de OK en de processen verschaft en daaraan meegewerkt. En een leverancier heeft het product gebouwd. Maar uiteindelijk hebben wij toen we onze nieuwe OK's openden dat product weer gekocht. Dus aan de ene kant hebben we een heleboel toegang en een heleboel bijdrage geleverd. Maar uiteindelijk moesten we nog steeds een flink bedrag afrekenen voor dat product. En dat is wel tekenend tussen waar we tussen de 5 a 10 jaar geleden stonden.
Maar op zich, research technisch, ontwikkel technisch is dat project gewoon heel goed gelopen. Dus zelfs met een Living Lab loop je dus nog het risico dat een product-market fit dat dat toch nog beperkt is.	Dat we kijken van oké zo'n product moet ook iets opleveren voor de organisatie. In de zin van, we zijn ofwel mede-eigenaar van het product, ofwel we spreken van te voren af dat we het product gratis geïmplementeerd krijgen als het succesvol wordt. Dat soort dingen. Maar dat zorgt er dan wel weer voor dat het starten van dit soort projecten moeizamer wordt. Want dan moet je ineens financiële deals, en juridisch kloppende deals gaan sluiten. In plaats van kom binnen, kom eens even meekijken.

Appendix 4 Drivers and Barriers from literature labelled per article

	Article	Autor(s)	Drivers	D_Code	Barriers	B_Code
1	Best Practices, Innovation and Development: Experiences from Five Living Lab Innovation Environments	Irma Mäkäräinen-Suni	Develop a working plan (intended results, budgets) and plan for continuous evaluation at start, incl. participatory nature, major boundary spanning issues, etc.	D_1	Boundary spanning issues	B_1
			Early involvement of users	D_4	Legal issues, like liability, IP issues, data ownership and access	B_2
			motivation of actors to participate	D_5	Avoid large numbers of actors, powerful/dominant actors and strong interdependency; avoid actors that do not comply with living lab values	B_3
			Adequate capabilities/skills of actors to perform roles and interact	D_7	Settle issues concerning access to places, and implementation of new infrastructure (timing, responding to willingness-to-pay)	B_4
			openness and flexibility	D_3		
			Multiple approaches and collaboration tools	D_8		
			Ability to deal with unpredictability	D_9		
			Ability to handle conflicts and work with intermediaries	D_10		
			Sufficient gaining and absorption of end-user feed back	D_4		
			Transparent project selection and decision, eventually, design of business models	D_1, D_3		
			User-values: trust, privacy, cultural identity, wishes of self-determination, cultural 'distance' to ICT, transparency in decision-making	D_2		
			Values among managers: commitment, passion, risk-taking	D_2		
			Societal values, like sustainability and responsibility	D_2		

		Give attention to upscaling, financial investment, regulators, contractors, etc.	D_1		
		Develop embeddedness with focus groups, community of practice, etc. and supportive policies (region, sector)	D_8		
		Shape an 'inviting' arena where improvisations and tacit knowledge are shared, and inventions created and validated	D_3		
2	A framework for the evaluation of living labs as boundary spanners in innovation	Marina van Geenhuizen	Living Lab's area of industry is appealing, current or unique	D_2		
			Users and other actors of Living Lab are actively participating in the R&D projects	D_5		
			Living Lab offers a platform or a physical space for different actors of meet and share ideas	D_11		
			Different kind of users or user groups are available for R&D projects	D_4		
3	Living Labs in Health Innovation: Critical Factors in their Application	Marina van Geenhuizen, Nick Guldemond	The involvement of users, particularly the need for close and intensive interaction.	D_4	Differences in values, etc. between university and industry	B_3
			The composition of stakeholders and the required functionalities of the networks, in view of creation of vertical cooperation in the value chain.	D_7	Improve financial factors and reduce financial risks	B_5
			A sufficient involvement of technology, referring to ICT –use in monitoring and analysis of user response to inventions.	D_4	Compensate for lack of 'critical mass' in the business ecosystem	
			An adequate use of business models, referring to dividing tasks and distributing costs and benefits over the participants.	D_6	Speed and effectiveness of valorisation	B_7

		A set of important practical factors including ethical issues and intellectual ownership, balancing interests of stakeholders, and issues concerning safety and legal liability.	D_12	Sixth, dealing with potentially disturbing legal issues, such as intellectual ownership protection and legal liability issues following from the collaborative nature of living labs and the involvement of human health.	B_2
		First, an appropriate selection of users, such as patients, risk groups and hospital personnel, regarding their needs, motivation, capabilities, representativeness, social influence, loyalty, etc.	D_4		
		Secondly, sufficient trust and alignment between the partners involved such as the medical faculty, supplying faculties, academic hospital and non-academic hospitals, multinationals and smaller firms, etc., avoiding that 'one goes its own way', but also a partner composition that guarantees a sufficient access to multiple disciplines.	D_2, D_3		
		Third, business models that divide tasks and distribute costs/benefits, yet allow for openness, and value chains that are fully integrated to enable economic success; also, after some years, a critical evaluation of the leading concept, eventually followed by shifts to stronger commerce and international operations.	D_6		

				Fourth, a one-stop-shop for medical researchers at university and academic hospital and for user-groups, and a structured innovation process, no matter the nature of the invention (medical instruments, drugs, and care concepts, etc.), with clear go/no go decisions, and with attractive project formulation to raise the interest of investors	D_11		
				Fifth, attention for technology as a means for monitoring of patients and risk groups at home and for analysis of user-response to the inventions but avoiding dominance of technology and the rise of barriers, such as with 'soft' aspects in health care.	D_4		
4	Living Labs for User-Driven Innovation: A Process Reference Model	Javier García Guzmán, Alvaro Fernández del Carpio, Ricardo Colomo-Palacios & Manuel Velasco de Diego	Society needs new ICT services and products to sustain well-being.		There is no widespread understanding of the living lab concept, making it difficult to implement benchmarking initiatives at research and practitioner levels.	B_6
			Companies need to explore new business models, facilitating the development of new ideas that come from different types of users.	D_8	Due to the economic situation, there is a lack of public funding, and other successful business models that could serve as examples are not properly reported in the literature.	B_5
			There is strong political support at all levels for this kind of open innovation initiative.	D_1	It is difficult to demonstrate the long-term value of a living lab for businesses, user communities, and territories.	B_7

		There are very active networks supporting the collaboration of different stakeholders to create living labs, such as ENoLL (European Network of Living Labs).	D_13	Creating a living lab requires long-term funding. This may necessitate non-traditional models to fund innovation, such as crowdfunding or the implementation of joint ventures to sell products and services created in collaboration with end users and software companies.	B_5
				The effectiveness of a living lab depends on the involvement of lead users and a relevant set of early adopters in the innovation process. If the user groups participating in the innovation processes are not appropriate in terms of profile and scale, this could lead to unfinished or failed innovation initiatives or the creation of products or services that do not have an appropriate target market.	B_8
				There is a lack of dedicated personnel who have the required competencies and skills to manage living lab innovation projects and initiatives.	B_9
5	Living Laboratory and eHealth: People, Regulation, Industrial Partners	Andras Kuba, Tibor Torok, Csenge Csoma, Peter Uhlir, Emese Szab, Eva Acs, Annamaria Takats			Information about the patients' health status and the patients' personal data must be handled with utmost care along the whole procedure.	B_10
				The methodology of the experiment within the Living Lab must be authorized by a regulatory organization.	B_11

6	Participation in Living Lab: Designing Systems with Users	Birgitta Bergvall-Kåreborn, Debra Howcroft, Anna Ståhlbröst and Anita Melander Wikman	important to attract a varied group of participants	D_4	A recurring challenge within PD concerns how to communicate the needs of users in such a way that developers can understand them while developers need to be able to feed back their understanding of system requirements in a manner such that the users can make sense of it.	B_12
			the project illustrates that it is not the quantity of user involvement that determines the categorization, but rather the influence that is wielded by the users.	D_4	the link between successful design and successful implementation may be weak, non-existent, or irrelevant	B_13
			Building a strong, ongoing relationship with users was crucial, since their involvement required a considerable time commitment on their part as well as psychological involvement.	D_4		
7	Living Labs Sustainability Strategies and Rural Development Policies	Tuija Heikura, Hans Schaffers	Community members are willing to contribute resources to the development of the rural Living Labs	D_7	Living labs operations appear to be based on individuals as opposed to being deeply embedded into the member organization functions and structures, which leads to sustainability risk	B_8
			Unique advantages: e.g. one Living Lab has a 'non-stop flow' of exploitable new technologies and coming from community member organization.	D13	The management of the user groups have issues and processes yet to be resolved or further developed as some current management methods are not scalable	B_9

		Has quick and efficient work networking processes or clear focus areas.	D_13, D_1	The level of end user involvement is lower than what can be expected considering that the Living lab movement endorses the user focus.	B_12
		Good understanding of collaborative working environment methods, processes and tools	D_6	Language and versatility of approaches may be a barrier in the way of living lab-to-living lab collaboration	
		The Living Labs have been able to secure project funding for projects, often from more than one type of funding organizations	D_14	Some of the Living Labs are operated by networks without the status of a legal entity	B_2
		Collaboration relationships have been formed with regional development organizations	D_13	Weak funding base; Living Labs heavily relying on public funded projects	B_5
		Good understanding of policy issues expressed in ability to secure public project funding	D_1	Public project funding may shift focus in a way that is not beneficial for rural Living Labs	B_5
8	Exploring Factors Influencing Participant Drop-Out Behaviour in a Living Lab Environment	Abdolrasoul Habibipour, Ali Padyab, Birgitta Bergvall-Kåreborn, and Anna Ståhlbröst			Instability/non-functionality of the prototype	B_12
9	Care living labs' effect on care organization and quality of working life	Anselm Yennef Vereycken, Leen De Kort, Geert Vanhootegem and Ezra Dessers	To profoundly tackle care fragmentation, more targeted interventions are necessary. A more integrated care delivery can be attained by bundling activities in multidisciplinary care teams (Körner et al., 2016) or inter-organizational care networks (Sheaff and Schofield, 2016).	D_1	Hence, the care living labs projects seem to affect mainly care fragmentation by improving coordination and communication, rather than aiming at the underlying cause by reshuffling existing care inter- and intra-organizational boundaries.	

					the limits of controlled experimentation due to messy social responses and co-creation activity;	B_9
10	Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance	Franziska Engelsa,b, Alexander Wentlandb, Sebastian M. Pfotenhauer				
					a tension between lab-like open-ended experimentation and pressures to demonstrate success;	B_7
					the opposing needs of local socio-cultural specificity and scalability, i.e. the inherent promise of test bed outcomes being generalizable or transferrable because the tested "model society" is presumed to represent a future society at large.	B_13
11	Critical factors in health innovation in cities: from ivory tower to living lab	Marina van Geenhuizen	an active involvement of user-groups and in special cases, learning about user needs and abilities prior to the project or along the process	D_13		
			particular network features like covering all parties involved and allowing sufficient critical mass as well as access to multidisciplinary knowledge	D_13, D_4		
			a structured innovation process based on a funnel or a network model in starting open processes which gradually become more tight with on the operational level a clear go/no-go and an easy access	D_6		

		a limited role of ICT, unless the technology itself is subject to co-creation and testing			
		dealing with practical requirements, mainly management issues like the model of management, e.g., balancing interests between different partners	D_6		
		the 'human factor' including particular interaction and management features like trust and willingness to take risk and being passionate as decision makers	D_3		
		adaptability of the legal concept/status, e.g., a shift from a public-private network to a company	D_15		
12	Living Labs as intermediary in open innovation: On the role of entrepreneurial support	Guido Baltes, Jerome Gard	Lead users are described as both, well-motivated to actively participate in innovative collaboration and qualified as they are a source of anticipative needs that can (only) be satisfied by innovative solutions. The integration of lead users in the early stages of the innovation process provides insight into tacit and latent needs and possible solutions.	D_5, D_6	lead users and technology providers do not generally have adequate resources and incentives to bring these solutions to market.	B_13

		This requires an infrastructure, i.e. a physical environment that enables lead users to experiment with prototypes provided by technology providers to foster the creation of fast feedback loops. These feedback loops allow lead users to gain experiential knowledge and at the same time enable researchers to transform the tacit experiential knowledge into valuable solutions.	D_11		
		Living Labs as an intermediary in this aspect should not only present solution prototypes but provide an environment that allows lead users to interact and modify solutions based on the specific user group's horizon.	D_11		
		the third aspect of the intermediary role of Living Labs: latency-free access to the various resources crucial for successful commercialization of technology. In order to achieve this, Living Labs have to maintain extended networks of stakeholders.	D_13		
		Living Labs, with its limited network size and specific technological focus in continuous projects, may function as a trust catalyst between partners.	D_1, D_13		

		It is argued that not only lead users and technology providers but also entrepreneurs play a vital role in the process of Living Lab implementation	D_15		
13	Living Labs and Regional Innovation Policies in the Mediterranean Area	Ana GARCIA, Jesse MARSH, Francisco PEREZ TREJO, Jon Matthew SWITTERS	*Introducing the territorial dimension to regional innovation policy* Funded measures grounded in existing programmes can introduce mechanisms that encourage partnerships to reach out to other actors and expressions of need.	D_13, D_1		
			Jumping outside of traditional innovation policy sectors in this approach, Living Labs are supported in a regional policy arena outside of the technology research domain. The emphasis is on social and non-technical innovation using e.g. readily accessible Web 2.0 platforms that do not require significant expertise nor investments.	D_8		
			Funding innovation through procurement, linking it to concrete needs Instead of considering innovation as an abstract exercise to be carried out by universities and industry, specific regional spending needs can become innovation opportunities through open calls for ideas. This approach, called Pre-Commercial Procurement (PCP),	D_1, D_14		

		Exploring the role of social networks and "design thinking" in user-driven innovation Many initiatives are taking a fresh look at how innovation and capacity-building happens, mainly through Web 2.0 approaches:			
		Integrating impact assessment into innovation programmes As such broader approaches are experimented, measuring the impact of innovation on regional wellbeing requires new approaches capable of capturing the systemic nature of interactions among the social, political, and economic agents involved and build feedback loops into regional innovation policies and projects themselves.	D_6		
14	Towards innovation in Living Labs networks	Seppo Leminen, Mika Westerlund	Treating users as equal co-creators instead of research objects	D_4	Further formulation and development of a standardised (multiple) Living Labs model	B_9
			Common learning process	D_2	Engaging the Living Labs network in the long-term strategic goal development	B_9
			More effective collaborative and concurrent processes	D_6	Distinction between the openly shared and internally held company issues	B_2
			New product and service development practices	D_6	Transition from a single project to a chain of projects	B_7
			Dynamic adaptation of the network	D_13	Productization and quantification of knowledge	
			Efficiency of the network	D_13	Ensuring continuous participation and expressing relevant experiences	B_7

		Transition and evolution of knowledge in the network	D_3	Promoting trust and transparency	B_2
		Experience of the Living Labs innovation method	D_16	Depicting benefits of the Living Labs network	B_7
		Successful reference case for future purposes	D_16	Tying parties to long-term objectives	B_7
		Support for future projects and activities in retail process development	D_15	Shifting and combining individual objectives with those of the network	B_8
		The accumulation and development of new knowledge, tools and competences	D_17	Balancing differing motives and expectations	B_8
		Training and learning as a part of the Living Labs project	D_17	Ensuring exploration and exploitation for resources	B_5
		Accumulation of knowledge	D_17	Ensuring flexibility and continuation of the project	B_9
		Learning experience	D_17		
		Documentation and conceptualisation of the development activities and tasks	D_6		
		Arranging workshops and seminars to identify development needs in the Living Labs model in different contexts	D_8		
		Communicating the potential of commitment with the Living Labs network	D_16		
		Defining open innovation policy and guidelines	D_3		
		Focusing on long-term goals, knowledge and expertise when participating in the chain of projects	D_1		
		Documentation and analyses of the accumulated knowledge	D_6		
		Paying regard to users (motivation, rewards and fun) and their relevance for innovation	D_4		

15	Moving an innovation from a Living Lab to the Real World: Politically Savvy Framing in ITAIDE's Beer Living Lab	Eveline van Stijn, Boriana Rukanova, Anthony Wensley, Yao-Hua Tan			Our perspective suggests that engaging people in a network is an on-going process. Where situations and context shift over time, so too will peoples' understandings and interests.	B_8
					In many cases Living Lab innovations require not only technological but also socio-political and institutional changes to be made in order for them to be adopted. The need of socio-political and institutional changes becomes especially visible in cases where Living Lab participants attempt to propose innovative solutions for domains that are highly regulated. The reason for that is that in such cases, often the existing legal requirement would need to be adjusted first, in order to create grounds for the further adoption of the innovation.	B_8
16	Importance of living labs in urban Entrepreneurship: A Portuguese case study	Margarida Rodrigues, Mario Franco	Open network	D_13		
			Entrepreneurship	D_15		
			Benefits/Results	D_16		

| 17 | From "living lab" to strategic action field: Bringing together energy, mobility, and Information Technology in Germany | Weert Canzler, Franziska Engels, Jan-Christoph Rogge, Dagmar Simon, Alexander Wentland | The living lab setting institutionalizes an arena of exchange and experimentation that allows the actors involved to "move into the unknown" and to use the "unavoidable failures or mishaps as a basis for learning" without immediately facing market pressure. | D_18 | Policy implications: With more and more countries aiming to increase the share of renewable energies to their national energy supply and the growing diffusion of electric vehicles, the ties between mobility and energy will become even stronger in the future. The foundations of how these ties are going to look are laid out in living labs like the innovation campus we studied. Therefore, it is crucial not only for scholars but also for businesses and policy makers to pay close attention to the developments in these arenas. The living lab of today might become be the new strategic action field of tomorrow – with all kinds of path-dependencies. | B_8 |
| | | | Intense communication and joint events between partners from different sectors and disciplines help create an atmosphere of innovation and co-operation, even though, this does not happen automatically | D_17 | | |

		Thus, the living lab not only allows for experimentation and data collection on various aspects of the connection between mobility and energy by using ICT but also sets the stage for the competition between differing frames and views of the field. The development of interdependent interests is a necessary condition for the emergence of a new SAF, but this interdependence does not bring about a shared understanding.	D_2		
	Krassimira Paskaleva, Ian Cooper, Per Linde, Bo Peterson and Christina Götz	Involve stakeholders early in the process, before projects are clearly formulated.	D_2		
18	Stakeholder Engagement in the Smart City: Making Living Labs Work		Work together on joint articulation of aspirations and concerns as a starting point.	D_2	
			Engage users with diverse backgrounds, competencies and agendas and stress how, through their collaboration, they will complement and learn from each other.	D_17	
			Identify and work upon what participants can gain from taking part. Active engagement rests upon how beneficial it proved to be for each individual partner	D_16	

		Assure different levels of impact, both in terms of the direction of political decision-making and significance for other communities represented by influential participants.	D_1		
		Be sensitive to possible sources of conflict, not only internally within the network but also outside of the network with important others.	D_10		
		Use both direct and indirect methods for recruiting	D_8		
		Use alignment to achieve match-making and accelerated buy-in	D_2		
		Ensure co-production creates a unique project space with outcomes beyond what might have happened in any case.	D_17		
19	Living Labs in Action - Designing coordinated collaboration in innovation processes	Ebru Turgut, Berhard Katz	A portfolio of successful collaborations could then enable the Living Lab to develop a new business model in terms of funding.	D_16	Only high performing Living Labs can be differentiated from other organizations with inexplicit organization and activities and gain a sustainable position in an open innovation market	
					Monitoring and managing the collaboration took up much time and financial efforts. The study revealed that a sustainable implementation of any coordination between innovation agents strongly depends on public funding again.	B_9, B_5

20	Integrating Living Labs with Future Internet Experimental Platforms for Co-creating Services within Smart Cities	Hans Schaffers, Annika Sällström, Marc Pallot, José M. Hernández-Muñoz, Roberto Santoro, Brigitte Trousse	there is a clear need to enhance user involvement and user support in experimental research related to the Future Internet.	D_4		
			We therefore foresee an increasing need to create easy and context-specific access to common technical and non-technical resources and capabilities that can be shared for complex experimentation and innovation projects.	D_17		
21	User engagement in living lab field trials	Annabel Georges, Dimitri Schuurman, Bastiaan Baccarne and Lynn Coorevits	Based on academic literature on field trials, user engagement and the technology acceptance model, the authors argue that several factors play a role in the participation of users in field trials. An influential factor that emerged is the functional maturity of the innovation, the extent to which a prototype resembles the functionalities and the processes of the final, go-to-market product at the moment of the field trial	D_4		
22	Urban living labs for sustainability and low carbon cities in Europe: towards a research agenda	Yuliya Voytenko, Kes McCormick, James Evans, Gabriele Schliwa	geographical embeddedness	D_13		
			experimentation and learning	D_17		
			participation and user involvement	D_4		
			leadership and ownership	D_6, D_12		

			evaluation and refinement	D_6		
23	Learning from an electromobility living lab: Experiences from the Estonian ELMO programme	Liina Joller, Urmas Varblane	For fast market uptake of radical (eco) innovations the active role of government is crucial;	D_12		
			Radical innovations that involve multiple regimes require a systemic approach in order to avoid the 'chicken and egg' problem;	D_6		
			Together with creating the incentives, the protection phase-out process should be planned as well;	D_15		
			New business models that offer experience with new technologies, without requiring immediate ownership, should also be supported in order to enhance consumer acceptance;	D_15		
			Participating in market pilot projects gives valuable feedback for companies before heading to export markets.	D_15		
24	Living Labs as open innovation systems for knowledge exchange: solutions for sustainable innovation development	Dimitri Schuurman, Bastiaan Baccarne and Lieven De Marez	Need information	D_17		
			Solution information	D_17		
			Stimulating economic and social value creation	D_17		
			Market strategy	D_15		
			Showcase infrastructure			
			Fun	D_4		
			Participation/empower ment	D_4		

		Research data for academic valorisation	D_17		
		common or compatible long-term goals	D_2		
25	Developing a regional design support service	Juho Salminen, Satu Rinkinen and Rakhshanda Khan	user involvement in the beginning of service design process	D_4		
26	A Living Lab research approach for mobile TV	Dimitri Schuurman, Katrien De Moor, Lieven De Marez, Tom Evens	thorough involvement of the user within the innovation process, resulting in a two-way street with advantages for the user as well as for companies	D_4	The major weaknesses of the present study were, as mentioned before, the absence of compelling, mobile specific content, and of an iterative research approach	B_12
			By using a real-life community, a Living Lab can already generate a future market	D_15	the requirement of a lot of time and budget to set up a Living Lab-approach is a general weakness for the Living Lab-approach	B_5
			Living Labs can also be cost-effective as they avoid making costly changes at a later innovation stage	D_14	Another disadvantage, especially in Living Lab-settings with smaller amounts of users, is the difficulty to ascertain whether the findings can be extrapolated to the market. This can be seen as the problem of outliers	B_13
			They also generate better ideas and allow to eliminate bad ideas faster	D_17	The most prominent threat for Living Labs is the need for substantial financial support, mostly external funding, to establish them	B_5
			cooperation between Living Labs in order to benefit from each other's experiences	D_13	The stakeholder-model for Living Labs assumes the symbiotic nature of the stakeholder roles. However, as the primary focus of the developer is his/her own market and business opportunities, in practice, a symbiotic cooperation is not very evident.	B_8

			A further awareness of Living Labs can also lead to positive changes in innovation policy (Schaffers and Kulkki, 2007), as Living Labs can enhance economical, social and cultural systems cross-regionally and cross-nationally	D_13	As already mentioned, there still exists confusion regarding the exact interpretation of the Living Lab-concept and there is a lack of empirical studies regarding research parameters, appropriateness of underlying business models and effectiveness of Living Labs as a system for innovation	B_6
27	Linking Living Lab Characteristics and Their Outcomes: Towards a Conceptual Framework	Carina Veeckman, Dimitri Schuurman, Seppo Leminen, and Mika Westerlund	A clear strategic intention	D_1		
			A minimum of shared value creation and sharing among all stakeholders	D_2		
			A minimum level of openness	D_3		
			A minimum set of users and establish a strong communication	D_4		
			A mixed set of living lab tools to discover new opportunities	D_8		

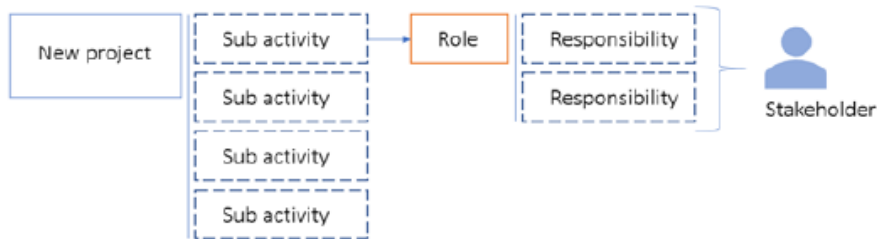| Functions	Theory	Practice	
		LL coordinator	Innovation mana...
1 Mapping the stakeholders and their roles and responsibilities	The cognitive dimension of social capital enables collaborations from disparate teams. This leads to a more in-depth knowledge of team projects (Bartelt et al., 2020).	**WHAT**: start new project --> identify sub activities --> identify roles and responisbilities. This also makes it easier to see if there are stakeholders with the same role or if there are roles missing. **FORM**: checklist	**WHAT**: Do this together w... stakeholders, this will resul... commitment. But first iden... to start with. **FORM**: Depending on the r... of a contract
2 Mapping the projects and the required and available resources		**WHAT**: initiative taker of project often pays. **FORM**: checklist	**WHAT**: Make a roadmap a... Living Lab project with the ... Also think of a subsidy advi... **FORM**: Visual, maybe exce...
3 Creating a mission and a vision for the total Living Lab		**WHAT**: set up criteria for parties that get to have a say in the development of the vision and mission. Should have long term ambitions for the Living Lab and not just for themselves. **FORM**: website with text about it and a presentation at the start of a new project.	**WHAT**: Start the conversa... partners in the Living Lab **FORM**: Present the outco... or in a presentation or port...
4 Mapping the current management structure (including roles and responsibilities)	There is a difference between conventional project-based innovation development and the open innovation model. Westerlund & Leminen describe six main differences (Westerlund & Leminen, 2011).	**WHAT**: inventarisation of project administration - how many ours did people work - income/expences Documentation - Activities - agreements **FORM**: project management meeting	**WHAT**: Make an organo... activities of the Living La... **FORM**: Excel

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A flowchart with the sub activities per new project and the roles and responsibilities that follow increases the shared understanding of the Living Lab as a whole through the cognitive dimension of social captial.

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Meeting with stable Living Lab stakeholders

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ab coordinators.

| #	Topic	Theory		
5	Evaluating the current management structure	A performance assessment tool can help the Living Lab coordinators to identify where the strengths and weaknesses lie in the current management style (Osorio et al., 2019).	**WHAT**: reflect on what already has been done: is it viable? Is it for on the long term? **FORM**: starting point should be mission and vision --> management structure follows --> evaluate based on experiences and learn from assiociated companies.	**WHAT**: Set up criteria to current situation **FORM**: Meeting of the Li coordinators.
6	Balancing the time, energy and money spend on management and research	Ingen & Bennis describe management as doing things right, and leadership as doing the right things (Ingen & Bennis, 2007). Both are essential. Blending bureaucracy and community appears to be a solution, and would then lead to a *'high reliability learning community'*.	**WHAT**: the end goal of the project should be the number one priority, and not just sticking to the plan you made at the beginning. --> project goal determines the balance between management and research --> Background stakeholder influences the balance per stakeholder **FORM**: should follow from vision and mission	**WHAT**: It is important to project development so t stakeholders can focus on
7	Creating clear goals for Living Lab projects	Transition management aims to align innovation processes through a combination of network governance, self-organization and process management leading to modulation of ongoing dynamics. This way of management can be described as goal-oriented modulation: between planning and incrementalism (Kemp et al., 2007)	**WHAT**: mission and vision should help determining long term ambiitons --> those should lead to project goals. These are also stakeholder dependent. There is a difference between a student project and a collaboration with Philips.	**WHAT**: Depends on the f should be registered with
8	Creating synergy between the different Living Lab projects		**WHAT**: beneficial because you can use what you learned from one project in the next. The synergy should be a result from the mision and vision. Sometimes resources are leading. **FORM**: a list of criteria new projects have to meet.	**WHAT**: Use your vision a road map.
9	Determining the position of the Living Lab in the network of participating stakeholders	Community of practice theory (Wenger-trayner & Hutchinson, 2014).	**WHAT**: idenify what the Living Lab has and stakeholders need (trust from the hospital (imago), real life setting, money).	**WHAT**: Communicate a possibilities of the Living position. **FORM**: Publications, co media
#	Determining the position of the Living lab in its field of profession	Community of practice theory (Wenger-trayner & Hutchinson, 2014)	**WHAT**: identify current position and desired position of the Living Lab based on its corporate purpose. Clear profilation of the goal of the Living Lab can help reaching the desired position in the field.	**WHAT**: Living Labs are t between innovation and therefore that you are t **FORM**: Networking

evaluate the

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a small team.
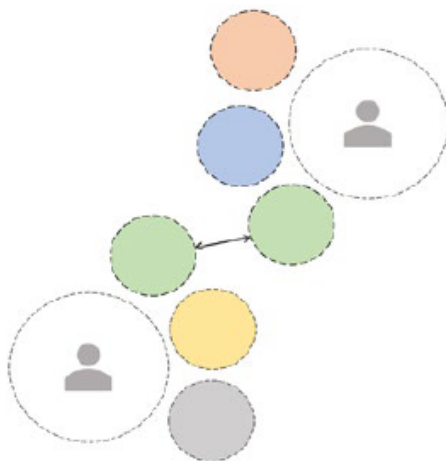
Stakeholder goal matching: When setting
up a first draft of a project, stakeholders
will develop certain goals. Putting those
goals on the table and matchng and
selecting suitable goals for the project
will make sure stakeholders are on
board.

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