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Workflow Design for Research Projects at Alliander's Research Center

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Abstract

The Research Center for Digital Solutions of Alliander is active in the research side of R&D practices. The projects are all related to IT solutions to practical problems, Alliander wide, with many different approaches. The goal of this research is to find a solution to the lack of structure in the research process. This is a workflow problem, for which the Business Process Modeling Notation is used as a notation for the design. This workflow is designed by following the design science cycle steps, which starts with an extensive problem analysis. The requirements for a solution design are investigated by means of interviews and observation, which resulted in multiple alternatives. The chosen alternative fits the requirements best and is worked out in a solution design. This solution entails that the projects are categorized by Technology Readiness Level, and three different workflows are designed for every TRL category. The solution design is validated by a round of interviews, for each of the stakeholder groups involved. This research contributes to the TRL literature and the literature about Technology Readiness Assessment, with an expansion to the process and information needed to design a Technology Readiness Assessment.

Keywords *R&D · Workflow Design · Technology Readiness Levels · BPMN · Energy Sector*

Management Summary

This research initially started with the goal of developing a Technology Readiness Assessment for the Research Center, to enable a clearer communication of the relevance of projects towards the rest of the company. The problem analysis resulted in a lacking structure as the main problem, where this problem led to a lack of data to develop a Technology Readiness Assessment. Therefore, the structure problem was identified as main problem for this research.

The goal for this research is to provide a workflow that meets the requirements of the team. Three alternative options of designs are described. The first alternative, The Selection of Best, is selected, since this provides a solution with most of the requirements met. Therefore, the three workflows are designed and displayed according to the Business Process Model Notation. This design is validated by interviewing the different stakeholder groups involved in the process.

An implementation plan is included, consisting of three different stages: preparation phase, implementation phase and monitoring and reflection phase. These phases all have different action points. The preparation phase should last 2-3 weeks, in which the awareness and explanation meetings can be provided before starting with the implementation phase. The duration of the implementation phase is dependent on the number of suitable projects to start working according to the new method and can start after a few recommendations are followed through and decisions are made.

The first recommendation for this implementation is: finding a feedback and reflection method that can be used by the members of the Research Center. This can be done by providing a training about reflection and feedback, so a uniform and suitable method can be found. The second recommendation is to appoint one of the team members as being responsible for the implementation and monitoring of the workflow, so the progress is overviewed. The third recommendation is to provide enough guidelines to store and retrieve projects, in addition to providing reporting guidelines. This is important to preserve continuity, since the Research Center is focused on technologies that are interesting in the long-term. The last recommendation is to focus on the Technology Readiness of researched technologies when the workflows are implemented. This will provide uniform data that can be used to develop a Technology Readiness Assessment. Working with the workflows will enable communication of the relevance of the Research Center, in addition to provide clarity and uniformity within the team.

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1 Introduction

The energy sector is on the verge of a change. Environmental concerns as pollution and climate change result in a transition to cleaner and more efficient energy generation. New technology development enabled this transition (Sagar & van der Zwaan, 2006) and became more important to energy suppliers. Sagar & van der Zwaan (2006) also describe that realization of potential benefits of innovative technologies is often complicated and require effort.

In addition, policies designed by politics influence the rate of innovation in the energy sector (Jacobsson & Bergek, 2004). The transition in the energy sector requires technological innovation on every company level, which makes R&D in the energy sector an important research topic for Alliander, who is also invested in this transition and technological change.

This research focusses on problem analysis and designing a solution for projects concerning technical innovations and R&D practices at Alliander through a design project.

1.1 Company Description

This research is commissioned by the Research Center for Digital Solutions of Alliander. Alliander is a Dutch utility company, consisting of Liander, Qirion and Kenter. It provides the distribution of energy and gas for one third of the households in the Netherlands. Alliander is mainly active in Gelderland, Friesland, Flevoland and North-Holland and has two large business units: Qirion and Liander.

Alliander, together with Enexis and Stedin, deliver the service for energy transport, connection and measurement in the Netherlands. The Autoriteit Consument en Markt (ACM) supervises the acceptable rate for the services. All shares are held by Dutch provinces and municipalities, or companies held by provinces or municipalities.

Alliander originated from Nuon, which was an integrated energy company that was responsible for the whole chain, from electricity production to delivery to the client. In 2011, a law was passed in the Netherlands that the integrated companies to split their production, transmission and distribution activities. In 2008, Nuon became Liander, a part of Alliander. Alliander has about 7,000 employees. It has inhouse research centers, which research and develop new practical and digital solutions and innovations.

The Research Center oversees researching new IT innovations and non-IT, innovative technologies. The concept of a “technology” in this research will mean a system based on technical knowledge to support physical objects, software, and organizational methods. It is a relatively new formed team, formed little over a year ago, and consists of about 10 members and is researching different subjects and technologies. After finishing the projects, they are presented to other teams and management for implementation. Examples of research projects are related to Internet of Things, Virtual Reality, digitally measuring cables, chatbots and robotics. The technologies are in different stages of development and have different potentials and impacts.

Different companies and markets are explored to find new technologies or techniques. Sometimes, a demand for technology comes from inside the company, this is called business pull. This is a method for the Research Center to explore options of new technologies, but for this team, it is not used as often as technology push, where the team determines potential interesting technologies and research them without a clear assignment from other teams. They house their project under one of the following two research programs: “Digital Mesh” and “Supporting Technologies in Field and Office”.

During the time this research was conducted, the R&D department was redirected into the Research Center. The approach of the Research Center was slightly different from the original approach of the R&D department. This change was necessary because the Research Center had little responsibility for developing the technologies and was more invested in the research and finding new opportunities for the digital innovations of Alliander. This reformation in the R&D department of Alliander, also changed the responsibility of the newly introduced innovation circle.

1.2 Research Motivation

There are different aspects of technological innovation where problems can arise. This technological innovation is needed to both support the company in new developments in both radical and incremental level in operational and IT practices. R&D practices play an important part in this technological change process (Sagar & van der Zwaan, 2006). The research motivation is originally stated by the Research Center as follows: *The Research Center, does not have one way to assess new technologies or innovations in the context of Alliander. First of* *all, showing the relevance of technologies to the rest of the company is complicated. There is a need for a guideline to have a certain standard of assessing the technologies and innovative projects without disturbing the creative atmosphere within the Research Center of Alliander.*

There is not a uniform method to classify technologies or projects, and Technology Readiness Levels (TRLs) were mentioned as a possible method for this purpose. The importance of using the TRLs or other methods to classify technology development and projects is a knowledge question which also needs to be answered during this research. The motivation for the RC is practical and arose from the fact that the team is looking for structured and routinely like practices, without eliminating the flexibility and creativity in the research projects about the technologies.

1.3 Initial Problem Statement: Determining TRL

The initial problem is described in this section. The initial problem as described by Alliander is the lack of a method with which a technology's readiness can be determined. The technology readiness assessment should be a way to show the value of the technologies that are being researched to the company. Estimating the value of the projects in relation to the company strategy of Alliander to enable showing the relevance of the Research Center's projects to the rest of Alliander. The clarity of the technology assessment should enlighten the potential of the project and make it easier to terminate projects and make conscious decisions. The initial problem was the lack of a technology assessment method to determine the value of projects by the Research Center. The literature about Technology Readiness Levels is discussed in this section, where this is a part of the initial problem statement and the options first should be explored, before a revised problem statement is stated in section 2.

A Technology Readiness Assessment is developed by NASA in the 1970s. The original TRLs by NASA are developed specifically for aerospace practices. Mankins (2009) wrote a retrospective paper on the technology readiness assessment for NASA. Since 1995, the technology readiness levels have been adopted by many organizations, to explain the developmental status of technologies. The Technology Readiness Levels and descriptions can be found in Table 1. Therefore, Hicks, Larsson, Culley, & Larsson (2009) developed a generalized concept of the Technology Readiness Levels and expanded this to the Technology Readiness Levels of the Product (TRL_{PROD}).

Table 1 Technology Readiness Levels (Hicks et al., 2009)

Level	Description
1	Principal research into the core properties of a technology.
2	‘Invention’ of a concept or application for the technology. From principle to applied research.
3	Initial ‘proof-of-concept’ of critical functionality through active R&D.
4	Low-fidelity validation in laboratory environment. Technological advancement now focused on meeting project requirements.
5	Validation of basic technology elements in a relevant environment. Test ‘set-up’ to be of higher fidelity than TRL 4.
6	High-fidelity ‘alpha’ prototype demonstrated in a relevant environment.
7	‘Beta’ prototype demonstrated in an operational environment.
8	Completed component, sub-system or system qualified to relevant project requirements and/or regulatory standards.
9	Certified component, sub-system or system proven to meet all project requirements through ‘real worlds’ operation.

Sarsby (2016) concludes there is a big need of methods to support the discovery of innovative technologies and the assessment of their applicability and readiness for the product development in the relevant environment.

As an example, Fernando Leite et al. (2015) researched the development of a technology readiness assessment (TRA) methodology for the R&D department of an energy company in Brazil (Petrobras). The implementations of the TRA methodology by the Department of Energy in 2011 are relevant for assessing the maturity of a technology development project in several industries and was the basis of developing a Petrobras TRA methodology.

Another method to assess the technology readiness is the S-curve described by Altunok & Cakmak (2010). Altunok & Cakmak (2010) developed a TRL calculator tool for systems engineering and technology management. In addition, they elaborate on the Technology Maturity Process, which can also be used to assess the stage of development of a technology. This technology lifecycle is shown in Figure 1 (Altunok & Cakmak, 2010). The stages of the technology maturity process are incubation, growth, maturity, and decline. The stages are characterized by a S-curve and are dependent on time and commercialization capabilities (Altunok & Cakmak, 2010).

The interest in a certain technology can also be dependent on the maturity of a technology in the market. Sood & Tellis (2005) question the unified theory by authors about the S-curve and research empirical evidence to substantiate the evidence. This study concluded that there is not one single S-curve found in the empirical evidence. The curve has intermittent periods with no growth and performance jumps. Sood & Tellis (2005) also stated that the evolution path is predictable in a limited way, and rate of change in technologies and the number of new technologies increase over time.

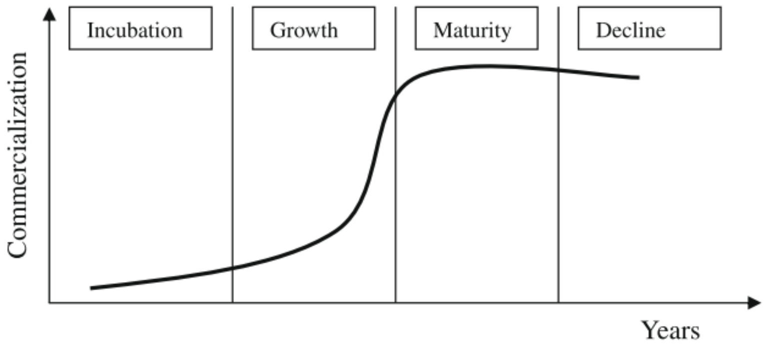

Figure 1 Technology Maturity Process as S-Curve (White, 2004)

1.4 Problem in Literature

The literature about TRLs describes a broad explanation for the boundaries of the levels of a technology and the qualifications of the technology. However, the literature does not mention the qualifications of the process to enable development of a Technology Readiness Assessment. Since data to base the TRLs is needed to develop the TRLs for a specific company or team, more literature is necessary to develop TRLs or a Technology Readiness Assessment. This research will contribute to the literature about the use and development of company specific TRLs or TRAs.

2 Problem Definition

The initial problem is translated into a revised problem statement in this section. To analyze the problem, a stakeholder analysis is done to define the interests in the process. A problem mess is made to describe the problems in relation to each other.

2.1 Current Research Process

This subsection is dedicated to explanation of the current situation. The actual process lacks structure, which makes it difficult to estimate the standardized process, so these are the main activities in the current process. The information about the current research process is retrieved from different interviews, since the process is not yet documented.

The activities consist of:

- *Project Selection*: In this activity, the project subject is selected from own interests or from one of the research programs, based on technology trends.
- *Project Research*: In this activity, the research is carried out, and findings are reported.
- *Presentation*: In this optional activity, the findings or relevance of the technology is presented to either the team or outside stakeholders or interested people.
- *Completion of project*: During this activity, the project is being finished and reported upon. There is a completion form that is ought to be filled out, with findings and report on decisions.
- *Storage of project*: The storage of the project is the last activity in the chain, which is described as the saving of a project somewhere. However, it is not clear where, how and with what purpose the project is saved.

Decisions made during the process are not done at fixed time, or with a rational background. These activities in the process also need to be considered when developing the solution design. The process does not have strict requirements or goals, which complicates the data gathering to develop TRLs for the Research Center. The process thus needs a more elaborate problem analysis to find the problems that lead to this complication, before TRLs can be developed.

2.2 Stakeholder Analysis

A stakeholder analysis is an approach to evaluate the actors in processes or decisions, either individuals or organizations with different interests in the matter a certain policy (Schmeer, 1999; Varvasovszky & Brugha, 2000). In the case of the Research Center this policy will be the researched innovative technology.

Table 2 gives an overview of the stakeholder groups of the Research Center the stakeholder roles are described. Figure 2 gives the actors and their interest in the Research Center's process. The actions regarding those stakeholders are "keep informed", "monitor (minimum effort)", "keep satisfied", and "monitor closely". The stakeholders that should be kept satisfied are the innovation shell and employees or teams with IT related innovative needs.

The stakeholders that should be kept informed are the portfolio managers and the specialists. Lastly, stakeholders that should be monitored closely are team leaders.

The stakeholders from different stakeholder groups are interviewed individually to get more insight in the problems of the Research Center's research process and find out what the problems are in relation to each other.

Table 2 Stakeholder Analysis

Group nr.	Stakeholder	Role
1	Specialists	The specialists perform the research projects and focus on the content and technological specifications of the topic. They have a relatively high interest in the innovations and projects but have relatively little power within the organization and influence in the implementation of the researched innovation. For the specialists, creativity is important, so they have less interest in the approach and impact of the project.
2	Portfolio Consultants	The portfolio managers keep an overview and manage the process and portfolio of the projects. They have more power within the organizations, since the portfolio managers usually have a broader network within Alliander. In addition, they manage the planning and costs.
3	Team Leaders	The team leaders have insight in the corporate goals and budgets. They have less insight in the creative processes. They do not have a certain method of assessing the projects and measuring outcomes. They have a relatively high power, and high interest.
4	Innovation Shell	The innovation shell is responsible for finding the right destination of the innovative technologies, according to the RC. The innovation shell is part of the restructuring of the RC, and the roles are somewhat vague for now. Their interest is less than the Research Center's members themselves since they do not take part in the project, but they (are supposed to) have more power.

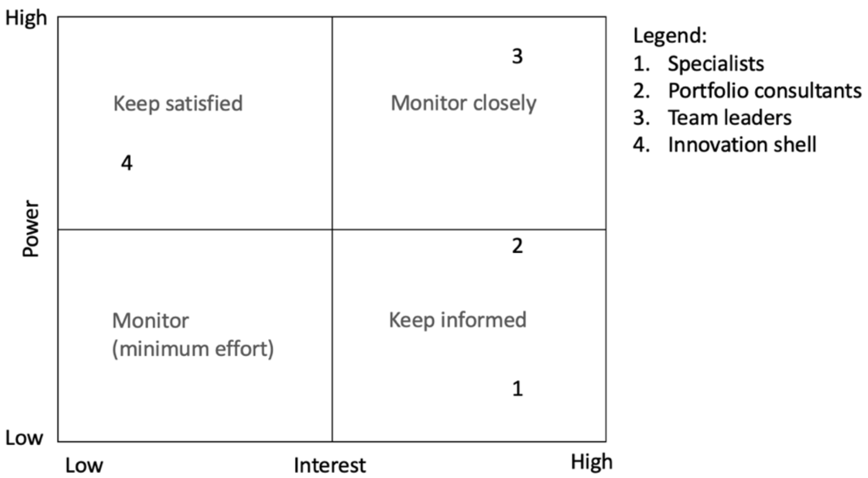

Figure 2 Stakeholder Analysis

2.3 Problem Mess

To start the analysis of the problems, a problem mess is made, which gives the relation between the different problems and can be used to prioritize the problems. The problems are stated by members of the research center, specialists and portfolio consultants, as well as team leaders and an innovation shell member are stated in Table 3.

The unclear guidelines for termination of projects are caused by multiple other problems, lack of an overall structure for the research projects, the lack of a systematic feedback loop, the unclear definition of success, and the lack of time limitation per project. In addition, finding the right person or (potential) end user to pitch the new technologies to is sometimes complicated. The problem that is most involved in the other problems and is the cause of the other problems mentioned initially, is the lack of a structure/guide for the execution of the projects.

Table 3 Problems Stated by Stakeholders

Nr.	Problem	Description
1	Lack of Guide/Structure	There is no clear way to assess technologies or innovations, this was one of the initial problems mentioned. The structure would be clear when certain criteria are met. The criteria will be elaborated upon on the next section.
2	Ambiguous project success criteria.	There is not an agreement in the definition of success by all team members. Success can be something personal or on organizational level. This gives some ambiguity about the end of a project, and sometimes even at the beginning.
3	No clear time limitations per project.	The specialists and portfolio managers are free to make their own planning for the research projects they perform. However, there is a global agenda during the year and quartiles, which gives an indications of the aims per time period.
4	No learning from previous projects.	During the interviews, team members and team leaders indicated that there is no system or loop where the outcomes of previous projects, which either were used to innovate or not used, to evaluate whether they are useful later.
5	No guidelines for termination of projects.	This is one of the initial problems stated by the RC. This ambiguity makes decision making about the termination of projects harder.
6	Sometimes hard finding the right person	Some interviewees gave attention to the problem of finding the right person to pitch the projects to.
7	Continuity	Continuity is an important aspect in long-term R&D projects. For now, the goal of continuity is not yet very clear within the Research Center and is marked as a problem.

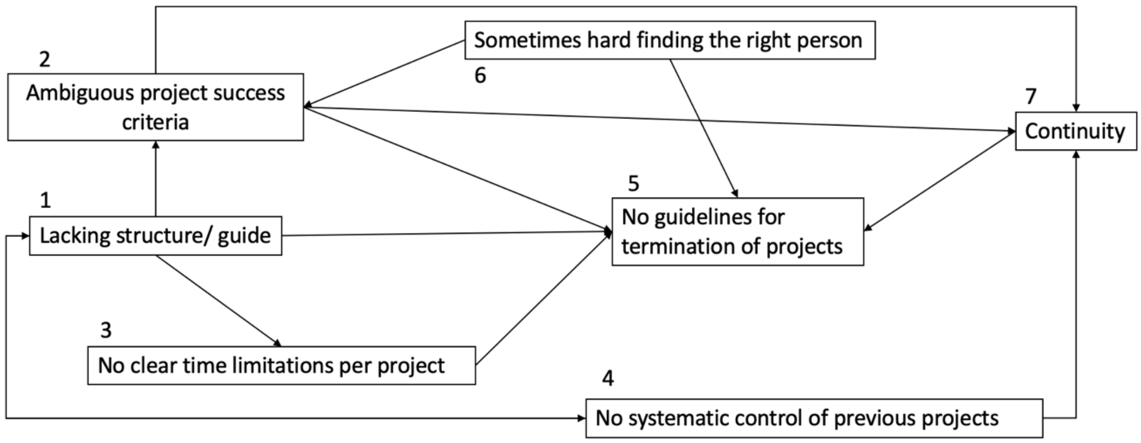

Figure 3 Problem Mess

2.4 Revised Problem Statement and Possible Solution Direction

To state the revised problem, the problem mess and the stakeholder analysis were used to analyze the revised problem. The problem mess indicates a difference between the initial problem by the Research Center and the problems stated after the interviews held with different individuals. The initial problem was described as a difficulty to show the rest of the company the relevance of the Research Center's problems. However, the stakeholders mention more prominent problems, which should be solved before the initial problem can be solved. By solving the project structure problem, the rest of the problems can be taken into account.

The core, revised problem can thus be described as the lack of a structure or a guide for research projects of the Research Center. This problem can be classified as a workflow design problem. In this case, a workflow with the structural guidance based on workflow and business process theory.

2.5 Research Goals

The revised problem for this research is the lack of structure in the research projects. A solution needs to be found to this problem, before the development of TRLs becomes optional. The research goals are furthermore to provide a guideline with which the researchers can run through the research process, and the awareness about the decision-making process. Another goal of this research is to provide a way of communicating activities by the Research Center to other stakeholders outside of the team.

In addition, the research would enrich the existing literature in literature about surrounding problems regarding the development of a TRA in a practical situation. The goal of this research will be that the literature will be expanded on the aspect of TRA development and requirements needed to enable this. A secondary goal is to provide literature about a business case of developing a TRL in a R&D department and addressing underlying issues that complicate this.

3 Research Design

After the problem analysis is done, research methods can be established. Then the design study's activities are explained, with regard to the design science cycle. Then the method for the solution design is mentioned and reviewed.

3.1 Research Questions

The research questions for this design study are based on the problem analysis and theoretic background. From the problem analysis and the main research goals, the following research question is conducted:

"HOW COULD THE RESEARCH CENTER SET UP THEIR PROCESS WHEN CONDUCTING RESEARCH PROJECTS BASED ON TECHNOLOGY READINESS LEVELS?"

From the main research goal, different sub goals are stated. This led to the following sub-questions. These sub-questions are:

- How can TRLs be included in the research process of the Research Center?
- How can conscious decisions about terminating project be included in the workflow?

These research questions are answered in section 7.1. In the next section the research method is discussed.

3.2 Research Method

3.2.1 Design Science

The research questions are focused on designing a workflow for the Research Center and therefore, a design science method is followed. The aim of design science is to create models, methods and systems that underset people in using, developing, and maintaining IT solutions

(Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). In this master thesis research, the design science method will be used, to analyze the problem and make a solution design.

According to Wijnhoven & Brinkhuis (2015) design science should exist of a kernel theory, identification of meta-requirements, listing possible meta-designs, and evaluation of key design propositions. The first, the kernel theory, will be described in this research, the rest of the components of the design science study will be described including the meta-requirements and designs during the research phase. Van Aken, Berends, & van der Bij (2012) describe the research process in different stages. The first one is the “problem definition”. The second is the “analysis and diagnosis” and the third is the “solution design”, the fourth is “intervention” and the last is “learning and evaluation”, after which this cycle can be repeated. These stages can be found in Figure 4.

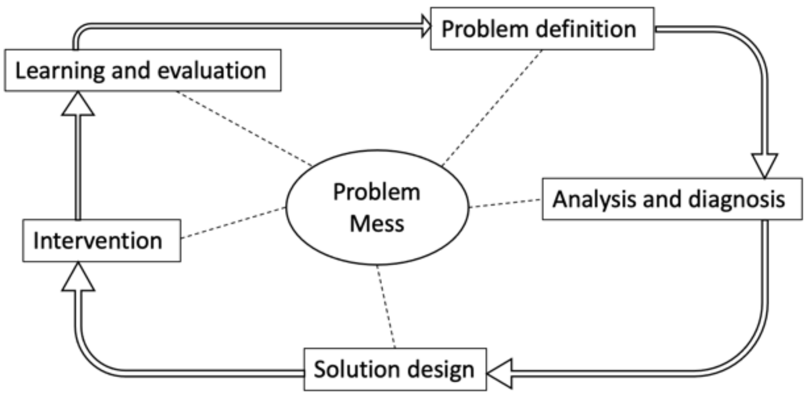

Figure 4 Design Science Cycle (van Aken et al., 2012)

The design study loop can be repeated, and the steps can be run through multiple times. The different stages are explained in the following section.

During the *problem definition* step, the initial problem is analyzed and stated, with regard to the principal’s problem statement. The first component, the initial problem statement is to be found in section 1.3. A thorough problem analysis is done to revise the initial problem. A problem mess, stakeholder analysis and SWOT analysis is done to select a revised problem, for which a solution is designed. This problem analysis can be found in section 2.

The following step, *analysis and diagnosis*, the problem is analyzed, and the revised problem is brought to light. This step is worked out in section2, where the current situation around the revised problem is analyzed. For this step, multiple stakeholders from different stakeholder groups are interviewed individually. The participants were team leaders, researchers, and a member from the innovation circle. The interviews were one hour each and the interview questions can be found in the Appendix. From these interviews, the relevant information is labeled under problem, requirement or informative, or irrelevant. The information from the interviews is also used in the different steps.

The next step, the *solution design,* is the step where the solution design for the problem gets presented and explained. In this step, the relevant theory is taken into account to enable designing a usable workflow for the Research Center. Different options of a solution design are discussed, from which one is chosen. In the solution design step, the identification of meta-requirements, listing possible meta-designs by Wijnhoven & Brinkhuis (2015) are taken into account. This design is adapted to the specific requirements of the stakeholders and process. This solution design will be discussed in section 4.

The *intervention* step of the research is done by presenting the solution design to the stakeholders, who provide feedback about the design. This feedback is used as a validation of the design, and points in which the design needs to be improved. This is done by interviewing the stakeholder groups who provide insights in the solution design, in order to determine whether the solution suits the requirements and potential new insights in the usability of the design. At the intervention step, the meta-requirements Wijnhoven & Brinkhuis (2015) in the alternative designs are validated by the stakeholders.

The last step is the *learning and evaluation* phase. This learning and evaluation step is done after most of the learning has been achieved. This evaluation will be included as an action in the implementation plan in section 6.

3.3 Method of Solution Design

3.3.1 Benefits of a Workflow for the Research Center

According to Dumas, la Rosa, Mendling, & Reijers (2013), Business Process Management (BPM) is described as “the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities”. BPM is not focused on the individual activities, but the chain of activities, which gives an overview of the process (Dumas et al., 2013).

The desiderata of a scientific workflow are mainly based on the scientific aspect of the workflow, which is based on the data input of the workflow (White, 2004). However, the benefits of a workflow for R&D projects, are derived from the desiderata. The benefits will be clarity and uniformity for the specialists and portfolio consultants and results in improved reportability and clearer data flow. The other stakeholders can be informed based on the walkthrough of the workflow. The time management can be improved by experiencing the time it takes for certain activities to be completed, this gives a better time indication for the completion of projects. Feedback loops can be implemented in the workflow, which gives a higher awareness of continuous learning from others and own (im)perfections during the projects.

3.3.2 BPMN

Flowcharts are a way of charting and visualized a business process. This is used to be executed in a step-by-step manner, in which animations can be utilized to increase understandability (White, 2004). The benefits of having a flowchart to give a visual presentation of the process are firstly, the comprehension of the dynamics or complications of a process and secondly, to enable running the workflow with different project types and subjects. The flowchart could thus be used as a method or concept to make a visualization of the workflow or process of the RC, as a universal display for different types of projects with different subjects.

Another part of structure in an environment with many research projects, as for the Research Center of Alliander, is the data or project reports. To provide a structure, data flow diagrams can be used to report the process model of a system (White, 2004). This can increase the awareness of reporting the projects and structuring the data flow of the Research Center.

Business Process Modelling Notation (BPMN) is a language in which the business processes can be notated, described by the Business Process Modelling Initiative (BPMI) (White, 2004). (White, 2004) describes the basics of the notation. Figure 5 contains a short description of the figures in the notation by the BPMI. The BPMN shows a Business Process Diagram which is based on the flowcharting technique, used to create graphical models of business process operations (White, 2004).

BMPN is used to map processes in a universal way, to make sense into the endless ways of modelling tools and notations. The BPMN can be used to make an understandable workflow visualization of the process for the Research Center of Alliander.

Chinosi & Trombetta (2012) discuss the BPMN principles in workflows and business processes in order to enlighten the need of a uniform notation in modeling. A business process is a "set of one or more linked procedures or activities executed following a predefined order which collectively realize a business objective or political goal, normally within the context of an organizational structure defining functional roles or relationships" (Chinosi & Trombetta, 2012, p.126). The BPMN is then used to make this process understandable by business analysts, but also to staff working according to a workflow. Chinosi & Trombetta (2012) describe the components of the BPMN as 4 categories:

- *Swim lanes*
  - Pools
  - Lanes
- *Flow Objects*
  - Events
  - Activities
  - Gateways
- *Connecting Objects*
  - Sequence Flow
  - Message Flow
  - Association
- *Artifacts*
  - Data Object Group
  - Annotation

With the process modeling, the components of a Business Process Model, according to the notation of BPMI, are visually displayed in different icons. Every component has a distinct icon to represent the Flow Object, Connecting Object, Swim Lane or Artifact.

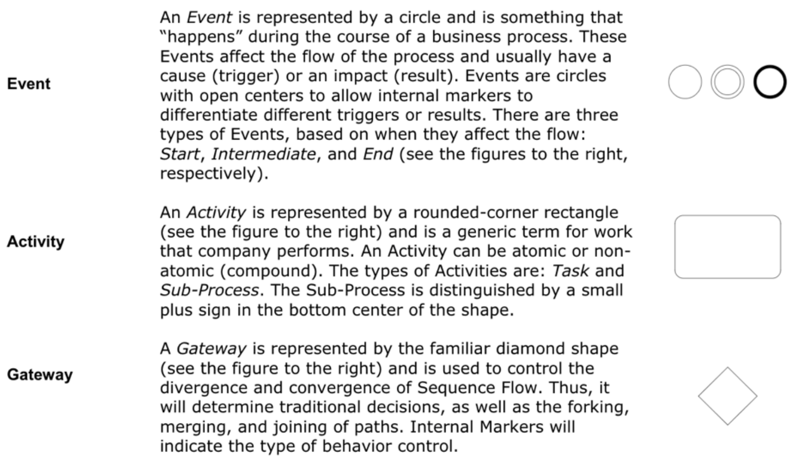

Figure 5 Example of the BPMN (White, 2004)

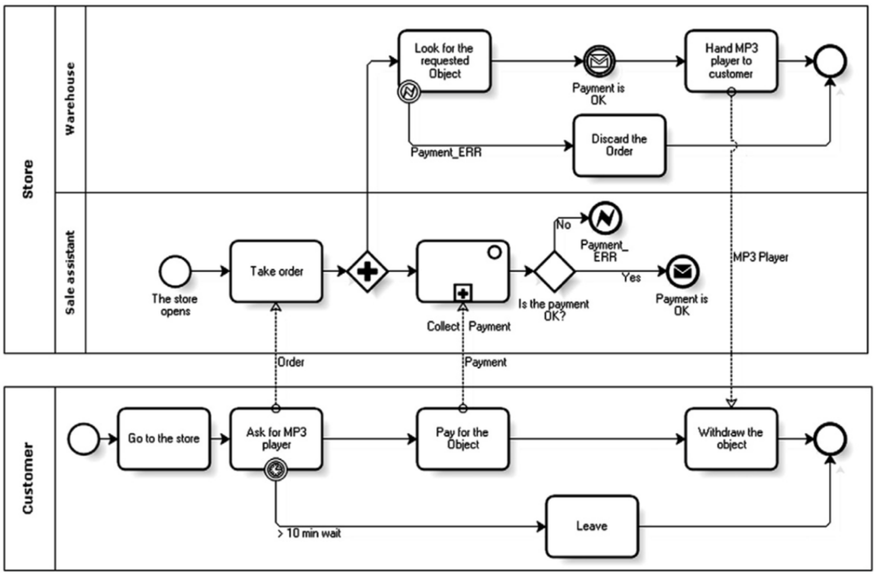

Figure 6 Example of a model notated according to the BPMN as stated by the BPMI (White, 2004)

The Business Process Model represents the full process, by using the Connecting Objects the Flow Objects can be connected. This connects the different Swim Lanes and can give insight in the cohesion of the process components. The artifacts can then be used to structure the process by grouping and annotating Flow Objects and Connections. An example of a business process notated according to the BPMN can be found in Figure 6.

Business Process Modeling can be used to design workflows and other business processes. This can thus be used to make the solution design for the workflow for the RC of Alliander. Which will provide a clear guideline for the research process, with regard to to-be-determined, requirements to the process and the stakeholders.

4 Solution Design

4.1 Introduction

The solution design is made in different stages. The first stage is the determination of the needs and requirements of the design. The second is the consideration of different alternatives. The last stage is the description of the design. In this section, these three stages will be described.

4.2 Needs and Requirements

The information gathered during the interviews resulted in a list of requirements that is stated by the team. Different stakeholders were given the opportunity to provide input, worries and requirements to a potential workflow for the research projects. In
Table **4**, the different requirements are stated and numbered, with an explanation in the third column. The requirements are related to the problems stated in section 2.2.

Table 4 List of stakeholder requirements

Number(s) of corresponding problem	Requirement or need	Explanation
5	Easing the decision about termination of projects	Different stakeholders stress the difficulty of determining whether to terminate projects and when. The termination requirements should be clear and making the decision should be factual and not emotional.
2	Preserve continuity	The continuity should be improved. Projects are not consciously stored for usage, even if the outcome is positive or could have a positive influence in the future. The design should be stimulating the continuity and reflection on projects in the future.
5, 6	Integrate TRLs in process	According to the stakeholders, the TRLs should be used as a reference with which can be communicated what kind of project is done and what development can be expected from the technology.
1, 5	Provide a simplified guideline	The researchers stated that a structured process can help them make conscious decisions about the activities during the research projects.
	Preserve creativity and flexibility	One of the qualities that makes the research process of the Research Center unique is the creativity and flexibility of the research and creating opportunities. This creativity and flexibility should still be possible to a lesser extent.
1, 4, 7	Increase awareness	The design should increase awareness of the process and working towards goals. This is important to be aware of a common goal and keep eyes on the result.
4, 7	Include periodic reflection on both process and projects.	The researchers also indicated a lack of reflection and learning in the process. This reflection and learning are important to improve de process and results.

4.3 Alternatives

In this section, the different alternatives for a solution design are discussed. The solution design is then discussed in section 4.4. The alternatives are different workflows to be considered in the design process. The requirements are used to check the fit with each of the alternatives to eventually select one alternative.

The activities in the solution design differ from the current situation of the process. The requirements of the overall process were stated in the interviews about the current situation and requirements of a solution design.

The different stages of the desired design are determined to be:

1. Determining Project Type
2. Determining Duration and Goals
3. Execution of Project
4. Goals Check
5. Concluding Feedback Session
6. Completion and Storage of Project

These activities are taken into account when making a solution design. However, before a solution design with the mentioned activities can be established, different alternatives are weighted out to each other. For this research, three different alternative design options are discussed. These options all differ in the way the design process is categorized per project. The alternative designs are discussed in the following sections.

4.3.1 Alternative 1: Selection of Best

The first alternative is described as three different designs for different project categories. This means that at the start of the project, the determination of the project type takes place. The determination of the project is based on literature described in section 1.3. Compared to the current process, this is a new addition to the process activities. After the determination of project types, three different workflows can be followed, one for each project type. These workflows are thus specialized for the needs for each project type. The benefit of this design is that actions can be specific. In contrast, the project type first need to be explored, which takes time.

4.3.2 Alternative 2: One Fits All

The second option is a design for all sorts of projects. This is a workflow design, which could be used for all activities in all (program based) projects.

The benefits of one design for different projects is the simplicity of the workflow. There is no need to first determine which workflow to use, but the workflow could be not as accurate as project specific workflows. This could limit the design to a too general workflow design without enough project-specific decision gates.

4.3.3 Alternative 3: Stage Gate Design

The third and last alternative would be different workflows with an included decision-making process. This design would have multiple branches and includes the determination of the project type. The workflow would have a significantly more complex design with more components and decision gates. The branches would describe the workflow for different project types and different decisions made during the different research types. This design is more complicated and harder to use by the researchers and portfolio consultants.

4.3.4 Solution Choice

The choice which solution design is most suitable for the Research Center's projects should be made based on the requirements. The requirements for the solution design are stated in Table 4.

To estimate which alternative would have the highest impact on all requirements stated, a rating is made for every requirement and each alternative. The alternatives are all rated on a scale from 1 to 3 from best to worst for each requirement. This rating is given in Table 5, where the requirements, alternatives and ratings are given, and the average is stated. Based on those numbers, a decision is made to which alternative is chosen. If this approach results in an ambiguous average, the requirements will be weighted, and the average will then be re-calculated.

Table 5 Rating per alternative (scale 1-3 for best-worst fit)

	Requirement	**Selection of Best**	**One Fits All**	**Stage Gate**
1	Easing the termination of projects	1	2	3
2	Preserve continuity	1	2	3
3	Integrate TRLs in process for transparency	1	3	2
4	Provide a simplified guideline	2	1	3
5	Preserve creativity and flexibility	2	1	3
6	Increase awareness	1	3	2
7	Include periodic reflection on both process and projects.	1	2	3
	Average	*1.3*	*2*	*2.7*

Table 5 gives average per alternative on all the requirements. Alternative 1 is rated best overall, with the average closest to 1. This requirement scores best out of the alternatives on easing the termination of projects, preserving continuity, integrating TRLs in process for transparency, increasing awareness, including periodic reflection on both process and projects.

The activities in the workflows for Alternative 1 are specified for a category of projects in the same development phase, this gives the opportunity to describe the activities in more detail than the other alternatives. The Selection of Best alternative scores second on providing a simplified guideline, since it is simpler to work with a One Fits All workflow. It also scores second on preserving creativity, because a One Fits All workflow is less detailed in activity description, which would provide more room for creativity and flexibility than the Selection of Best alternative.

The Selection of Best is the best fit for the requirements overall, therefore, this alternative will be worked out in section 4.4.

4.4 Design Description

This section is divided into the three, separate workflows for each of the three categories, to further design the workflows, and starts with explaining the categorization. These workflows should offer a guideline in the research process and can offer clarity. It also enables a critical research environment, in which goals and reflections become a larger part of the decision-making process. This provides a standard in which research is critically approached and a learning environment is being build.

4.4.1 Categorizing projects according to TRLs

The design execution is dependent on different roles in the process. These roles are given in the Appendix 1, Table 12. The role of feedback partner is new in the designed process. This feedback partner is a sparring partner that is independent from the project, who provide input and determines goals with the researcher.

Before working with one of the three different workflows, the projects need to be classified. The categorization of the projects is of importance, since the process of research projects is complex when the projects have a broad range of different themes and subjects. This complicated the design for the Research Center's process. Therefore, the decision is made to categorize the projects in three categories.

The TRLs are another method to distinguish differences in technologies and categorize the project by technological development. The first three TRLs are the developmental stages from principal research to initial proof-of-concept. These are the different stages in which research is done by the Research Center but are all research on the theoretical side of the technology. Thus, for the activities of the Research Center, the classification of the first category of projects consists of technologies to be researched in TRL 1, 2, and 3. The Category 1 projects are focused on the principal research and proof-of-concept. Category 1 projects can consist of one or more of the following technological development phases:

- Technologies that are not yet developed further than theoretical research done by other research institutions.
- Technologies that are in the transition stage from principal discovery to applied research.
- "Proof-of-concept" of critical functionality by R&D.
- These projects are mainly 'desk' projects where research is done by reviewing existing research.

An example of this type of projects is a so-called "Wizard-of-Oz" experiment concerning voice-activated applications in the field. This Wizard-of-Oz experiment is testing the user's interaction with the speak application in the field. This is done under mechanics, where the researchers play the role of chatbot. In this case, they test the application of the theoretic possibility of the technology, but the technology itself is not developed enough to enable testing.

The second category of projects are projects that are in between the implementation phase and the initial research phase. In practice, this includes finding an application and/or validation for Alliander. This results in a second category. Other technological developmental phases included in Category 2 are:

- Validation of low demands, basic requirements, and an alpha prototype and in a laboratory environment. Project requirements are now important.
- Finding an application for Alliander.
- Comparing requirements of technology in practice of Alliander, or application.
- Showing alpha prototype in relevant environment.

An example of this type of projects is the digital measurement of cables, which can be used in the field to map the exact location of electricity cables placed by Alliander. This technology has a working prototype in a simple environment, and its possibilities are still being tested. The technology needs further development to enable usage by mechanics in the field. Therefore, the technology is not yet ready to be tested in realistic situations but can be developed to meet the requirements. This technology needs to be explored for its opportunities and reported on the developmental possibilities.

The third category of projects are the last phase of development. These are projects with researched technologies that are almost or already implementation ready and are focused on the environmental requirements in a relevant situation. Other research activities in Category 3 projects are:

- Beta prototype demonstration in relevant environment.
- Requirements and regulatory standard checks.
- Certifying component testing or implementing and proving of meeting all the requirements.
- Stakeholder requirements check and updates, demonstration and implementation plan.

An example of a type 3 project is a project regarding the HoloLens. This technology is already developed into a working prototype, that just needs to be developed into a working application for mechanics in the field to use. This augmented reality can help with training mechanics in the field by showing them objects or increasing ease with video calling on the job, to provide remote assistance.

The categories are given in Table 6, with in the first column the categories and descriptions, the second column gives the TRL, and the third column gives the TRL description.

Table 6 Classification by TRL

Category	Level	Description
1 Principal research and proof-of-concept	1	Principal research into the core properties of a technology.
	2	'Invention' of a concept or application for the technology. From principle to applied research.
	3	Initial 'proof-of-concept' of critical functionality through active R&D.
2 Finding implementation and validation for Alliander	4	Low-fidelity validation in laboratory environment. Technological advancement now focused on meeting project requirements.
	5	Validation of basic technology elements in a relevant environment. Test 'set-up' to be of higher fidelity than TRL 4.
	6	High-fidelity 'alpha' prototype demonstrated in a relevant environment.
3 Technology ready for implementation, environmental requirements check	7	'Beta' prototype demonstrated in an operational environment.
	8	Completed component, sub-system or system qualified to relevant project requirements and/or regulatory standards.
	9	Certified component, sub-system or system proven to meet all project requirements through 'real worlds' operation.

4.4.2 Workflow for Category 1 Projects

This is the workflow for Category 1 projects. These projects are usually done on theoretic level, with expansion to finding application possibilities for Alliander. The technologies itself are not yet developed enough to produce working prototypes but can be used as ideas where the application is found and tested, but with the intention of developing the technology or waiting until the technology is far enough developed to use it.

Table 7 gives an overview of the activities and decision gates in Workflow 1. The lanes give the different kinds of activities. Lane 1 gives the research activities, Lane 2 gives the reflective activities, and Lane 3 gives the reporting activities in the process.

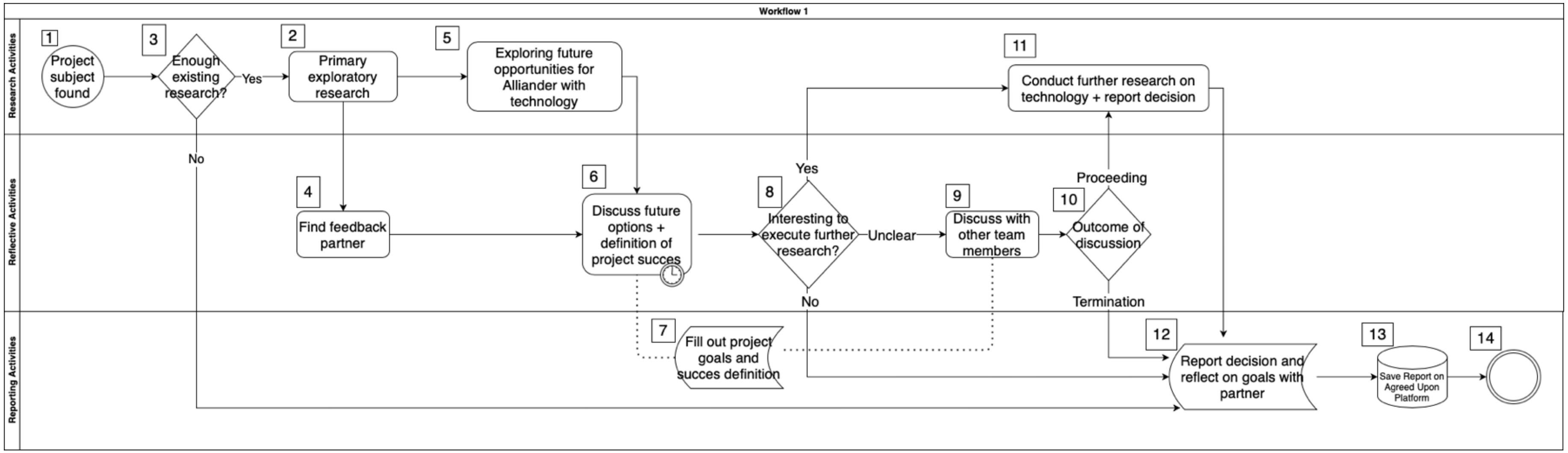

Figure 7 Workflow for Category 1 projects

Table 7 Components in Workflow 1

Number Figure 8	Action	Description
1	Project subject found	After classifying the researchable technology by TRL, the subject is reported.
2	Primary exploratory research	When the subject is clear, the first exploratory research is done. This is to find out whether there is enough information to gather and report about a technology. In Workflow 1, this is the first research into existing research at institutions.
3	Enough existing research?	At this decision gate, the decision is made whether to proceed with the project or not, based on the existing research done and the conversation with the feedback partner.
4	Find feedback partner	During the first exploratory research, the feedback partner is pointed out and with this partner, the goals and requirements of the project are discussed. This gives a reference during the whole project process, especially when making decisions. The definition of success is also determined, so there is one reference to work up to, without
5	Exploring future opportunities for Alliander	If there is enough existing research found in the first activity, the opportunities for Alliander can be explored. It is important that the exploration of opportunities is in line with the goals and success definition.
6	Discuss future options + relation to success definition	The feedback partner is again included in the process in this reflection on the goals and success of the direction of the opportunities. These reflection meetings should take place at least every two weeks.
7	Fill out project goals and success definition.	This is important, because the definition of success and goals need to be reported to enable reflection upon these statements during the process.
8	Interesting to execute further research?	In consultation with the feedback partner, a decision is made to either proceed or terminate the project.
9	Discuss with other team members	If the decision is not unanimous between the researcher and the feedback partner, the team can be consulted to help deciding whether to terminate the project.
10	The outcome of the discussion leads to a	Based on the discussion with the team, a decision is made to proceed or terminate the project. This decision needs to be reported.

	decision to either proceed or terminate	
11	Conduct further research on technology + report decision	The research can be deepened or broadened, based on the opportunities found. The decision to proceed needs to be reported, so when reflected on previous projects, the decision can be read.
12	Report decisions and reflect upon findings	After the last research cycle is finished, the decisions taken during the process need to be reported and findings need to be reflected upon, based on the goals and success definition stated. This is including the success definition and requirements, to see whether they are met.
13	Save report according to data flow	The data needs to be saved according to the (still to be determined) data flow and structure.
14	End of process	

4.4.3 Workflow for Category 2 projects

Workflow 2 can be found in Figure 8. The lanes in Workflow 2 are the same as in Workflow 1. This category projects are focused on the technologies where the technology is developed in basic requirements. This technology can have a first prototype but is not yet developed into a fully working prototype. In Table 8, the components are discussed per corresponding number in Figure 8.

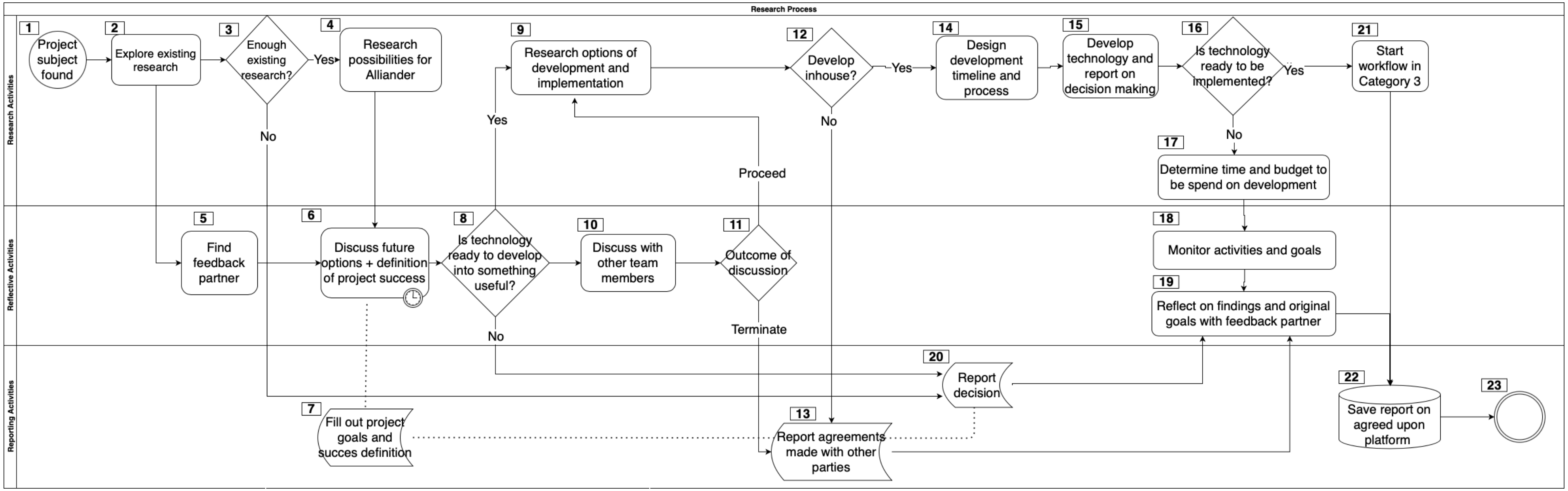

Figure 8 Workflow for Category 2 projects

Table 8 Components of Workflow 2

Number Figure 9	Action	Description
1	Project subject found	After classifying the researchable technology by TRL, the subject is reported.
2	Explore existing research	When the subject is clear, the first exploratory research is done. This is to find out whether there is enough information to gather and report about a technology.
3	Enough existing research?	At this decision gate, the decision is made whether to proceed with the project or not, based on the existing research done and the conversation with the feedback partner.
4	Research possibilities Alliander	If there is enough existing research found in the first activity, the opportunities for Alliander can be explored. It is important that the exploration of opportunities is in line with the goals and success definition.
5	Find feedback partner	During the first exploratory research, the feedback partner is pointed out and with this partner, the goals and requirements of the project are discussed. This gives a reference during the whole project process, especially when making decisions. The definition of success is also determined, so there is one reference to work up to, without
6	Discuss future options + relation to success definition	The feedback partner is again included in the process in this reflection on the goals and success of the direction of the opportunities. These reflection meetings should take place at least every two weeks.
7	Fill out project goals and success definition.	This is important, because the definition of success and goals need to be reported to enable reflection upon these statements during the process.
8	Is technology ready to develop into something useful?	At this decision gate, the technology readiness is discussed, based on the previously done research. This leads to a decision to either proceed or terminate the project, or to discuss further actions.
9	Research options of development and implementation	This step is researching possibilities about the development implementation of the technology. Different options need to be carried out and reported.
10	Discuss with other team members	If the decision is not unanimous between the researcher and the feedback partner, the team can be consulted to help deciding whether to terminate the project.
11	Outcome of discussion	At this decision gate, a decision whether to proceed is made based on the discussion with the team.
12	Report decisions and reflect upon findings	After the last research cycle is finished, the decisions taken during the process need to be reported and findings need to be reflected upon, based on the goals and success definition stated. This is including the success definition and requirements, to see whether they are met.

13	Report on agreements made with other parties	Agreements or deals made with parties when outsourcing the development of the technology is discussed.
14	Design development timeline and process	When inhouse development is chosen, a development timeline and process need to be determined. This is done to properly think out the development goals and timeline, so the process can proceed in a conscious manner.
15	Develop technology and report on decision making	When the development is started, the decisions made during the process need to be reported to make sure that the continuity is preserved, especially when the development is dependent on outside factors.
16	Is technology ready to be implemented?	When the development is done according to plan, the requirements of the technology for implementation are to be met.
17	Determine time and budget for development	If the technology is not yet ready to be implemented, a new plan and budget need to be determined for further development.
18	Monitor activities and goals	During the development process, the activities and goals need to be monitored and requirements need to be checked.
19	Reflect on findings and original goals with feedback partner	After development, reflect on original goals and discuss with feedback partner. Report on the reflection about the process and technology.
20	Report decision	If project is terminated, the decision should be reported and store decision about the technology in current state, so in the future, the reflection can be used to determine interest in technology.
21	Start workflow of Category 3	When the technology is already ready to be implemented, the workflow for the development within Alliander is to be started.
22	Save report on agreed upon platform	When the project is finished, the report, including all the decisions made and reflections done with the feedback partner are reported and stored on the storage platform.
23	End of process	

4.4.4 Workflow for Category 3 projects

Figure 9 gives the workflow for category 3 projects. These technologies in the projects are already developed into a prototype and are ready to be used in a laboratory environment. In the third workflow the emphasis thus lies on the application and implementation of the technology.

Table 9 gives a representation of all the components in Workflow 3, with descriptions at every number corresponding to the numbers in Figure 9.

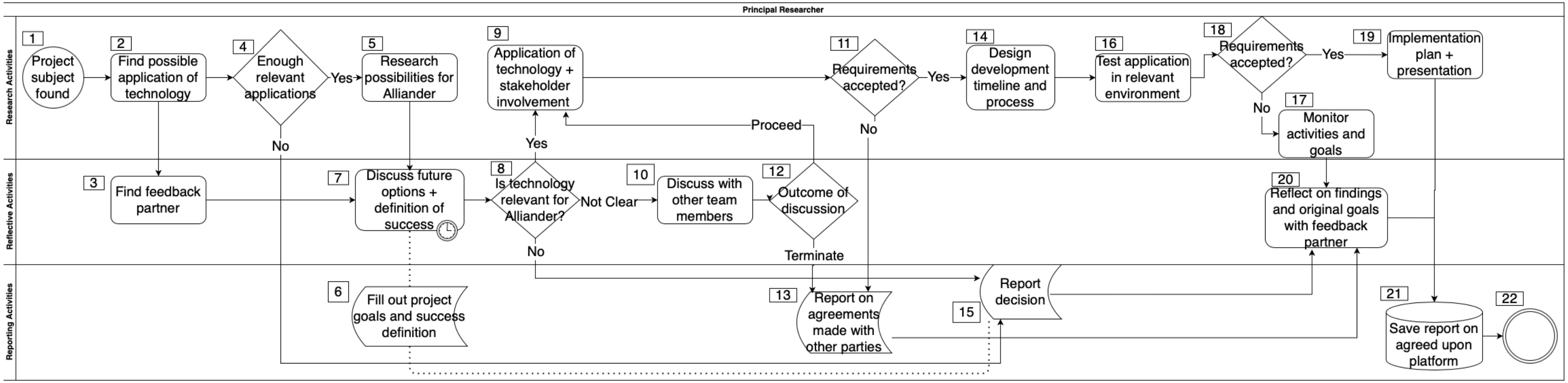

Figure 9 Workflow for Category 3 projects

Table 9 Components in Workflow 3

Number Figure 10	Action	Description
1	Project subject found	After classifying the researchable technology by TRL, the subject is reported.
2	Find possible applications of technology	Category 3 projects are ready for usage and already have a prototype, but the application within Alliander still needs to be determined. Different options of applications need to be explored.
3	Find feedback partner	During the first exploratory research, the feedback partner is pointed out and with this partner, the goals and requirements of the project are discussed. This gives a reference during the whole project process, especially when making decisions. The definition of success is also determined, so there is one reference to work up to, without
4	Enough relevant applications?	If there are enough possibilities found in the first activity, the implementations for Alliander can be explored. It is important that the exploration of opportunities is in line with the goals and success definition.
5	Research possibilities for Alliander	The possibilities for Alliander need to be assessed for their relevance, this can be done by seeing which application is most useful and has the most impact in contrast with the costs or time needed to implement it.
6	Fill out project goals and success definition.	This is important, because the definition of success and goals need to be reported to enable reflection upon these statements during the process.
7	Discuss future options + relation to success definition	The feedback partner is again included in the process in this reflection on the goals and success of the direction of the opportunities. These reflection meetings should take place at least every two weeks.
8	Is technology relevant enough for Alliander practices	In this decision, the relevance of the technology for Alliander is reviewed. If it turns out that the application is not according to the goals and success definition, the project should be terminated.
9	Application of technology + stakeholder involvement	Find out which stakeholders have interest in the application, and what the stakeholders' requirements are.
10	Discuss with other team members	If the decision is not unanimous between the researcher and the feedback partner, the team can be consulted to help deciding whether to terminate the project.
11	Requirements accepted?	If the requirements of the stakeholders and the situation the application needs to meet are met, the project can proceed, otherwise the project needs to be reported.

12	Outcome of decision	If the discussion leads to a positive advice in proceeding with the research, the project can be continued and otherwise should be reported and terminated.
13	Report on agreements made with other parties	Agreements or deals made with parties when requirements by stakeholders are discussed.
14	Design development timeline and process	When inhouse development is chosen, a development timeline and process need to be determined. This is done to properly think out the development goals and timeline, so the process can proceed in a conscious manner.
15	Report decision	When the project is not continued, report on findings, so continuity is preserved.
16	Test application in relevant environment	The application needs to be tested in a relevant environment to make sure the technology is suitable for the implementation at Alliander.
17	Monitor activities and goals	The implementations and goals need to be monitored.
18	All possible?	If the technology testing has a positive outcome, the implementation phase can begin.
19	Implementation plan + presentation	The implementation plan and presentation need to be done to implement and enable change for the new technology.
20	Reflect on findings and original goals with feedback partner	Report the findings on the new technology, the proceedings from now on and reflection on the process and goals with feedback partner
21	Save reports in agreed upon place	When the project is finished, the report, including all the decisions made and reflections done with the feedback partner are reported and stored on the storage platform.
22	End of process	

5 Validation

The solution design is both validated by the stakeholders, through interviews, and checked with the requirements that were stated.

5.1 Stakeholder Interviews

To validate the design, the alternative for the design is presented to the different stakeholders. The stakeholders were interviewed by stakeholder group, so that every stakeholder could provide feedback to the design ideas. The stakeholders gave insight in the values and usability of the workflow design. The three groups interviewed were: portfolio consultants, team leaders and researchers. The interviews all were one hour, where the core elements, the integration of feedback, and the eventual design were discussed. This resulted in validation of the requirements and input in the implementation plan.

The portfolio consultants were mostly interested in the communication to stakeholders outside of the Research Center. They were positive about classifying the projects into three categories, based on TRLs. It should lead to an easier way to explain the technology's development to others. Therefore, it could give insight in the determining value for the Research Center's projects. In addition, the portfolio consultants are positive about the introduction of feedback cycles but are still looking for the best way of providing the feedback and the format of the feedback session. They also think that the feedback partners could provide a reflection without the emotional side of the research, which leads to critical thinking and awareness of the result.

The researchers were positive about the structure of the workflow. They think that a workflow like this could increase the awareness of the decision-making in the research projects. The feedback partner was received as a nice proposal and quickly thought along to the feedback partner as being someone that was not as close to the research, and thus could provide an honest reflection to the process and the research. Since the researcher actually have to use the workflow, their input is important. They agreed that the workflow could help them find a more uniform way of the research process and enable the conscious decision-making process. They, however, were worried about the storage part of the workflow is not yet well defined within the team. Still, they think with including it in some form, the team could take steps to improve the continuity within the team and provide a database with all the projects. This is needed to make sure the projects are used, and they see that, but also know that it still needs work to improve it. By including it in the workflow, the need for a storage is made clearer.

The team leaders were also positive in having a structure and agreed that there were still things to be done before it could fully implement the workflows. They were positive about the inclusion of regular feedback sessions in the way that this was included in the workflows. They were, however, also hesitant in the detailed description of how these sessions were going to take place in the daily activities. They could see that there is a possibility of providing trainings in feedback and reflection, which could help the members of the team to improve the engagement in those activities. Besides for the implementation, the team leaders think that this gives more insight in the activities of the Research Center.

5.2 Requirements Check

The requirements are checked for the solution design. This check is shown in Table 10 where is checked whether every requirement is met. The explanations on whether the requirement is met is found in the fourth column of Table 10.

Table 10 Check per Requirement

Number	Requirement or need	Solution Design Check	Explanation
1	**Easing the termination of projects**	✓	The termination of projects is easier, since a decision gate model is included in the workflow. The inclusion of stating the goals in the beginning of the workflow, which gives perspective for the rest of the process. When the activities are not leading towards the goals anymore, there will be less discussion on whether to terminate or proceed with the project.
2	**Preserve continuity**	x	Is not yet met with implementing just this workflow. To meet this requirement, a more elaborate research needs to be done in the sense of storage and data bases. This is something that should be done to use this workflow as optimal as possible. This will be further discussed in section 7.2, the recommendations.
3	**Integrate TRLs in process for transparency**	✓	The TRLs are used to classify the different projects into one of three categories. These categories can be used for communication to outside stakeholders and to further explain the workflow from the day the project starts.
4	**Provide a simplified guideline**	✓	The workflows for each category give a simplified guideline, which the researcher can use. The activities in the workflow can be followed and this provides the structure the researchers were looking for.
5	**Preserve creativity and flexibility**	✓	The creativity and flexibility are still possible, since the activities are not defined in the finest detail. This gives the opportunity to be flexible and work according to own creative processes.
6	**Increase awareness**	✓	The awareness about decision-making and the process workflow is increased, since the projects are firstly categorized and then the goals are determined before starting the research. This results in a consciousness around the research goals and decisions made during the process.
7	**Include periodic reflection on both process and projects.**	✓	Reflection is used in this design to learn and innovate the process according to findings during the research. The reflection style still needs to be formed and established.

Except for preserving continuity, every requirement is met with this design. It is accepted that this requirement is not met, since this is dependent on outside factors. The overall conclusion is that the solution design is validated.

6 Implementation Plan

In addition to the solution design, an implementation plan is worked out. To enable implementing an implementation plan needs to be presented to the Research Center from which they can take action to implement working with the workflows. This implementation plan is divided in three phases. The first phase is the preparation, the second phase is implementation, and the third phase is the monitoring phase. The phases and actions are described in Table 11. The table gives the activities per phase in the implementation plan, which could be used by the Research Center to implement working the workflow designs.

The implementation should be done gradually, by starting to use the workflow designs at the start of projects. Thus, the 4 weeks term of the implementation phase, should be extended when the four weeks are not enough time to implement the workflow in at least multiple projects. These projects are then monitored during the monitoring phase, which are just focused on the projects working according to the workflows.

Table 11 Implementation check in different stages

Phase	Objectives	Actions	Communication	Duration
Preparation	During the preparation phase, members of the team are informed and prepared for change. The workflows are presented and made sure that they are understanded. The members are prepared for change. After the preparation phase, the implementation can begin.	• Determine change management style. • Prepare forms to fill out during projects including goals, decisions and results. • Determine which projects can be started with using the workflows. • Prepare database for project storage.	• Informing the team members. • Present the workflows.	2-3 weeks
Implementation	During the implementation phase, the workflows get implemented. The implementation of the workflows needs to be supervised and there needs to be room for questions. It is important that the team keeps communicating about the process, so that possible problems with the workflow.	• Start working with the workflows during the process. • Monitor the implementation of the workflow and usability by the team members. • Fix possible flaws. • Database for projects should be used correctly.	• Make sure forms (start and goals) are used correctly. • Have a reflective meeting about implementation	4 weeks/ dependent on the number of projects started as pilots
Monitoring	This stage begins when every member is confident about working with the workflows and understands the importance of using it. It also is the phase where the monitoring of the activities and making sure that the workflow is followed is most important.	• Monitor activities and struggles. • Secure storage and methods of documenting.	• Engage in the conversation about the process.	Depending on the number of problems occurring and/or resistant by researchers.

7 Conclusions and Recommendations

7.1 Conclusions

This design study started with an initial problem statement by the Research Center. The problem was described as a missing of a method to assess technology readiness during the research projects for Alliander. This would help improve the success chance of the Research Center and help explain the value of the projects. The possibilities of technology readiness level development were firstly explored in literature, where the TRLs by Altunok & Cakmak (2010) and Mankins (1995, 2009). This however, lead to the finding of a literature gap, where the TRL literature is not expanded to process requirements, before enabling development. Therefore, a problem analysis is conducted to find the core problem for this research.

When analyzing the initial problem and situation, a stakeholder analysis and problem mess were made to look into the situation and problems in the Research Center's process. During interviews and observation, another problem came to light: the lack of a structure in the research process resulted in more problems than just not having a method to assess technology readiness. The relations between multiple problems found in the problem analysis stage, were then worked out in a problem mess, and the stakeholders involved in the problems were also analyzed. This analysis resulted in a decision for a core, revised problem, which is "the lack of structure during the research projects".

The research questions formulated for this thesis research were: "How could the Research Center set up their process when conducting research projects based on scientific methods?". The sub questions were:

- How can TRLs be included in the research process of the Research Center?
- How can conscious decisions about terminating project be included in the workflow?

This problem is classified as a workflow problem. There is a need for a guideline that can be used by the researchers and portfolio consultants to structure the research process.

A workflow approach is chosen where the projects are firstly classified by TRL categories, especially made for the Research Center's projects. In designing this workflow, a BMPN method is used (White, 2004). Then, three different workflow designs are worked out. The solution designs are then checked relative to the requirements and the research questions can be answered.

The research question “How could the Research Center set up their process when conducting research projects based on scientific methods?”. Can be answered with the solution designs made for the three different project categories. In addition, the classification of the TRLs is part of the solution, to enable communication of activities to other parts of the company.

The first sub question “How can TRLs be included in the research process of the Research Center?” is answered by the integration of TRLs in categorizing the projects or technologies. The TRLs can be included in the process by using TRLs as a categorization tool, with different workflows for each of the three determined categories. The categories are principal research and proof-of-concept, finding implementation and validation for Alliander, and technology ready for implementation + environmental requirements check. The classification can be used to determine which one of three workflows should be used during the project and to determine the goals.

The second sub question “How can conscious decisions about terminating project be included in the workflow?” is answered by the inclusion of careful determination of the goals of a project at the start of the projects, to which can be reflected during the research project. This enables making decisions about the termination of projects. This is included in the workflow as decision gates at which point the researcher needs to think about the proceedings of the project.

There are a few limitations to this research. The first is, since this is a new team, the practices change over time, if a newer or better way of working or organizing is found. These are slide changes, but without documentation, there is a chance that the research done is not usable over a longer period of time.

There also is the fact that this research is entirely done during the COVID-19 lockdown. This means that the research process could not be followed life, all the information gathering was done through video meetings. This can limit the overview on the process and could result in a discrepancy with the actual process. However, all steps are validated by team members, to limit the chance of this happening.

A third limitation is that the literature found on the implementation of workflows in combination with TRLs is not available. This gives a lack in previous research done about the subject in other companies or sectors and limits the conclusions to Alliander only. A future research opportunity could be to expand the research to other companies or sectors.

7.2 Recommendations

There are some aspects in which the Research Center has to improve before the structure of the workflows can be optimally implemented. First, the feedback loops require critical reflection on both the process as the research. Therefore, a method of feedback and reflection needs to be found. It is recommended to let the whole team participate in a workshop to improve the feedback giving and receiving skills and learning about the personal preferences of team members. The information can then be used to find a structure for reflection upon the projects and providing feedback to team members. It is important to explain the relevance of giving and receiving feedback, and to provide the opportunity to learn from each other and a professional. This workshop can be given by an external party, there are multiple companies that provide specific workshops, or by an internal professional with experience in providing workshops about feedback and reflection. The team can decide which option it prefers and should choose the person that fits them best.

Secondly, the implementation of the workflow designs in this research needs supervision. The activities need to be monitored and controlled. To provide the structure needed, the workflow needs to be supervised by one person. Since the Research Center is a somewhat self-managing team, it is recommended that the person that supervises the implementation is to be chosen, before the implementation starts. It is recommended to determine the responsible person before starting the implementation plan. The team then also needs to decide whether this person is the same person that is supervising the implementation phase, but it is recommended to appoint a supervisor to every phase of the implementation plan. This needs to be done before starting the implementation of the workflows. In addition, the team needs to make sure that the supervisor is interested in and makes sure that the change in process is actually done, it is seen in the past that implemented structures slowly fade with time, and the eye is taken of the monitoring. Therefore, the monitoring phase, and the appointing of a supervisor is especially important.

Thirdly, the continuity of the Research Center should be an important issue. The projects are not stored in a uniform way on a single platform, in a way that in the future, there can be learned from the projects and technologies. The projects and decisions should be stored completely, clearly and in the same place. The names of files stored should also be uniform, so old projects can be found and learned from. It can also be used to reflect on the past projects periodically, like every quartile. Therefore, it is recommended to make decisions on which storage platform will be used and design, and make sure that it is understood by every team member. This platform and format of the storage is to be determined and is of importance, so it is recommended to make sure this is done properly and before starting the implementation plan.

After implementing these workflows, the focus can be redirected to developing a Technology Readiness Assessment. With this structure, the relevant data about the projects can be collected and company or division specific requirements per level can be stated.

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Appendix

Interview Questions Researchers/Team leaders:

- When is a project successful?
- How do the goals get determined?
- Do you follow some kind of workflow?
- How do you process the results and where are they documented?
- How can this be improved? Do you have other requirements?
- Who is responsible for implementation/monitoring of the research process?
- What is done with project in the long term?
- How can the Research Center be improved on one of the points discussed?

Interview Questions Innovation Circle:

- What are the goals of the innovation circle?
- What is the purpose of the Research Center in your eyes?
- What does the innovation circle focus on in terms of technologies?
- How do you keep in touch with the different places where research is conducted?

Table 12 Roles in workflow

Role	Description
Specialists	Still offer their research skills and knowledge to execute the research. But include another mind called the "feedback partner" as second opinion on the projects.
Feedback partner	Can be anyone from the team, but it is recommended by both specialists as portfolio consultants that it is someone that can provide a critical reflection on the projects and thus should not be someone that has the same role or is taking part in the same research program as the principal researcher.
Portfolio consultants	Are an included helicopter view in the processes, with a critical view on the matter. The portfolio consultants can be included in the process as feedback partner.
Team leader	The team leaders can be included into the research process as feedback partners but are mainly occupied by other activities. The team leaders can be included as they please by providing feedback and their opinion.