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# The Efficient Work with Resources in TRIZ - Resource-Oriented Search (ROS)

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**Abstract.** First, the paper provides a definition of the term resource and need. Then, after defining the state of the art in the work with resources, an enhancement to the process flow of resource-oriented search is proposed. It is recommended to add a super effect analysis and Failure Anticipation Analysis after a first solution has been found and sketched. These enhancements aim at addressing the ambivalence of an introduced or derived resource into a system with which the solution was obtained. The new resource first solves the problem but after that might cause a different one later. Therefore, the implementation of resources could provide possible solutions and cause future problems at the same time. Super effect analysis helps to make the most out of a found solution, increase the good, and Failure Anticipation Analysis is used to discover possible hidden problems or reduce the bad after the implementation. Together with the additions, the proposed process flow of resource-oriented search helps to deal with resources in an efficient and structured way. It provides newcomers to TRIZ a guideline to follow, i.e. it shows where to begin and how to proceed without overlooking important steps or constraints.

**Keywords:** resource, resource-oriented search, failure anticipation analysis, process flow, need

## 1 Introduction

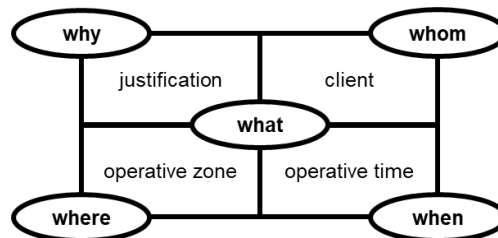
Any kind of system is designed to fulfil at least one main function. This main function usually addresses a human need and should be carried out as efficient as possible. If the required efficiency of the system is not achieved or a problem arises, the system should be improved. Resources play a vital role within this improvement process. On the one hand, a resource could be used to solve a problem but on the other hand, it might be the cause of a problem in the first place. Therefore, there is always a great ambivalence of applying and developing resources. This ambivalence is investigated closer in the later part of the paper. First, a short definition of the term resource is provided:

1. DUDEN: A resource - a) natural production means for the economy; b) means of help; source of help, reserve; money [1] (translation by the author).

2. THE CONCISE ENGLISH DICTIONARY: A resource - a means of aid, support or safety; an expedient, a device; means of support and defence, especially of a country; capacity for finding or devising means; fertility in expedients, practical ingenuity; possibility of being aided [2].
3. Souchkov: A resource - a means, a tool to carry out an action or a process. Within a technical environment, this usually refers to means of production, money, raw material, energy or people, within psychology skills or character and within sociology knowledge or health ([3] translation by the author.
4. Pevzner: Resources are all substances, fields and other properties/capabilities of a technical system and all elements of neighbouring systems and the environment, to improve a system or solve a problem [4].
5. Orloff: A problem always arises, if a needed resource is not present to achieve the required functional property [5].
6. Mann: A resource is anything in or around the system that is not being used to its maximum potential [6].

In [7] the term need is defined and some classifications are given. Needs could be vital or important, local and more like a nice to have. The distribution might range from mass needs, to niche or a narrow field of users. Furthermore, needs can be present, e.g. a market pull, and needs can be created - technology push followed by a market pull.

Human, vital needs are essential for living - food, drink, warmth, shelter. A need in respect to systems created for humans, something, which is derived from the objective requirement to improve a system, e.g. to reduce loss, to enhance the energy flow. A desire, something for which there is a strong urge to get or to have. A wish, something you would like to have but can do without if necessary. A demand, which represent a market pull for something instead of a technology push.

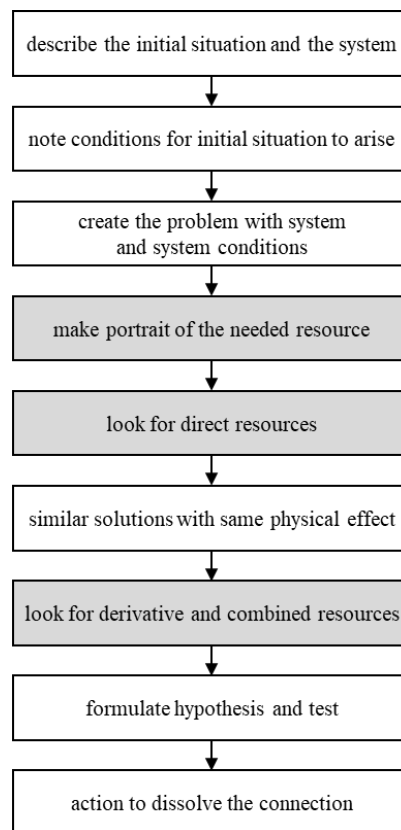


**Fig. 1.** Analysation of the initial situation and its constraints

As mentioned earlier, resources could be utilised to fulfil or address perceived needs. Doing this, five general aspects of dealing with resources should be kept in mind. These aspects are shown in figure 1. In the centre is the question: What - exactly - is the problem? The next step is - Why is the change, development or problem solving necessary? Moreover - For whom is this change/improvement necessary or important? The answer to that question plays an important role of constraints to possible solution ideas or concepts. These constraints should be clarified as early as possible to avoid waste and to have good criteria to evaluate a solution.

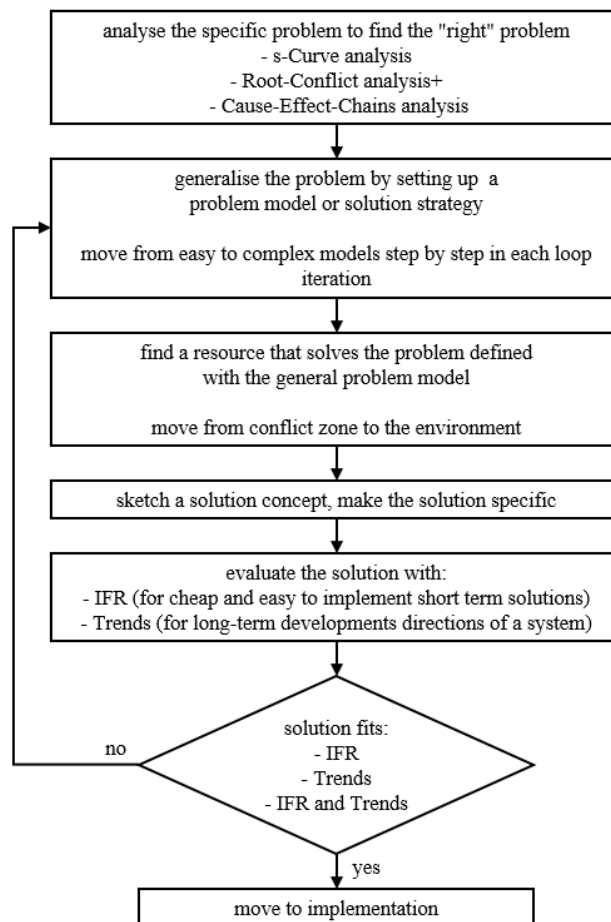
Another constraint is where solutions/resources could be introduced. Where it is most suitable (the operating zone) and where it is not allowed to add something. These areas do not necessarily coincide. Furthermore, when should or could resources be introduced. ARIZ85C forces you to explicitly state the operative time, i.e. when does the conflict arise, what is prior to the conflict and what could be after the conflict.

In [4] two process flows are proposed to work with resources. One process flow deals with problem solving and the second with system improvement. The steps of both process flows are shown in figure 2. The later contains three steps (displayed in grey) and the first all the eight steps shown. In it, there are some advanced TRIZ tools like anticipation failure determination which are difficult to use for a TRIZ beginner. On the other hand, resource analysis as taught in TRIZ Level certification trainings focuses on writing a list of what is present in the system. To make this list as complete as possible checklists are available but there is no direction given of where to look. Thus, this helps to create possible solution ideas in general but in a somewhat unstructured way.



**Fig. 2.** Resource related process flow by Pevzner [4]

In [8] and [9] resource-oriented search is proposed to work with resources in a structured way, following the steps shown in figure 3. This process includes elements of analysis and elements to create solutions. It can be applied either for problem solving or system improvement without the need to change it. In addition to that, it comprises elements of sketching the solution concepts and evaluate them with the concept of ideal final result (IFR). If the evaluation is satisfying the moving on to implementation is recommended. At the beginning, the ambivalence of resources was already mentioned. This ambivalence and the addition of further steps at the end of the process in figure 3 will be discussed in the next part.



**Fig. 3.** Process flow for resource-oriented search as proposed in [8, 9]

## 2 Resource Oriented Search

New materials and new production processes could be a great new resource for solving problems, which existed in systems for quite some time. Two examples from the past are lead and plastics. Both materials were and in the case of plastics are widely used before it was realised that they represent a great danger to the environment and the human health. Lead played an important role in the food industry to seal tin cans, in the automotive industry as a fuel additive and in electronics as a part of solder material. Furthermore, lead fittings and pipes were used in house hold plumbing. After the discovery and first application of lead in sub systems, complete system were made from lead followed by the banning of lead in many areas. This legal ban took place on the super system level after the discovery of illnesses cause by lead. Figure 4 shows this moving through the different system levels. For this the system operator (usually 9-windows) were expanded to 15 to illustrate the state the discovery of lead prior to its application within sub systems and the need for new substitute materials or processes after the legal banning within different areas of technology.

The same could be done with plastics. After the discovery, many sub systems appeared which decreased the cost of many products. Now many people could afford them and this created an even bigger mass demand. On system level, plastic drinking straws pushed natural straws to a niche market. Recent problems with sea pollution and health risk changed this and now drinking straws from natural resources re-enter the market because legal bans of plastic drinking straws are now in effect in several countries.

Getting back to the mapping of the generalised timeline of the two examples above to an expanded system operator figure, the first column on the super system level represents the discovery (of an effect, a material or any other resource). Moving on in time shows first applications on the sub system level, i.e. first components or parts of these are made from the discovered raw material or production process. Later on complete system are made from the material. After a certain time the exposition to the materials and experience with waste leads to a different perception of the material and its value. A complete life cycle of a product has been passed through and possibly quite some time has gone by.

This knowledge, together with the proposed process flow of working with resource in [8] and [9], suggests an additional step after having found first solution concepts. The new process is shown in figure 5. Now, the enhanced work flow embraces even more elements which not only refer to resource analysis but embrace moving and evaluating a solution as well.

The solutions should be as close to the ideal final result as possible. Therefore, this evaluation could be done easily by taking the problem analysis and considering the constraints which were defined in the first step of work flow. After the solution is deemed feasible, it is possible to move on to the implementation. Especially, if time is a relevant factor, this would be the way to follow. Nevertheless, after the introduction of the solution a critical evaluation is helpful because either the introduced resource could create additional advantages that have not been foreseen or a Failure Anticipation Analysis could be carried out for this new solution. The ambivalence of resource always do bear the potential harm of making a system worse after being introduced.

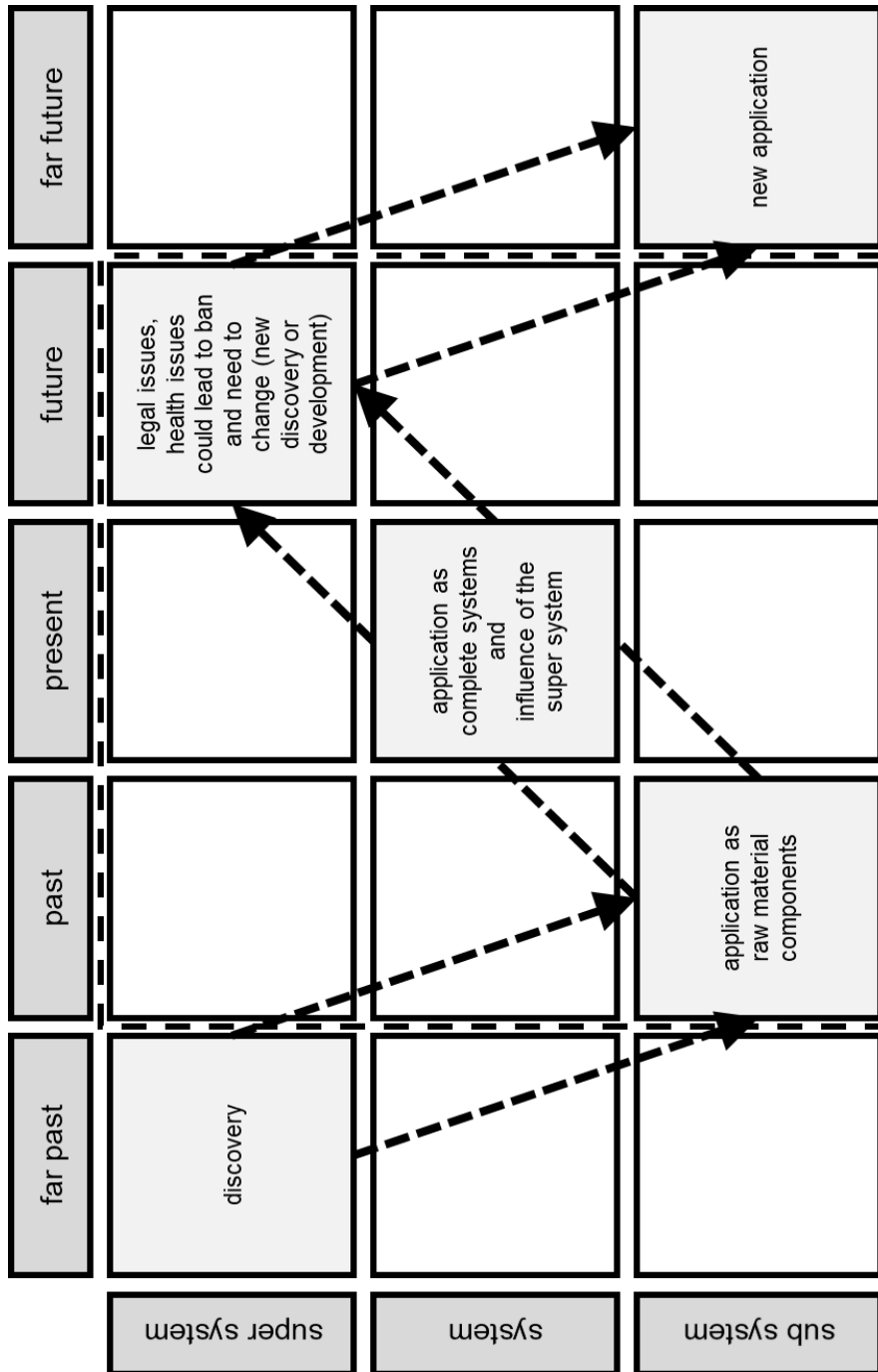
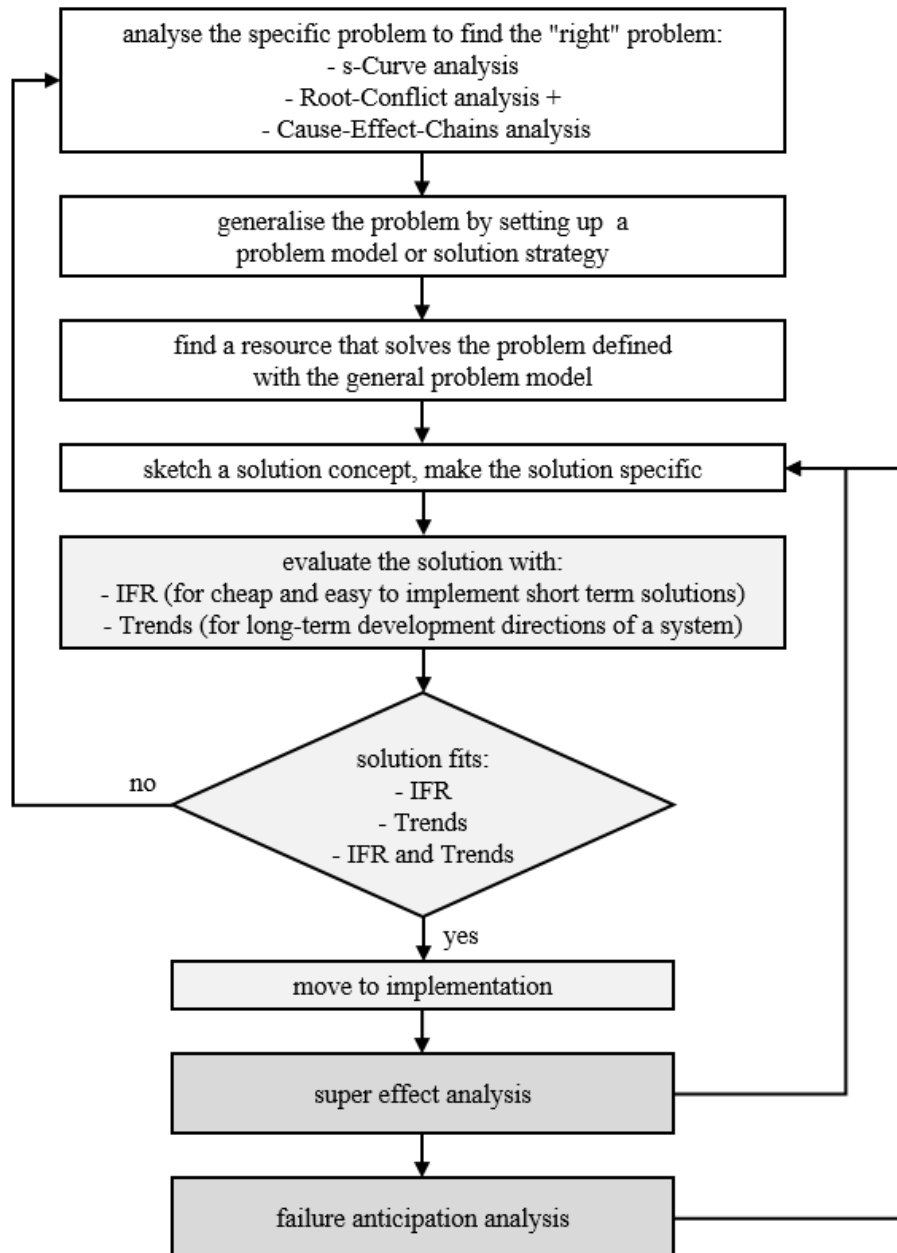


Fig. 4. 15-windows to visualise the possible ambivalence of resource





**Fig. 5.** Extension of resource-oriented search with anticipated failure detection

To anticipate possible failures or threats could lead to an advantage over competitors, e.g. being the first to the market and provide a solution that solves the problem of lead in solder. Being first to the market usually creates a competitive edge. Therefore, if a company could offer developed and tested electronic components which could withstand the higher solder temperature needed to use lead free solders might increase its market share.

For the two introduced examples this could be outlined in the following way.

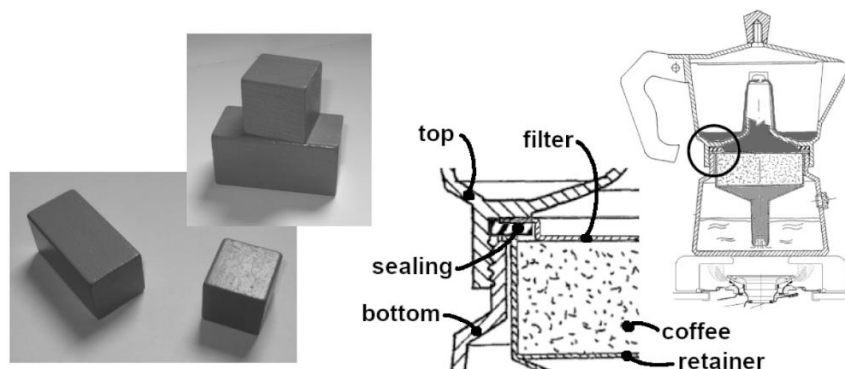
Using lead [10]:

- Discovery of lead and its properties.
- Parts and components made from lead - fittings, solder, pipes.
- Systems with lead as major - complete plumbing house installations.
- Health risks lead to ban of lead in certain areas - illnesses.
- Need arises to find alternatives - pipes made from composite material.

The plastic drinking straws:

- Discovery of plastics, its properties and manufacturing possibilities.
- Parts and components made from plastic - cost saving, possible mass production.
- Systems made from solely from plastics - drinking straws, packaging foils.
- Pollution of the environment and human health risks lead to ban of certain plastic parts.
- Need arises to find alternatives - metal drinking straws, biodegradable packaging or no packaging at all.

The following paragraph contains two examples of the proposed additional process flow steps. The first example is the building of a structure with wooden building bricks. This is shown on the left hand side in figure 6. On the right hand side of figure 6, the second example is illustrated ([11, 12, 13] edited by the author). It consists of the improvement of an Italian coffee-making machine, a moka.



**Fig. 6.** Building bricks and moka machine example

The problem in the building brick case is the insufficient stability of the created structure. The slightest touching of an already instable construction might ruin the building. Therefore, the player has the need for an increased stability. On the other hand, any change of the brick has a great impact on the manufacturing and the associated cost of the brick. The supplier would like to change the brick as little as possible. Looking at available resources and developing them a little further could lead to the following solutions (incomplete):

- introduce a mediator - additional components from the environment (little sticky paper, corner parts supplied as increased business)
- transition to  $\mu$ -Level: increase the surface roughness of the bricks (higher friction)
- transition to  $\mu$ -Level: introduce magnetic particles into the paint of the bricks

See also [8, 9] for details on the solution finding process.

As stated previously, the constraints for an ideal final result of the problem are:

- player: increase stability of the structure
- supplier: no change of the production process

If the solutions are evaluated, the changing of the painted seems a feasible solution. The only change is the change of the paint by adding magnetic powder to it. The increase in cost might be acceptable and compensated with an additional market share, if the users like this feature. After the introduction of this new resource, a super effect should be carried out as well. The metallic powder might also be used to increase the surface roughness and the implementation of the second solution is achieved without any further change. A shift in parameters, i.e. different grain sizes of the powder might lead to further improvements.

If this solution sounds like a good idea, great. However, what could happen after the implementation. The paint might be a health hazard to a child after the change is made. In addition to the health risk there might be more problems that have not been perceived yet, because there were no particles present in the paint before the change.

To foresee such problems prior to the implementation it is proposed to carry out a Failure Anticipation Analysis (FAA) including this new introduced resource, i.e. the substance and the field (magnetic, mechanical). The little magnets and its magnetic field could harm data storage or key cards: The increase of the surface roughness could cause scratches on the skin. These effects could be considered secondary problems and if they are solved prior to the market appearance, it helps avoiding dissatisfaction. FAA might help doing that in a structured way.

The second example deals with an improvement of a moka machine to make Italian style coffee. The coffee making process consists of filling the bottom with water, inserting the retainer into the bottom, filling the retainer with coffee powder and screwing the assembled upper part of the moka onto the bottom. In the upper part, the top holds the sealing and the sealing holds the filter. A groove in the bottom represents the rest of the retainer and the cylindrical area of the bottom provides guidance for the retainer. With the design illustrated in figure 6 (right), the filter surface in the direction to the coffee is completely parallel with the surface of the sealing holding it inside the top and

is therefore very difficult to remove. Again, the user encounters the problem. The manufacturer would like to change as little as possible but still is assumed to make the life for the user as easy as possible. With a change, a supplier might gain an advantage over the competition.

It is recommended to start looking for resources in the conflicting zone, i.e. the touching surfaces of the bottom and the retainer - in respect to the conflicting pair, the bottom and the retainer. If nothing is found a gradually moving away from the operating zone but sticking to the conflicting pair, e.g. areas of the bottom close to the retainer of moka might help solving the problem. The question is, do additional areas of touching of the conflicting components appear somewhere else. If not, are they close to each other somewhere. There is a similar approach in ARIZ85C, which is named stepping back from the ideal final result. And yes, the water inlet of the filter is very close to the inner surface of the bottom - they nearly touch. A solution idea is to introduce a spring, which is mounted on the retainer. This spring is compressed when the upper assembly is screwed onto the bottom and lifts the retainer after the disassembly. If a spring is now present, it could be made of conic shape (shifted parameter) to provide additional guidance of the retainer prior to the mounting. A spring is easy to manufacture, cheap and could be supplied as a service part.

On the other hand, the introduced metallic spring creates a thermal connection from the bottom to the retainer. The heat of the bottom is conducted to the retainer. This might be good, because the surface of the retainer could heat the water as well. The heat of the retainer might also do something to the coffee, which is bad because it would influence the taste. The touching of the spring on the bottom could affect the bottom because the spring is usually of hardened steel while the bottom is made from aluminium. The additional presence of heat might wear the bottom and the lifetime of the moka is reduced. These are only some examples of what could happen after the introduction of an additional resource. Failure Anticipation Analysis helps to find these problems early and ideally, the problems could be solved before the implementation of the solution.

The presented examples give an impression of the suggested way of working with resources in a new enhanced way. Instead of solely listing existing resource as in resource analysis, resource-oriented search is a combination of resource analysis and resource aided problem solving.

It requires the drawing of solution sketches and the explicit evaluation of the obtained solution against the ideal final result which has been derived in the first step of the process.

In ARIZ85C super effect analysis is carried out after finding a solution. The proposed process workflow contains this element as well. The recommended final step would be a Failure Anticipation Analysis (FAA) after the introduction of the new resource and the created solution sketch in which all new interaction could be discerned. The first helps to make the most of the new concept and the later helps to avoid possible problems prior to their appearance. In great need of a quick solution, FAA could be done after a first implementation followed by an option successive implementation step. Super effect analysis and Failure Anticipation Analysis are both pretty advanced TRIZ

tools and people, especially TRIZ beginners, who use the resource-oriented search because it is easy to grasp might not be familiar with it. Maybe the help of an external expert solves this problem for the first projects and when the knowledge is built up internal staff would take over.

### 3 Conclusions

The proposed process flow of resource-oriented search helps to deal with resources in an efficient and structured way. It provided newcomers to TRIZ a guideline to follow, i.e. it shows where to begin and how to proceed without overlooking important steps or constraints. As explained, resource-oriented search integrates elements from other TRIZ tools and is still easy to use. The process flow could be adapted in a stepwise manner, which limits the training or the help of external experts, i.e. apply the steps to the implementation and leave the following steps for a second implementation round. Nevertheless, the super effect analysis and FAA are important, because with these suggested additional steps the competitiveness of the company could be further improved.

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