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AN INNOVATION MANAGEMENT FRAMEWORK TO ENHANCE TRIZ DIFFUSION IN SMES

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Abstract: *SMEs cannot pursue long-lasting and wide innovation projects, rather they request focused innovation steps. The same can be said about learning TRIZ: they do not want to learn a methodology, they want solutions in brief time. Warrant Innovation Lab has already worked on this topic. However, the interest in learning TRIZ were not arisen. To enhance the chance to spark interest about TRIZ, the authors propose an Innovation Management Framework to orchestrate a tailored innovation process relying on TRIZ-skilled partners. This framework generates two main results: a) the customer familiarizes with TRIZ and gradually acquires some basic TRIZ-skills; b) the one-shot session service becomes a continuative R&D support formula.*

Key words: *SME, Innovation Management framework, TRIZ-based service, TRIZ diffusion, Tailored innovation process.*

1. INTRODUCTION

One of the most common barrier to the innovation in SMEs is the lack in time and resources to spend on it [1]. The same is true also for TRIZ, which needs a long training period to become an efficient and effective resource. Because of it, the SMEs find it difficult to take advantage of TRIZ.

In SMEs, the incentive to innovate comes from the customers, who ask for improvement in performance or reduction in cost of the products, or from information given by the suppliers, who propose new technologies or products, or from the market competition, which forces toward cost reduction.

Irrespective of the reason for the request, SMEs rely on the insightful-ness, expertise and knowledge of their staff in order to innovate, who usually has traditional designing tools, but lacks in systematic methods specialized in innovation. They tend to outsource the R&D projects that are burdensome for the internal staff, both in time-consumption and in skills request.

The approach seems to be aligned with what open innovation approach suggests [2], that takes advantage by strategically leveraging internal and external sources of ideas and takes them to market through multiple paths.

However, there are major difficulties in open innovation adoption in SMEs, due to the scarcity of resources and time. This is the main reason for which SMEs are generally interested in solutions to the problem rather than learn methods to achieving them.

Warrant Innovation Lab (WIL) is a consultancy firm which proposes innovation services based on the open innovation approach to build bridges between private companies, mainly SMEs, and academia, research labs and universities. WIL operates as a facilitator for technology transfer and innovation boosting.

Due to the mindset of Italian SMEs, WIL cannot propose TRIZ courses. It exploits the request of solutions to convey the method and present it as a fast-track for innovation, sometimes without cite or explain it, only working with it. In most complex cases, the strategical problem-solving phase is carried out with the support of University of Bergamo (UniBG) which is a WIL's partner since 2017.

In the open innovation approach, TRIZ plays as the enabling methodology driving the specific

method used in the innovation services to achieve the best level of reliability of the results.

Although TRIZ lays the foundation of the way to proceed in an innovation process, it cannot solve the lack of skills and knowledge required for develop new successful solutions. WIL has been growing over year a network of partners, an innovation ecosystem, involving players that share methods and tools in order to optimize the operations and, at the same time, evangelize the customers about TRIZ.

An innovation project tailored for a SME is a delicate equilibrium in term of time request to the company experts, that typically performs more than one task in the company, and economic commitment, that tends to rise with effort request to the supplier. To find and maintain this balance, the consultancy firm often relies on its own experience, best practices and methods to minimize uncertainty and risk.

In this paper, the authors introduce an Innovation Management Framework they are developing to coordinate and support the innovation processes of their customers, mainly SMEs. They propose the framework as a tool for tailoring the innovation process for each customer and at the same time preserving a high level of systematization of TRIZ-based activities. The chance to tailor the innovation process enhance the likelihood of arouse interest in TRIZ by the customer.

2. APPLICATION FIELD (OPEN INNOVATION)

Traditionally, processes about new product or business development took place involving only company inner resources. In last decades, the innovation paradigm has been changing towards a collaborative approach that include also external players. They contribute with ideas, technologies and competences to the innovation process of the company in what has been dubbed open innovation [2].

Ideally, it extents the knowledge and competences of the firm outside its own laboratories to reach knowledge and competences of external partners. Thanks to the opening of firm's boundaries, the effectiveness of the innovation processes increases significantly.

As an expected benefit, the company gets fast time-to-market solutions, building of supply-chain during the development process, knowledge acquisition and, sometimes, business acquisition. More, the same idea can find different paths to reach the market, also outside the main course own by the firm who lead the innovation process. Of course, a crucial part concerns the IP management between partners.

In closed innovation, the funnel of ideas filters not successful idea out and only passes valuable ideas/solutions for the company. See Figure 1.

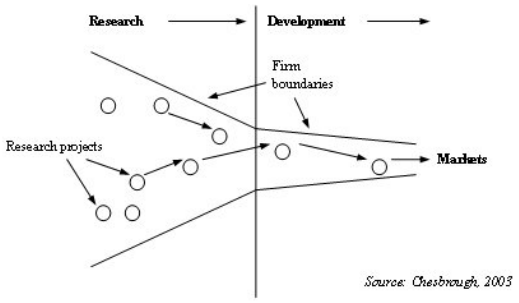

Fig. 1. Closed innovation funnel. Source: [2]

In open innovation, the funnel leaks for ideas towards other markets in which partners may play opening new markets. See Fig. 2.

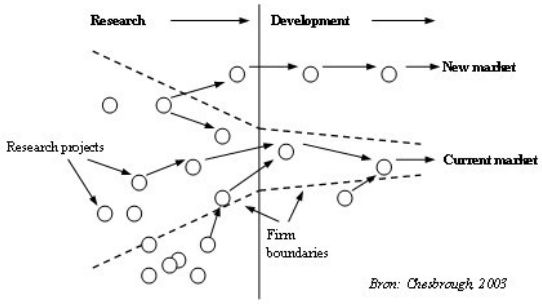

Fig. 2. Open innovation funnel. Source: [2]

However, the funneling boundaries of open innovation project, i.e. the firm which coordinates and drives the project is generally a large firm that has resources to spend on innovation to search, find and select projects and partners and to finance the development process.

Open innovation approach is well known in its practice by large firms. Unfortunately, the different dynamics between their businesses do not allow to transfer that knowledge to SMEs [3, 4]. Notwithstanding the SMEs play one of the

most relevant roles in large companies' open innovation programs, they cannot catch the innovation management method, due to the cited lack in time and resources [1, 4]. Rather, they play like a sort of 'black box' from which the large companies can collect innovative solutions or acquire the company converting it in a new business line.

In the all-day business, SMEs look for fast results and solutions at known costs. They do not want pluriannual projects, especially for innovation projects that have a high implicit level of uncertainty. They prefer focused work packages, that lead them to the final solution throughout a progressive sequence of development steps, having known costs.

Thus, to pull SMEs in an innovation perspective, unconnected to large firms, is crucial to split the innovation process into steps that should offer awareness about the growing solution deepening the knowledge about it.

Each step must reach a 'stable' result because the further step might be start after some months. Indeed, SMEs are, generally, characterized by a low level of inner bureaucracy, so also the tool by which the results are communicated has a great impact on the success of the innovation project.

On this way, WIL has been developing an Innovation Management Framework (IMF) to coordinate innovation project for SMEs offering focused activities aiming to reach expected results in term of level of development of the solution.

3. RESEARCH STAGES

The lack in time and resources to spend on innovation typical of SMEs conditions also the learning of TRIZ [1], which needs a long training period to become an efficient and effective resource. Because of it, the SMEs find it difficult to take advantage of TRIZ.

Aiming to support SMEs in the most strategic phases of an innovation project, WIL and UniBG have been starting a partnership since 2017, proposing to SMEs the service called Innovation Lab (IL), introduced in TFC 2018 and 2019 [5, 6]. It is a TRIZ-based service, expressly designed for Italian SMEs, consisting in a one-day team-working session of problem-solving.

The authors proposed IL with a double purpose: first, to support SMEs in solve a specific inventive problem they have been dealing with for some time and cannot solve; second, to boost the interest in TRIZ promoting its diffusion among Italian SMEs.

The assumption behind IL was that the co-work and the conceptual solution(s) generated during the one-day session should be able to persuade the customer that TRIZ is the way to enhance the effectiveness of the R&D activities and to reduce the time-to-market of new products.

Despite the solutions coming from IL have been considered interesting, up to be patented in most cases, the interest in learning TRIZ were not arisen.

However, the largest part of SMEs needed further help in developing the conceptual solution reached by the IL. Thus, WIL had to provide additional support to proceed in innovation process.

Although not formalized, the additional activities have been led using TRIZ as main approach to drive the innovation process. For example, evolutive laws have been used to drive the choice among available physical effects, trimming to simplify the system once the physical effect was validated and separation principles to solve contradictions arisen in engineering phase.

The customer was always involved in critical step, especially in decision making milestones. In some cases, WL act only as a supervisor of the work, while the customer itself made operative testing or design review.

As a result, some customers more interested in boosting the business about the new solution recognize a systematic method behind the activity and asked for a continuous support from WIL in coordinating R&D activity. Finally, they became interested in TRIZ.

4. METHODS USED

To enhance the effectiveness of IL in diffuse TRIZ in Italian SMEs, WIL is updating its offering of innovation services. It has been developing the IMF intended to highlight that

the whole offering relies on a systematic method that drives the innovation process to the most suitable solution for the customer.

IMF extends the critical point of IL to the whole innovation process: a) limited time; b) supervised work; c) shared choices.

While the main approach to the innovation process is aligned to the open innovation perspective, the core activities rely on TRIZ and FBS [7] methodologies, like partially described in [6].

To coordinate the IMF and make it plausible to the SMEs, a significant set of aspects should be considered and solved. The most relevant WIL is approaching are:

- split the innovation process out into sequential steps;
- specify the information in input required by any step;
- pinpoint which set of information a single step must generate in output;
- select the method by which each step should work to produce the expected output from required input;
- define the skills required to carry the method out;
- build a common way to share information and results between a step and the subsequent;
- set a way up to tailor the innovation process to the customer's project.
- Systematize the access to the knowledge;
- Sustain competitiveness of the solution by an appropriate IP protection strategy.

4.1 TRL to split the process out

According to the requirement given by EU in funding framework programmes Horizon 2020 [8, 9] and Horizon Europe [10], the level of development of a technological solution can be measured using the Technology Readiness Level (TRL) that comes from what adopted by OCSE [11, 12]. See Fig. 3.

The TRL index is an interesting way to split the process of innovation because it defines the advance of the project by its results, the knowledge about solution. It is independent from the method exploited to develop the solution.

More, the linear description of the readiness levels connects it to the 'stage gate' innovation

TRL	Technology status	Description
1	Basic principles observed and reported	Scientific research begins to be translated into applied research and development.
2	Technology concept and/or application formulated	Practical applications of basic key principles can be 'invented' or identified. The application is still speculative: there is not experimental proof or detailed analysis to support the proposal.
3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated: analytical studies to set the technology into an appropriate context, and laboratory-based work to physically validate that the analytical predictions are correct. These should constitute "proof-of-concept" validation.
4	Technology / part of technology validation in a laboratory environment	Following successful "proof-of-concept" work, basic technological elements are integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance. The validation is relatively small scale compared to the eventual technology: it could be composed of ad hoc discrete components in a laboratory.
5	Technology / part of technology validation in working environment	At this level, the reliability / scale of the component being tested has to increase significantly. The basic technological elements must be integrated with reasonably realistic supporting elements so that the total applications can be tested in a 'simulated' or somewhat realistic environment (which is almost always the working environment for energy technologies).
6	Technology model or prototype demonstration in a working environment	A major step in the reliability / scale of the technology demonstration follows the completion of TRL 5. At TRL 6, a prototype going well beyond ad hoc or discrete components is tested in a working environment.
7	Full-scale technology demonstration in working environment	TRL 7 is a significant step beyond TRL 6, requiring an actual system prototype demonstration in the working environment. The prototype should be near or at the scale of the planned operational system and the demonstration must take place in the working environment.
8	Technology completed and ready for deployment through test and demonstration	In almost all cases, this level is the end of true 'system development' for most technology elements. This might include integration of new technology into an existing system. Represents the stage at which an example of the technology is tried and tested
9	Technology deployed	In almost all cases, the end of last 'bug fixing' aspects of true 'system development' and represents the point at which the technology is proven, but not necessarily yet commercially viable in either a free or supported market. This might include integration of new technology into an existing system. This TRL does *not* include planned product improvement of ongoing or reusable systems.

Fig. 3. TRL definition. Source: [12]

management model [13], the most known or heard model also in SMEs.

The description given by [12] about levels defines in a clear manner the knowledge about the technology or solution you need to reach each level, that means TRL sets which information you must have about solution to declare a TRL value. See Fig.

Thus, setting the information up of input and output of each step between two subsequent TRL levels automatically defines the activity you have to perform to upgrade the TRL of the solution. WIL names each step with a verb that represent the activity.

As anticipated, TRL describes clearly which are the information or the knowledge about solution for each level. Then, splitting the innovation process out according to TRL means to have already defined which are the essential information to have in input for each activity and which is the expected result in term of knowledge.

The TRL is therefore a single tool that already includes what is needed to split the innovation process out and define what information each step requires in input and which one it should generate in output, regardless of the method or approach exploited to proceed in the process.

4.2 TRIZ as baseline method

Starting from IL first proposal in 2017, WIL is working in develop a set of services to support its customers base on TRIZ. At the begin IL was intend as a special service, fast and very focused, to solve a problem with a defined and easy to understand technical solution.

Deepen the experience in TRIZ, WIL started to configure some specific activities to exploit TRIZ in all other internal activities. An example is the digitization method introduced in TFC 2020 [14].

The problems and boundary conditions change every time, then is difficult to standardize the activity inside each innovation process step.

However, some TRIZ tools can be always used to set up the problem, at the first approach or to update it in subsequent steps. The most used tools are:

- TOP Model;
- IFR [15];
- ENV model [16];
- Market Potential [17, 18];
- Physical Contradictions;
- Separation Principles.

When an innovation programme about a new product runs throughout different subsequent steps and find the same tools, despite applied to different problems, the customer become familiar to them and starts to play with them, up to proposing to solve a problem arisen during, for example, the testing phase.

4.3 Skills and partners

Clearly, the most important skills to have are manage TRIZ and guide not skilled people in using it.

For the most strategical phases, in main problem solving and concept solution design, WIL relies on the support of UniBG with which provide IL [5, 6].

However, the innovation process is a long way, mainly lying outside from the mission of UniBG.

Despite knowing the skills requested by each innovation step eases the choice of which kind of partner involve in related work, there is a high risk to put into the process a significative amount of psychological inertia.

Exploiting UniBG which is one of the most active subjects in TRIZ education in Italy, WIL has grown a network of partners able to cover the most important set of innovation steps. The network includes partners, skilled in TRIZ, able to support the innovation process up to the prototyping & testing step.

Other steps, aver all technology validation, often involve research labs and universities to test e validate the choice of a specific physical effect.

At the most advanced steps, the solution is generally well known and the technology well defined. Thus, also partners not skilled in TRIZ can be involved because the impact of psychological inertia is limited, although ever present.

4.4 Communication tool

The communication tool derives once again from the innovation lab, as presented in 2019 [6]. The FBS map of alternative solutions is the most effective communication and results collection tool tested by WIL to date.

4.5 Tailoring the process

In approaching a customer which intends to innovate its own product you can exploit different kinds of criteria that let you to measure its ability to innovate. For example, they might be about economics, like R&D on revenue, number of R&D employees; or they might consider number of patents hold by the company or the methodology exploited to manage the innovation.

After some attempts, WIL understood these parameters are not reliable to build a systematic index for SMEs, for what said in introduction about scarcity of resources dedicated to R&D. Thus, the data cited above are not available to tailor the process on SMEs request.

Unfortunately, all the criteria you can discuss with customer, like for example desired result, amount of increment of performance of an existing system, ROI, payback period, etc., can be connected to the TRL.

The last opportunity to classify the services according to a parameter different from TRL is the goal of the project. As goal we mean the development direction of the system, e.g, new product design, troubleshooting, greener product or process, digitization of product, etc.

The goal does not change the innovation process itself. It acts on which information the process needs to reach the expected results and which specific skills you need to develop the solution.

Then, the framework can work in selection of the best partnership for a specific project considering:

- The goal of the project;
- The input information available;
- The expected result desired.

Anyway, despite TRL is a well-defined index, often the SMEs do not manage it accurately, so, when a new project starts the first activity to be done is to verify the information the customer gives and check the effective TRL reached by current solution proposal.

According to the TRL assumed, some strategy can be performed to check it. The most adaptable consists in produce a Minimum Viable Product (MVP) [19], but using it with the customer, not with final user. This allows WIL to test if the expected result of the project is aligned with what requested by the customer or if a review of the project is needed.

4.6 Knowledge base and intelligence

The innovation process consists in increasing knowledge with respect to a solution. In WIL's market, mainly focused on manufacturing SMEs, the necessary knowledge is often of a technical nature, so the most appropriate data sources are patent and scientific databases.

Structuring a systematic and flexible framework for innovation cannot be separated from the information gathering process that allows to receive the information already available to make technology development more efficient and reduce time to market.

For each innovation step, WIL has been defining which kinds of report or document navigation tool to boost the process development.

Usually, the knowledge base includes a large number of patents and scientific papers. To cope with such a large document pool, dedicated information retrieval and analytics tools must be developed. One of most strategical partners is a software house, skilled in TRIZ and patents that supplies an information retrieval platform for searching, navigating and analyzing patent and scientific literatures and generate customized reports for each innovation step.

4.7 IP protection strategy

The IP protection strategy is a fundamental asset in a framework that involves various actors. The framework also proposes a specific activity leveraging the map of alternatives to define the protection strategy.

Since the IP protection activity is strategic, we looked for a partner capable to cooperate with the transfer of information using the tree of alternatives method.

The protection exploits the reliable and comprehensive information produced by the KB too.

5. RESULTS

The framework derived from this approach is obviously linear because it is dimensioned only on the TRL. However, it can be applied to multiple business goals, which deal with innovation, but start from different interests, such as environment sustainability, product digitization and product/process innovation.

The development of the framework is still in progress. In particular, the construction of the network is an activity that has grown over the years and which thrives on relationships and collaborations.

Fig 4 shows the current provisional version of the framework. On the top there are the TRL levels and the general activities corresponding to the advance steps. In the squares are placed the service offered by WIL to its customers that aggregate some activities according to the need of the market. When a service takes more than one activity, generally, it is segmented in work packages that correspond to TRL steps.

As function of the request, some services can be extended to cover a larger set of TRL. The most frequent cases are depicted with dashed lines.

There are different main themes which collects different rows. Actually, there is no operational reasons to do this, but it has a value in marketing. Also the aggregation of activities is a way

However, it has been already proved that proposing the activities in such a progressive way, the customer changes its perspective about the services and TRIZ. Starting from focused activities, limited in time, it tends to consider a continuous collaboration for supporting its R&D activities, up to, in some cases, coordinating them. When happened, the customer understood that TRIZ is the way to speed the R&D activities up whit reduced costs, but it prefers learn-by-doing rather than take TRIZ courses.

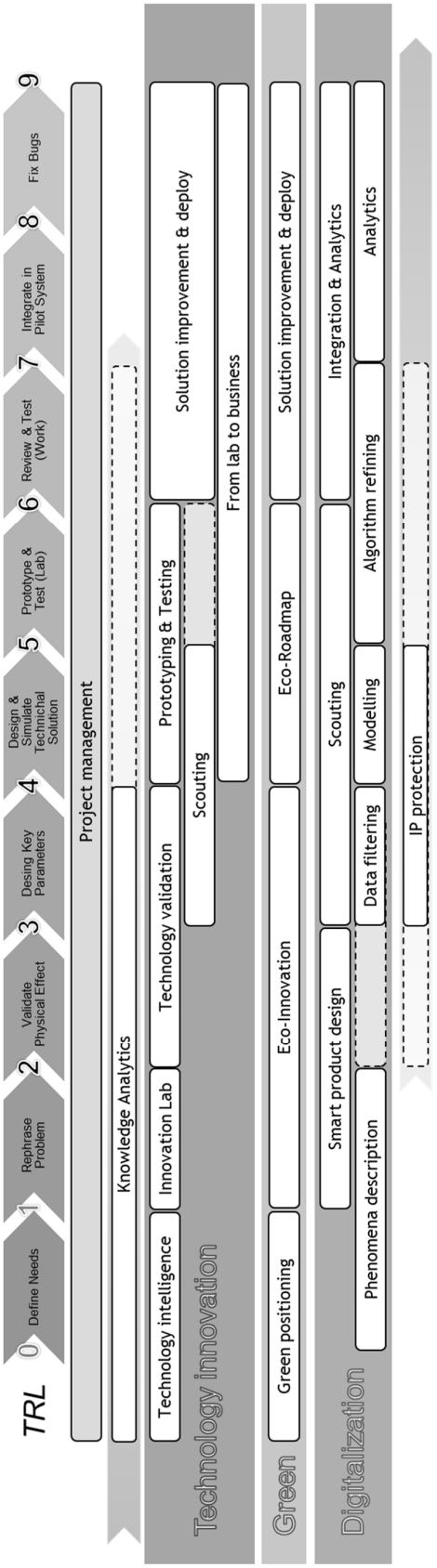

Fig. 4. The Innovation Management Framework that organizes innovation services by two parameters: horizontally the TRL and vertically the

6. FURTHER RESEARCH

As mentioned, the framework definition is in progress, both for the partnerships and for the standardization of the activities to build the services.

To date, few of the interventions described have been formalized, while the others are entrusted to the experience of the professionals who follow them.

7. CONCLUSIONS

The adoption of the open innovation approach from SMEs requires an effort to correctly size the activities, in terms of both economic commitment and time to dedicate, due to the limited amount of resources available for R&D activities, typical of SMEs

With the IL, a first attempt was made to contain the commitments dedicated to problem solving in the strategic phase of an innovation project. The operating result, the conceptual technical solution defined downstream of the IL was successful. The same does not apply to the interest aroused in TRIZ.

The interest in TRIZ was born after some complementary activities with respect to IL which led to a more advanced development phase of the solutions produced with IL.

To give greater evidence to the method and customize the development process, WIL has started to configure his activities in a framework that accompanies the customer in all the phases necessary for the innovation process, from the generation of the idea to the engineering of the final solution, with great flexibility to allow entry or exit from the process at all levels of progress.

The guiding parameter of the framework is the readiness of the solution defined using the TRL which summarizes the progress, the level of knowledge corresponding to each level, and indirectly defines the activities necessary to pass from one state to another.

The transfer activities were addressed by WIL with TRIZ. For each activity a method based on TRIZ has being developed which, as already happened for IL, allows to define the most effective work process.

Only some of the activities can be carried out independently by WIL. For the most, WIL has decided to involve external partners. The partner network or ecosystem is selected with a criterion that tends to minimize the risk of introducing psychological inertia. Especially for the more strategic phases it is necessary to select partners who know and use TRIZ and who share the chosen communication method.

This framework generates two main results: a) about TRIZ diffusion, the customer familiarizes with TRIZ and gradually acquires some basic TRIZ-skills; b) about business, the one-shot session service becomes a recursive/continuative R&D support formula.

In an operative perspective, the time-to-market of new solutions can take advantage of this approach, as well as the efficiency and effectiveness of the R&D activities to develop new products/services or processes.

The framework is under development, especially as regards the definition of the methods for each process / service

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Un cadru de management al inovației pentru a îmbunătăți difuzia TRIZ în IMM-uri

Rezumat: IMM-urile nu pot urmări proiecte de inovare pe termen lung și largi, ci mai degrabă solicită pași de inovare focalizați. Același lucru se poate spune despre învățarea TRIZ: nu vor să învețe o metodologie, vor soluții în scurt timp. Warrant Innovation Lab a lucrat deja la acest subiect. Cu toate acestea, interesul pentru învățarea TRIZ nu a apărut. Pentru a spori șansa de a suscita interesul cu privire la TRIZ, autorii propun un cadru de management al inovației pentru a orchestra un proces de inovare adaptat, bazându-se pe parteneri calificați în TRIZ. Acest cadru generează două rezultate principale: a) clientul se familiarizează cu TRIZ și dobândește treptat unele abilități TRIZ de bază; b) serviciul de sesiune one-shot devine o formulă continuă de sprijin pentru cercetare și dezvoltare.

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