APPLICATION OF AGILE PROJECT MANAGEMENT METHODOLOGY IN R&D TO ENSURE THE SAFE AND SUSTAINABLE DISPOSAL OF LEGACY WASTE

W. WACQUIER
ONDRAF/NIRAS
Brussels, Belgium
Email: w.wacquier@nirond.be

J. DENUL
Threon
Ghent, Belgium

Abstract

ONDRAF/NIRAS plans to build and operate a surface disposal facility for low-level radioactive waste in Dessel (Belgium). On 16 May 2023, the Royal Decree issuing the creation and operating licence needed to realise the surface disposal facility in Dessel was published. The construction of the disposal facility can start in 2024, and the first radioactive waste will be disposed of within a few years. The license (and the safety report) set the conditions that the waste must respect to ensure a sustainable and safe disposal. Besides radiological limits, physicochemical criteria are also defined. Indeed, the waste cannot unduly affect the performances of the Engineer Barriers that play a major safety function and cannot perturb the expected evolution of the disposal system. One of the main challenges is to ensure the disposability of legacy waste, which is a complex challenge with many uncertainties and high risks. For this kind of challenge, ONDRAF/NIRAS adopted an AGILE project management methodology in order to incrementally develop solutions, allowing a safe and sustainable disposal of this waste. With this methodology, we were able to speed up the process from idea to first solutions that enable the disposal of sufficient waste to allow the operation of the surface disposal facility to stay on track. These solutions will be further improved and expanded in order to keep the highest levels of safety standards. The paper describes the six key elements of our AGILE project management methodology in R&D and its application, illustrated by four examples.

1. INTRODUCTION

1.1. The surface disposal facility

ONDRAF/NIRAS, the Belgian Agency for Radioactive Waste and Enriched Fissile Materials, is responsible for the management of all radioactive waste on Belgian territory. ONDRAF/NIRAS plans to build and operate a surface disposal facility at Dessel for category A (conditioned low-level radioactive waste). On 16 May 2023, the Royal Decree issuing the creation and operating licence needed to realise the surface disposal facility in Dessel was published [1]. The next steps are the start of the construction and the operation of the disposal facility within a few years.

In the considered disposal concept, radioactive waste is emplaced and grouted in concrete standardised disposal packages called monoliths. The monoliths are subsequently positioned and stacked within concrete modules. The modules stretch over two areas – one of 20 and one of 14 – that will be covered in a later stage by a multi-layer cover to form a tumulus. The currently considered disposal concept is schematically depicted in Figure 1.

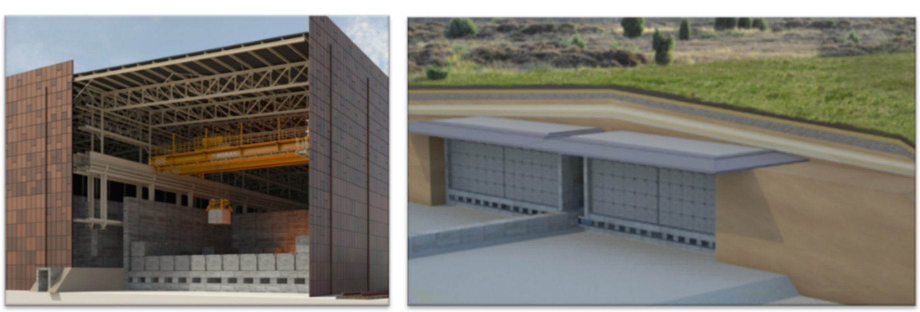

FIG. 1. Concept of the surface disposal facility.

1.2. The admissibility programme

The waste that will be presented for surface disposal must comply with the requirements and conformity criteria that are laid down in the creation and operating license and/or in the safety report [2], including their changes through the modification process. Besides the radiological limits, specific physicochemical criteria were defined so as not to jeopardise long-term safety. The waste should not have a negative impact on the Engineered Barrier System (EBS). Hence, limitations were defined for the chloride content (i.e., corrosion of the rebars) and sulphate content (i.e., concrete attack). Also, processes that can lead to the waste's expansion must be avoided during the period during which we rely on the physical integrity of the EBS. Hence, the concrete (waste and immobilisation matrix) should be insensitive to ASR (Alkali-Silica-Reaction) and DEF (Delayed Ettringite Formation) reactions that could lead to a potential swelling of the waste. Since the waste should also not lead to a significant increase in radiological impact due to leaching, limitations were defined for the chloride content and cellulose content. In order to confirm that category A waste (i.e. future and legacy waste) meets the various conformity criteria, the waste will have to undergo an admissibility process [3]. The admissibility process is illustrated in Figure 2.

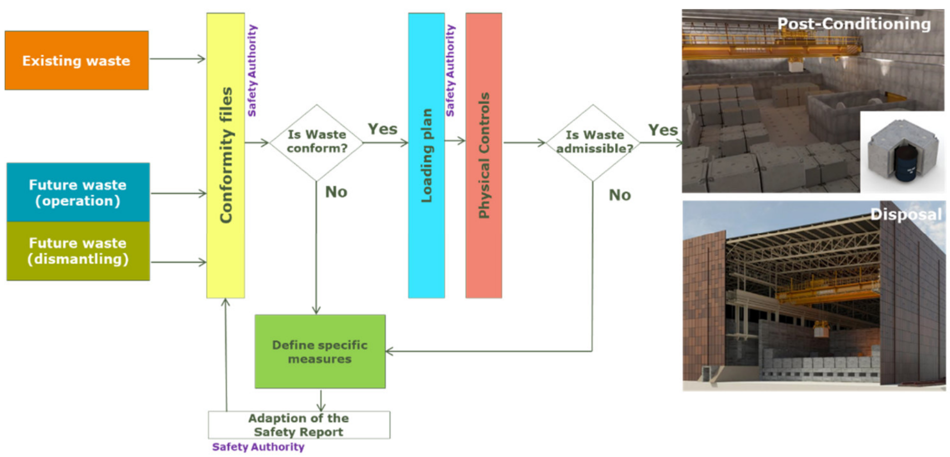

FIG. 2. The admissibility process

The main projects of the admissibility program are the establishment of conformity files to evaluate the conformity of both the future waste and the legacy waste, the establishment of the loading plan, the realisation of complementary tests through destructive techniques (DT) and non-destructive techniques (NDT) to confirm the conformity of the waste, as well as different R&D studies to discover and develop solutions for non-compliant waste.

2. THE AGILE PROJECT METHODOLOGY

Although the AGILE project management methodology in R&D is strongly inspired by the Manifesto for Agile Software Development [4] (hence the name: AGILE), it relies on approaches in R&D that go much further back in time. Takeuchi and Nonaka [5] described how, in the late 1970s and early 1980s, they observed a new approach to new product development emerging independently in 8 multinational companies. Many of the principles and practices have origins beyond software development. Hence, an AGILE approach to R&D outside software development is more logical than many would suspect.

In essence, the AGILE project management methodology in R&D combines the Incremental Platform Design approach to big challenges [6, 7] with a teamwork-enabling approach to leadership [8, 9] and a management approach focussed on flow in knowledge work [10, 11]. We refer to the mentioned references for a deeper understanding of the underlying concepts.

In 2019, ONDRAF/NIRAS decided to apply an AGILE project management methodology in the admissibility programme. ONDRAF/NIRAS wanted to apply certain principles of the AGILE methodology for critical, complex and transversal projects and programmes with many uncertainties and high risks. The aim was to break down these big complex challenges into smaller manageable questions to be tackled in short iterations. Over the past four years, we worked out and fine-tuned an AGILE approach to R&D, considering the specific content (e.g., specific challenges in the execution of tests and analysis) and context (e.g. the regulatory context). We identify six interrelated elements of this approach:

(1) Slicing and decoupling of problems
(2) Incremental discovery and delivery
(3) Learning by doing
(4) Risk management with options
(5) Nested feedback and learning loops
(6) Team autonomy within clear boundaries

Although we explain and illustrate these elements separately, it is essential to realise that, in practice, there is a very dynamic interplay of all elements. This dynamic interplay reinforces each element.

One of the first steps in tackling complex challenges in our AGILE approach to R&D is breaking up the seemingly interconnected tangle of challenges. Although this activity, which we call slicing, is a crucial starting point, we redo this activity regularly as new insights and a better understanding of precedence, dependence, and other relations between problems and potential solutions emerge. The key to slicing is to identify small enough parts of the bigger challenge for which we can envision a possible solution. The goal is not to get this perfectly right. The goal is to identify a small enough initial challenge to start working on. Through the subsequent learning loops, we will learn quickly. After several learning loops and regularly redoing the slicing activity, we end up identifying a partial solution that tackles a part of our big challenge.

The second key element in our approach is incremental discovery and delivery. As we start working on a small enough initial challenge (identified through slicing), we concurrently develop possible solutions and initiate studies and experiments to gain a deeper understanding of the problems. Through this divergent discovery activity, we identify multiple options and possible solutions for some of the identified problems. We then start the convergent delivery activity by combining different options and assessing the partial solutions that emerge. As multiple small enough challenges (aka slices) evolve through the divergent discovery and convergent delivery activity, we incrementally create a concept solution for a part of the big complex challenge we face. Throughout this process, we organise informal feedback loops with external stakeholders parallel to the internal feedback loops (as described below). We keep this external feedback process informal as there is too much uncertainty to initiate the formal modification process. As we progress through incremental discovery and delivery, we get sufficient certainty to start the formal modification process with the safety authority.

As slices move through incremental discovery and delivery (both in parallel and sequentially), new problems and possible solutions emerge. Simply put, we learn. Much of our AGILE approach to R&D aims to improve the economies of learning. Two factors help improve this:

(a) The slices must be small enough to move through discovery and delivery quickly. This is achieved by combining our AGILE approach's first two key elements.
(b) The discovery and development activities must primarily rely on doing and not just thinking, theorising, calculating, etc. This means we must make, build, or construct to visualise ideas, make them tangible and test them. We achieve this with a mix of physical mock-ups and prototypes and virtual modelling and simulations. This is the third key element of our approach: learning by doing.

The fourth key element is risk management with options. The incremental reduction of uncertainty as slices move through incremental discovery and delivery already contributes to risk management. However, from a risk management perspective, it is important how the multiple small challenges (aka slices) are chosen. The aim is to identify carefully thought-through options that sufficiently cover a priority risk. This relates to the concept of real options for technology investments [12, 13], but in the case of ONDRAF/NIRAS R&D, the emphasis is on reductions of uncertainty and risk instead of monetary value.

The first four key elements of our AGILE approach to R&D describe critical elements of our way of working without providing a clear process description. The fifth and sixth elements of our approach do provide a clear framework enabling the teams and the steering committee to operationalise our AGILE approach to R&D. We consciously keep this framework "high-level" in the sense that it describes (and prescribes) the immutable elements while leaving room to determine specific details of the operational approach depending on context and content. Figure 3 illustrates this high-level process framework in which we combine nested feedback and learning loops with team autonomy within clear boundaries.

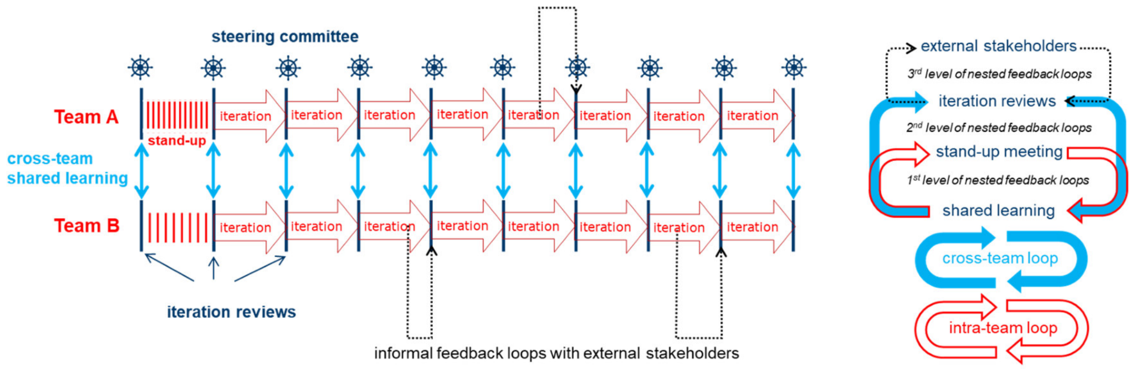

FIG. 3. The process framework with iterations, stand-up meetings and iteration reviews linked to the nested feedback loops

There are nested feedback and learning loops at three levels:

(a) The formal short feedback and learning loops within a team provide the heartbeat. Depending on the content and context, there are 1 or 2 so-called "stand-up" meetings per week where all team members share what has changed since the previous stand-up. These changes can be results, activities, insights, and especially obstacles to progress.

(b) The second level of feedback and learning loops is created by formal iteration reviews that occur every 4 to 6 weeks (depending on content and context). At this iteration review, all teams share their consolidated knowledge with the steering committee and other teams. This creates a cadence of powerful shared learning with the possibility of steering based on emerging knowledge. In between iteration reviews, we have an iteration that does not only establish a time boundary but also a scope boundary. This brings focus (during an iteration) while leaving room for much flexibility (between iterations).

(c) The third level is less frequent and less formal. As we incrementally create concept solutions for parts of the big complex challenge, we organise informal feedback loops with external stakeholders. Any feedback and learning from this third loop is tied into the formal loops during iteration reviews.

The iterations and iteration reviews also create the perfect framework for giving the teams autonomy within boundaries. Next to a shared learning function, the iteration reviews also provide the intervention points where the steering committee can steer. During iteration reviews, the steering committee determines "what" needs to be delivered (by deciding, making choices, and setting priorities) and can set boundaries on "how" the team can work out the deliverables. Within those boundaries, the teams are fully empowered to find ways to reach the priority objectives as quickly as possible. The "how" mainly falls within the team's autonomy, while the decision-power on "what" always remains with the steering committee. During an iteration, every team works fully focused independently of other teams.

3. APPLICATION

The admissibility programme is a large and transversal programme within the organisation. ONDRAF/NIRAS wanted to apply an AGILE approach to reduce the risks and the uncertainties. The following sections illustrate this methodology's application for the admissibility program's main projects.

3.1. Establishment of conformity files

The key issue for the establishment of the conformity file is the knowledge of the waste in order to assess the conformity of the waste. For future waste, the waste acceptance system of ONDRAF/NIRAS is currently evolving in order to integrate the new requirements and criteria set by the license, allowing the collection of all relevant information. For the legacy waste, the challenge is to fill in the missing information since the waste was accepted according to the rules valid at the time of their production, which did not consider the new criteria.

Based on the available knowledge, a slicing of all the waste packages was performed in three steps:

— for the first 20 modules exclude the waste packages that are the least likely to conform to the requirements (e.g. old historical waste with very limited information);

— categorise the legacy waste based on waste producer and potential non-conformities;
— identify the legacy waste expected to conform easily for the first conformity files.

Once the priorities were clear, we started making the conformity files, completed the missing data and started discussions with the safety authority.

This illustrates how the slicing and decoupling of problems in our AGILE approach enabled us to start working on conformity files despite the complexity of the complete set of legacy waste. We also identified the top priority for the potentially non-compliant waste: the development of a solution for concrete potentially sensitive to ASR/DEF (See § 3.4) [4]. This also illustrates the power of learning by doing.

3.2. Establishment of the loading plan

Taking into account the waste selected for the first 20 modules (See §3.1), the question is now how to load the modules taking into account the production of the waste (most of the waste will come from the dismantling of the nuclear power plants foreseen in the coming years) and the characteristics of the waste in order to respect the requirements and rules defined in the safety report.

To tackle this issue, a first loading plan was made "by hand" with a spreadsheet application. The main parameters were the production period of the waste and radiological data to ensure a homogeneous loading of the modules. Through this "manual" work, initial scenarios were defined in order to develop a loading strategy. We started developing a more robust IT tool parallel to the "manual" work. The IT tool was developed in close collaboration between the users and the IT team in full AGILE mode. The complete set of specifications was not defined at the beginning. We knew the global objective and the functionalities we wanted to achieve (such as calculating the radiological impact of a group of four modules). The tool was developed incrementally, step-by-step delivering and optimising the functionalities according to their priority. The end-users directly used every incremental version of the IT tool to get concrete results to develop the loading strategy (See Figure 4). Validation and use of this IT tool happened entirely in parallel.

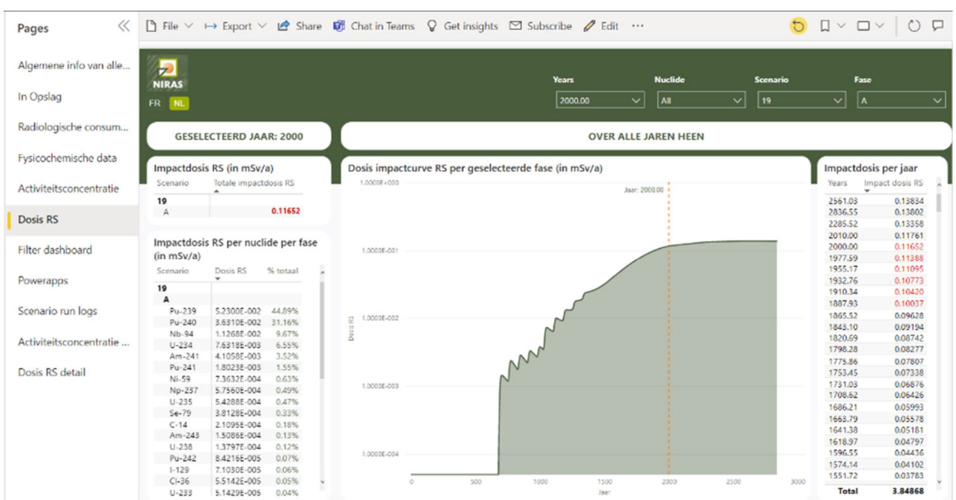

FIG. 4. Screenshot of one of the functionalities of the IT tool (specifically: calculation of radiological impact)

From this application of the AGILE methodology, we learned that establishing detailed technical specifications is not a prerequisite to starting the development of an IT tool. Development could start faster than expected, and we could also start using initial increments of the tool much faster than expected. This was only possible because of the close day-by-day collaboration of users and developers.

This illustrates the power of incremental discovery and delivery.

3.3. Realisation of DT/NDT

The conformity files (See § 3.1) address the conformity of the waste. To confirm the admissibility of the waste, it is also important to perform independent and complementary controls. The number of controls to be done depends on a risk matrix (what is the risk of exceeding a criterion considering the uncertainties, and what is the level of confidence we have in the data?). For future waste, the waste acceptance system of ONDRAF/NIRAS will integrate complementary controls at the level of the non-conditioned waste. For the legacy waste, the controls must be performed on already conditioned waste through non-destructive or destructive techniques. To realise these controls (and the characterisation of the historical waste to fill in the missing information), ONDRAF/NIRAS intends to build a DT/NDT building.

To gain knowledge to design an adequate concept of the DT/NDT building, ONDRAF/NIRAS decided to launch with BELGOPROCESS a pilot project using the existing installation and techniques. 11 legacy waste packages were selected in the high-priority legacy waste and were submitted to non-destructive and destructive controls allowing to build knowledge not only on the techniques needed for these controls on an industrial scale, but also on the nature of the legacy waste (See figure 5).

FIG. 5. Pictures of learning by doing in practice: building up knowledge about destructive techniques

Although this pilot project is still ongoing, it is already clear that we are learning much more than we initially expected. This again illustrates the power of learning by doing.

3.4. R&D studies to discover and develop solutions for non-compliant waste

As an illustration of the approach for R&D studies, we will describe the study of solutions for waste disposal with a risk of expansion due to ASR/DEF. As mentioned in §3.1, this was identified as a priority challenge early on.

There are mainly two main streams for this waste. The concrete waste already conditioned and stored in 400L waste packages will be placed in Monolith Type I (4 packages in one monolith), and the concrete waste arising from the dismantling of the nuclear power plants in the coming years will be directly post-conditioned in Monolith Type III (bulk waste in one monolith) - See Figure 6. This waste is potentially sensitive to ASR/DEF, and specific measures have to be taken to ensure a safe disposal if the risk is confirmed.

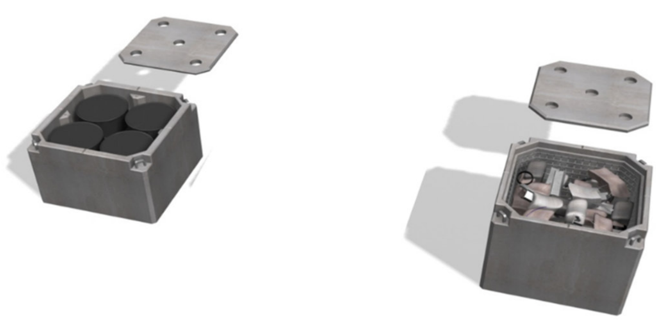

FIG. 6. Concept illustrations of two types of monoliths for disposal of different types of waste

Brainstorming sessions were organised in order to generate many ideas. Based on the brainstorming, we selected a preferred option: using a compressible PE material inside the caisson. However, to demonstrate the long-term safety of this option, long-term R&D studies must be performed (potential degradation of the material? impact on the sorption?). In order to accelerate the development of a solution, ONDRAF/NIRAS decided to also work on other options using inert material (such as steel or carbon). For all options, conceptual prototypes will be made and tested even if some alternative options currently (with our current understanding) seem sub-optimal (e.g. more challenging to make, more costly, etc.). Through the proof-of-concept testing of these multiple options, we want to show as quickly as possible to the different stakeholders that the safe disposal of this kind of legacy waste is, in principle, possible. An illustration of the different options is shown in Figure 7. For each of these three options, we intend to simulate and test the expansion of the waste in order to learn and further improve the development of the solution for potentially expanding waste. As a reference option, the expansion of the simulated waste will be achieved by using Betonamit® (a non-explosive cracking agent). However, in order to be able to gather detailed expansion and pressure data, we also started tests using inflating cushions. In short, we keep as many options open as possible to maximise the chances of success.

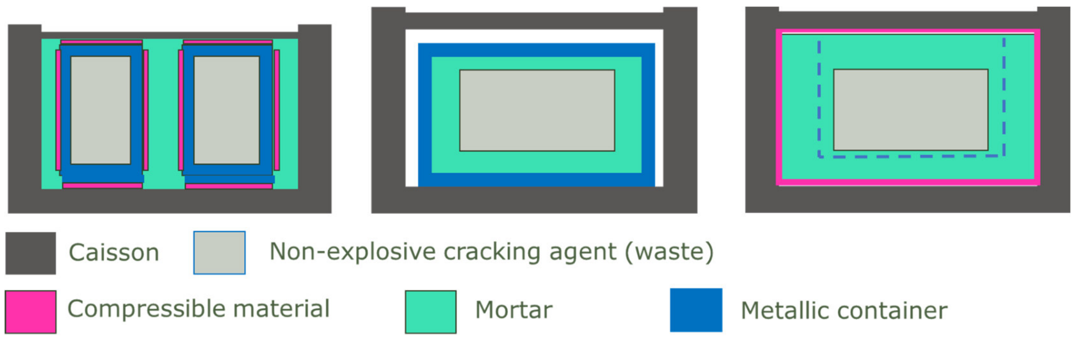

FIG. 7. Concept illustrations of three options for solving the risk of expansion due to ASR/DEF

This illustrates another key element of our AGILE approach: risk management with options. In this ASR/DEF study, we also learned how to slice a problem into small pieces and learn by doing. We also slice and organise our R&D projects in order to obtain quickly first preliminary results in incremental steps in order to reduce as soon as possible the level of risks and uncertainties [15]. This again illustrates how the different key elements of our AGILE approach dynamically reinforce each other.

4. CONCLUSION

Over the past four years, as we worked out and fine-tuned an AGILE approach to R&D, taking into account the specific content and context of ONDRAF/NIRAS, we discovered many advantages:

- This approach allows for a combination of focus and flexibility.
- There is so much more learning in so many ways. There is more and faster learning at the individual level. There is also more shared learning at the team level and across different teams (within the same program). Also, the managers and stakeholders in the steering committee gain a deeper understanding more quickly. This results in faster and better decision-making. This also helps us to stop or reorient our R&D studies quickly.
- Our AGILE approach to R&D also helps to avoid being overwhelmed by the enormity of a big complex challenge. Although solving the complete challenge may still take many years or even decades, the AGILE approach helps us to get started.
- The slicing and identification of carefully thought-through options changed our perspective on managing R&D projects and programs. We changed our mindset from "efficient project management" to "how to get fast results" and from "find the perfect solution" to "identify multiple options so we maximise our chances of success".

We also confirmed that this approach is ideal for critical, complex, transversal projects and programmes with many uncertainties and high risks. More specifically, it is an ideal approach for the fast development of new concepts up to the point where the uncertainty about the concept is sufficiently low for starting formal discussions with the safety authority and possibly discussing the concept with external stakeholders. Simply put, it is ideal for de-risking new concepts. We also confirmed that in our context it is also ideal for quickly developing new IT tools, e.g. for checking compliance with key requirements, for building scenarios, or for analysing and visualising data in an innovative way.

ACKNOWLEDGEMENTS

The authors would like to thank all their colleagues at ONDRAF/NIRAS and BELGOPROCESS who realised the work with agility, allowing them to increase their level of knowledge by doing and to deliver results quickly.

The authors would also like to acknowledge the support from the steering committee of the admissibility program in making this innovative approach work.

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