Agile'TRIZ Framework: Towards the Integration of TRIZ Within the Agile Innovation Methodology

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Abstract. Applying TRIZ is difficult, time-consuming and therefore requires implies important development costs: designers spend a lot of time to analyze the problem, to identify the contradictions, and then to develop innovative concepts and propose technical solutions. The efficiency of TRIZ strongly depends on the level of completeness of the problem and the experience of the designer with TRIZ tools. Agile methodologies are commonly used to efficiently develop new products toward an iterative, incremental and adaptive development cycle. They allow to rapidly provide a first technical solution and break the product development work into small increments for minimizing the amount of up-front planning and design. Agile'TRIZ is an Agile-based framework for TRIZ intended for enhancing the innovative skills and the efficiency of the designers, and to provide an efficient approach for quickly analyzing a problem and rapidly developing new innovative solutions using TRIZ tools through an iterative development cycle.

Keywords: TRIZ · Agile development · Agile framework
Concurrent engineering

1 Introduction

Customers nowadays have highly specific but also rapidly changing needs; although they still want high-quality and low-cost products. In order to stay competitive, the R&D engineers should on one hand integrate more technical innovations and on the other hand reduce their development time and costs.

The organization of the R&D teams within a company is so that the development process of complex products, such as vehicles, trains, aircrafts, is not performed by a single development team. The development is split into several teams (one team in charge of the development of the engine, one of the binnacle, …) and the design activities are all be occurring at the same time, i.e., concurrently. The systems developed by the several development teams should then be integrated into a global super-system that should be homogeneous and optimal.

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In order to deal with this competitive environment, current product design strategies tend to be more flexible, adaptive and involve agile frameworks [1]. Agility is the capability to react, and adopt to expected and unexpected changes within a dynamic environment constantly and quickly; and to use those changes (if possible) as an advantage [2]. An agile framework comprises agile values and principles as well as methods, which are commonly coupled through a process [3].

In order to integrate more innovation technologies, TRIZ is today regarded as one of the most comprehensive, systematically organized invention knowledge and creative thinking methodologies [4], it however has some drawbacks that have an impact on the introduction of TRIZ within the R&D teams in the industry. First of all, TRIZ is not an ideal theory as it does not guarantee a solution and then the feasibility or the success of the solution [5]. It does not provide finite and directly implementable solutions, only ideas or concepts: it does not provide tools for concretizing a standard solution [6]. It gives a very important number of ideas after the analysis phase. TRIZ tools are somehow difficult, time-consuming (especially the problem-analysis step) and can hardly be error-freely applied without prior expertise with TRIZ [7, 8]. The integration of TRIZ within an Agile innovation framework could solve those problems and offer a flexible, adaptive environment for rapidly developing innovative technologies and products.

The research work outlined in this paper aims to deal with such agility problems and aims to propose a first drawing for the integration of TRIZ in an Agile framework. The paper outlines a very first version of this framework which will be improved and tested in the future and will be presented in future communications.

This paper deals with the innovation design process and aims to propose a first concept of such an Agile framework, entitled Agile'TRIZ. The paper is organized in six sections. In Sect. 2, the Agile design strategy is introduced. The Sect. 3 discusses the interests and advantages of integrating TRIZ in an agile framework. In Sect. 4, a first concept of our Agile'TRIZ framework is presented. In Sect. 5, the concept is analyzed, and some research perspectives outlined. Finally, the conclusion presents some research perspectives in Sect. 6.

2 Agile Product Development Process

Agile is a microplanning project management methodology [9]. The Agile design strategies were first developed as software development strategies by seventeen software developers which published the Manifesto for Agile Software Development in 2001 [10]. However, iterative and incremental development methodologies are much older, with for example the evolutionary project management [11] and the adaptive software development [12, 13] process emerging in the 1970s. Several frameworks were designed for software development, like Scrum [3, 14, 15] or Kanban [16, 17].

Focusing on the innovation development process of new products, several frameworks were identified by [2, 3, 18]:

– Scrum [3], also used for software development, that structures the development process starting with Sprint Planning for each Sprint, Daily Scrums – brief daily

team meetings during which the progress is analyzed and the remaining hours of work are recorded –, Sprint Review and Sprint Retrospectives,
- Kanban, considered as an agile framework by Highsmith [13], which optimizes the current processes by mapping them, limiting work in progress and eliminating waste [19],
- Lean Startup [20], following the Build, Measure, Learn cycle actions according to [21], to develop businesses and products by adopting a combination of business-hypothesis-driven experimentation, iterative product releases, and validated learning.
- Design Thinking contains a process which comprises the phases understand, observe, define point of view, ideate, prototype and test [18, 22]. The Design Thinking framework stops with the concept development process and does not provides methods or tools for concept test, development, …
- Makeathons or Hackathons focus on iterative prototyping. After a set time the functions demonstrating the product's concept and its value will be presented [23],
- Agile–Stage-Gate Hybrids, developed by Cooper [23], which combines the Agile approach with the Stage-Gate innovation process model.

Figure 1 classifies the frameworks along the stage-gate innovation process model [24].

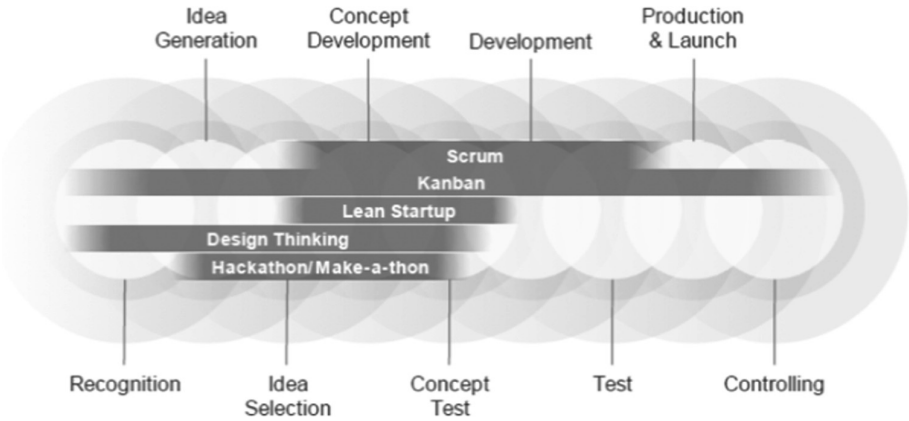

Fig. 1. Agile frameworks within the generic innovation process model [2]

Despite linear or iterative process models, an agile model passes several process phases at the same time with main aspect being to give priority to the innovation object within the innovation process. Starting with just a vision, the minimum feature set is derived to build a prototype and will lead to a first minimum viable product and a user interaction [2].

An agile innovation framework needs to be complemented with a systematic approach regarding physical product development. TRIZ presents a systematic approach for understanding and defining challenging problems and provides a range of

strategies and tools for finding these inventive solutions [25–27]. TRIZ may then be applied for providing an organized approach for creative thinking and problem solving, as well as rapidly develop new innovative products if it were combined with an Agile innovation framework.

In the next section, the interest and advantages of developing an Agile framework integrating TRIZ as a problem-solving tool is discussed.

3 Why Integrating TRIZ in an Agile Framework?

Before presenting the Agile'TRIZ framework which aims to integrate TRIZ within an Agile innovation strategy, it can be interesting to understand how this idea emerged and what the foundations of the framework.

The framework emerged from the statement based on our own experience regarding the application of TRIZ with industrials and non-TRIZ experts that, during or before the workshops for idea generation, the design team spends a huge amount of time for analyzing the initial situation and its problem to draw the problem graph with hundreds of technical problems and partial solutions. And the design team will then decide, eventually using some evaluation tools such as [28], to focus the problem-solving activities on one or two problems or contradictions only (usually the most significant ones or the problems with the highest innovation potential). In other words, the design team spends more time in analyzing its problem than to develop new ideas and concepts but finally skip most of the identified problems or tasks. From this statement emerged two main questions:

1. Could the design team spend less time in analyzing the problem and more time on creativity tasks?
2. How could we speed up the creativity tasks to quickly develop implementable innovative products?

Based on the statement that several design teams should work in parallel and develop innovative technologies which should than be integrated into a global super-system that should be as optimal as possible, the classical linear design approaches imply that this combination occurs at the end of the development cycle and some subsystems may be incompatible, not fit properly with the other subsystems. This problem will imply that the design teams will then have to adjust the subsystems in order to correct those problems. This development strategy then leads to global super-systems integrating optimal subsystems but without optimal interactions which are often the source of further failures or dysfunctions. From this other statement, one additional question:

3. How could we improve the interaction of the design teams during the innovation development and eventually rapidly correct the interaction problems as soon as possible?

To solve these research questions, the idea of integrating TRIZ within an agile innovation strategy emerged. On one hand, the agile innovation strategy uses an iterative and incremental development strategy which would allow the design teams to

rapidly develop new innovative products and to learn the positive and negative effects from the review of the prototype; but it does not provide tools for generating ideas and solving contradictions. On the other hand, TRIZ can be used for such purpose.

In comparison with the original TRIZ approach, a TRIZ-based agile framework would provide an iterative and incremental development strategy that should allow the designers to:

- Spend less time for analyzing the initial situation, as the designers may start the development with a minimal problem, which will be complemented in the next iterations,
- Use some TRIZ tools, such as the 40 inventive principles or the TRIZ database of technological effects, to provide a limited number of ideas for solving its problem,
- Rapidly go through the development of a first prototype,
- Learn the positive and negative effects from the evaluation, the review of the prototype,
- Improve the prototype during the further iterations (#2, #3, …),
- Improve the interactions between the different design teams and reduce the interaction problems of the final product.

The Agile'TRIZ framework, whose first concept is presented in the next section, is our response to those statements and research questions.

4 Concept of Agile'TRIZ

Agile'TRIZ represents the combination of the agile development strategy and TRIZ, as a process from idea to prototype through an adaptive, iterative and incremental innovation design strategy.

Figure 2 presents a functional diagram of the Agile'TRIZ framework.

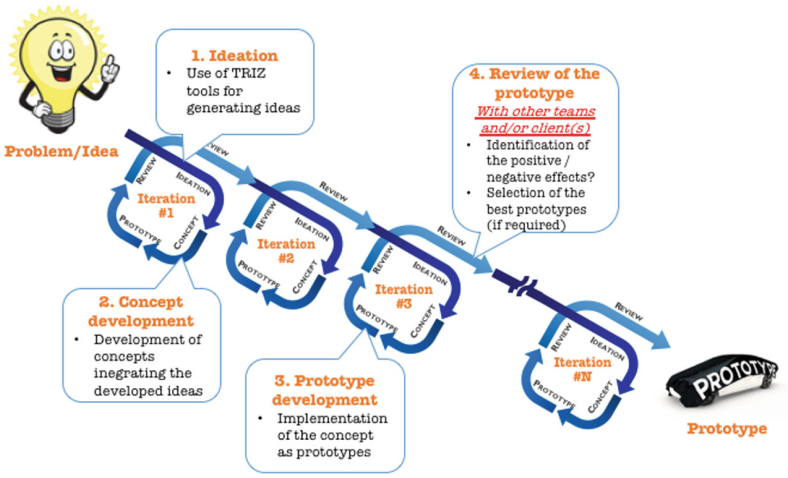

Fig. 2. Agile'TRIZ framework (concept)

Agile'TRIZ is based on the following strategy:

1. The design team comes with a user demand and analyzes it.
2. During the first iteration (Iteration #1), the design team uses the TRIZ tools (the TRIZ database of technological effects) or some other tools to develop a first virtual prototype. The team analyzes the positive and negative effects of the first prototype, eventually with the other teams (for highlighting eventual integration problems) and the client.
3. During the next iterations (Iteration #2, #3, …), the design team develops new improved versions of the prototype (Version #2, …) using some TRIZ problem-solving tools, such as the inventive principles, the standard solutions, … and reviews the prototype.

The framework includes, for each iteration, the following four steps:

1. **Ideation step.** The designer uses TRIZ tools to generate new ideas and summarizes the idea generation in a morphological matrix (see Table 1). Each row contains the several ideas generated for a single problem. If different inventive principles can be applied, the ideas are presented with each row representing an idea using one inventive principle.

Table 1. Morphological matrix from the ideation step

Functions /problems	TRIZ inventive principle	Ideas		
Problem A	*1. Segmentation*	Idea A1	Idea A2	…
	3. Local quality	Idea A3	Idea A4	…
…				
Problem Z	*23. Feedback*	Idea Z1	Idea Z2	…

2. **Concept development step**. The design team develops concepts by combining at least one idea from each row. This step can be computerized with the use of combinatorial optimization algorithms. An example of such approach has been previously presented in [29] (Table 2).

Table 2. Concept development step

Functions /Problems	**TRIZ inventive principle**	**Ideas**		
Problem A	*1. Segmentation*	Idea A1	Idea A2	…
	3. Local quality	Idea A3	Idea A4	…
…				
Problem Z	*23. Feedback*	Idea Z1	Idea Z2	…
		Concept C1	Concept C2	

3. **Prototype development step.** The design team develops prototypes that implements the concepts developed during the previous step.
4. **Review of the prototype.** The design team, together with the other development teams and the client/user, reviews the developed prototypes and extracts the positive and negative effects of each prototype. A possible approach for concept evaluation was proposed by [30] and can be adapted for our framework.

They also analyze with the other teams the implementation and interaction problems that may occur from the integration of the prototypes within the global super-system by considering the prototypes developed by the other teams. During this step, they may also be requested to select the most significant prototype(s) if the number is too important or if the overall prototypes cannot be processed (with the use of computer-aided innovation tools for example).

An example of such collaborative teamwork is shown in Fig. 3.

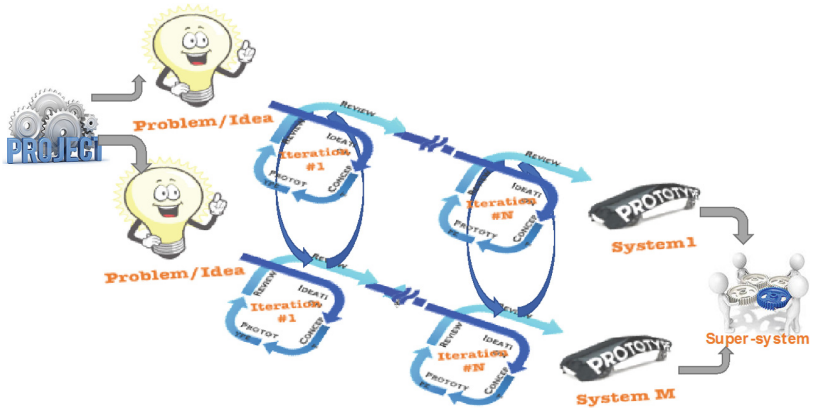

Fig. 3. Example of teamwork between different design teams within a project with Agile'TRIZ

At the end of each iteration, the positive and negative effects and other results from the review step are used as a basis for improving the prototype during the different steps.

This section proposed a first concept of the Agile'TRIZ framework we developed as an answer to the questions related with the integration of TRIZ within the agile innovation process in order to help the designers or the design team in rapidly develop a new innovative prototype and improve the prototype through an iterative and incremental strategy allowing better interactions with design teams (collaborative development strategy) and user interactions (the user can take part of the review of the prototypes at the end of each iteration).

The framework is discussed in the next section and some research perspectives related with the improvement of its integration with TRIZ and its evaluation are introduced.

5 Discussions and Research Agenda

With Agile'TRIZ and starting with just a vision, the minimum feature set is derived to build a prototype and will lead to a first minimum viable product and a user interaction. The several iterative steps allow to rapidly improve the prototype.

After a limited amount of iterations and time, the design team is able to provide a viable innovative solution to a set of user requirements, efficiently ensure that the product satisfies them by allowing regular user interactions through all the process (ideally after each iteration, during the review step) and rapidly change and correct the prototype regarding the report defined during the review step.

Agile'TRIZ also improves the ability of collaborative work and the possibility of the several design teams to work within a common project and simultaneously develop a portion of the global super-system. The review step indeed allows the teams to discuss and expose their prototypes and identify the interaction and integration issues. These issues can then rapidly be taken into account during the process.

In the future research work, the following tasks will be performed

- **Improvement of the framework.** The framework will be improved, and specific TRIZ-based tools be developed to improve the integration and compatibility of TRIZ with the Agile innovation strategy.
- **Experimentation and evaluation.** The framework will then be experimented in practice, first with our students and later with our industrial partners, in order to evaluate the framework regarding the Innovative Design Methodology based on TRIZ and the ability of the students/partners to rapidly develop viable prototypes as well as working in collaborative design teams. The quality of the process regarding its impact of the proposed approach on the outcomes of new problem development or the problem-solving process based on TRIZ.
- **Implementation and software development.** The framework will finally be implemented as a software platform to guide the designers through the framework and computerize some steps of the framework, such as the concept development and review steps. Some text-mining tools could also be integrated in the software to automate several steps, such as the analysis of the initial situation [31]; as well as some optimization tools to computerize the evaluation, the selection and the development of the concepts and technical solutions [29] or integrating product usage [32] and safety into the innovative design process [33].

6 Conclusion

This paper dealt with the innovation development process and aimed to provide a first concept of a TRIZ-based agile framework that integrates the advantages of TRIZ as a systematic problem-solving approach and the Agile innovation strategy as an adaptive, iterative and incremental development model.

After an introduction on the Agile development process, the interests and advantages of combining both approaches were discussed. Then, a first concept of the

Agile'TRIZ framework allowing the integration of TRIZ in an agile innovation process was presented. The framework was discussed, and some research agenda outlined.

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