TRIZ POWER TOOLS

Skill # 3 Idealizing Useful Functions

April 2012 Edition

Removing, Replacing and Adding Functions

TRIZ Power Tools
Idealizing Useful Functions
April 2012 Edition

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This book is the work of a collaborative group of coauthors.

Coauthors

Larry Ball

David Troness

Kartik Ariyur

Jason Huang

Steve Hickman

Petr Krupansky

Larry Miller

Editors

Erika Hernandez

Larry Ball

David Troness

Paul Dwyer

S. Robert Lang

Illustrators

Larry Ball

David Troness

Other Authors, Theoreticians, Practitioners Whose Writings or Teachings have Impacted This Work

Genrich Altshuller

Ellen Domb

Roni Horowitz

John Terninko

Alla Zusman

Boris Zlotin

Lev Shulyak

Yuri Salamatov

Victor Fey

Eugene Rivin

Darrell Mann

Sergei Ikovenko

Simon Litvin

Peter Ulan

Lane Desborough

Clayton Christensen

Renee Mauborgne

Kim Chan

The Algorithm

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Introduction

(If you are reading the PDF format—navigate the algorithms with the "Bookmarks" to the left. L1, L2, L3 correspond to levels of the algorithm. The levels are hierarchical; you can go as deeply as required to resolve your problem. Lower levels (L1, L2) have consolidated methods. If you are using the book then use the Table of Contents for the Algorithm)

All of the books in the TRIZ Power Tools book series are designed to be used as algorithms. Each algorithm can be as detailed or simple as required. This is done by going up or down in the hierarchy of the process steps. The top level (L1) of the bookmarks is the highest level. If more detail is required, the user can go to deeper levels (L2 and L3). .

Where the Book Materials Come From

Much of the material for this book was inspired by the thought leaders referenced. The original intent was to codify the insights of these thought leaders, but the exercise of codification ultimately led to the synthesis of other experimental processes. This is because codification required recognizing patterns of similarity of tools. Once this was achieved, the various tools were grouped with key decisions. Decisions require and create information which flows to the next decisions. Patterns and gaps became visible during this formative process. Experimental methods were inserted into the gaps. The proof of these experimental methods is whether they actually help the reader to identify product or process characteristics that will delight the market.

Idealizing Functions

In the website introduction (www.opensourcetriz.com) to this series of books, the concept of a Hierarchy of Decisions was introduced. One part of this hierarchy is repeated over and over, the idealization of functions. Whether we are creating a system, overhauling a system or fixing a problem with the system, we use tools to focus in on one function at a time. When we create a system, we add a function at a time. When we overhaul the system, we identify burdensome functions that must be changed. In each case, we are focusing on a function which we would like to make as ideal as possible.

Functions state changes that occur in time or *results*. If we use a function to describe the final state of an object's attributes, then we are describing a "result". If we are describing an ideal result, then we are describing an idealized function. Just as a method can be proposed to work the bucket problem backward, so a path is proposed to work backwards from the ideal final state of an inventive situation. This is effectively accomplished in the following steps for idealizing a useful function:

Step 1: Identify an ideal product.

Step 2: Identify an ideal modification (Step 1 and 2 give the ideal result. The path to this result is stated in the next two steps).

Step 3: Identify potential ideal physical phenomena to deliver the function.

Step 4: Identify an ideal tool to deliver the physical phenomena. (This completes the traditional IFR by stating a means to the ideal result.)

Step 5: Indentify resources (object attributes) that we will use to control the functioning of the system.

Step 6: Idealize the Attributes of the Objects and Fields. (Now we start to consider the ideal attributes of new objects. When we added objects for the product and tool, we created mental models of these parts of the system. This added problems that now need to be addressed.)

Step 7: Resolve the resulting contradictions. (This step considers the ideal distribution of the properties of the object, further solidifying mental images of the system into more ideal states).

These steps are for working with useful functions. The order is changed slightly for working with informing and harmful functions.

It is notable that many of the Solution Standards and other TRIZ tools were already stated in functional language. Suggestions for how we might find a more ideal functional part come from a restructuring and reinterpretation of the parts of the Solution Standards that deal with eliminating, redefining or replacing system parts (object resources). Idealizing Functions is the convergence the Ideal Final Result, Function Analysis, and the Solution Standards. Thus, there was a ready supply of approaches to describe the final state.

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L1-Idealize Useful Functions

The first step to idealizing a useful function is to identify and isolate the final ideal state in functional terms. We start by considering useful functions first, because informing functions are actually a special case of useful functions and one major path of idealizing harmful functions is to turn them into useful functions. Once they are turned into useful functions, they may be idealized using the steps shown in this book

One might ask "Why idealize something that is already useful?" We idealize useful functions, because there are so many options to either avoid performing the function or to eliminate elements from our system. When we eliminate the need for an element, we also remove the need for auxiliary functions which support this function.

Progression of Possibilities from Most to Least Ideal

As we go down the list of possibilities, we will generally start with the most ideal possibilities and proceed to the least ideal. The most desirable is that there is no modification required. In this case, no tool is required and hence, no supporting elements are required. . The least desirable is that the modification is required and a tool in the system must be required to perform the modification. In this case, supporting elements may be required to perform the function or mitigate its bad effects. (Remember that each element brings its own set of problems. Every element adds its burden to the system). In between these two extremes are all gradations of ideality. Let's look at the range of possibilities.

L1-Method

Step 1: Identify and Isolate the main modification

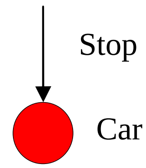
Step 2: Brainstorm the Ideal Product. Look for ways to not require the product in the first place. For instance, if a waste component is being modified, find a way that the waste component is not required. Find out why the product is needed. Remove the need for the product. Look for ways to have the product come with the function already performed

Step 3: Brainstorm the Ideal Modification of the Product. Find a way to avoid needing the offending parts by reversing the situation. For instance, make moving parts stationary and stationary parts moving. Consider harmonizing when things happen so that you get the most good out of them.

Step 4: Brainstorm the Ideal Physical Phenomenon to deliver the Modification. Consider using a different physical phenomenon that does not require the offending parts and is more abundant. Consider using a hybrid of the existing physical phenomenon and a new phenomenon without the problems of the existing system.

Step 5: Brainstorm the Ideal Tool to Deliver the Phenomenon. Find out why the tool is needed in the first place and remove the need for the tool. Consider simply removing the tool and allowing other elements of the system or the surrounding system to take over their useful function.

L2-The Ideal Product



Regardless of whether the function already exists, we want to identify the most ideal embodiment of the element that is being modified. Let's say that we are trying to come up with a way for the police to stop a speeding car without harming the occupants or other motorists. If we know a way to do this, for the moment, we will ignore this and concentrate on only two elements: the product and the modification that we are trying to achieve.

The product is the "car" and the modification is "stop". Now we begin setting up the IFR. Knowing only these two parts of the function allows us to ask the important question: What is the ideal product? The answer is surprising. The most ideal product is one that does not exist. (The car should not exist), hence the tool and all attending auxiliary functions are not required. Thus we come very close to the realization of the ideal machine. We may not require the product for a variety of reasons. It may be a transmission element that we can bypass. (Is the car a transmission element? Not really.) It may be a waste element that does not require existence in the first place. (Is the car considered waste? Not really.) A slight modification of the product may make the modification unnecessary. (If the car could be easily tracked, then I might not require stopping it) or the product may already come with the modification performed. (By the time that the police reach the car, the driver is compelled to not want it anymore and it is already stopped).

If the product is required, then we ask the question: What minimum part must be modified. (Is it the car that we want to stop? Maybe we only want to stop a part of the car such as the engine or the occupant). If only a small part requires modification then the resources required to perform the modification can also be minimized.

Finally, if the product is required, how can we get the most value for our effort? Let's make the modification as far reaching as possible. If the product comes in natural groupings, let's modify the whole group. If other objects nearby require the same modification then let's modify as many things as possible. This increases the value that the user derives from performing the function. (Perhaps the police signal all cars on the road to slowly decelerate thus making the situation safer for everyone)

L2-Method

Step1: Write the product and the modification

Step 2: Consider what change of the product would make it so that the modification is not required. Could it come with the modification already done?

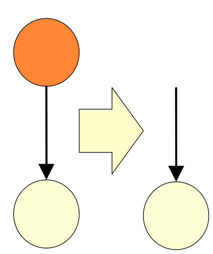
Step 3: If the product is a transmission element, consider bypassing it.

Step 4: What is the minimum part of the product that requires modification?

Step 5: Consider modifying natural groupings of like and unlike elements

L3-Consider only the Product and the Modification

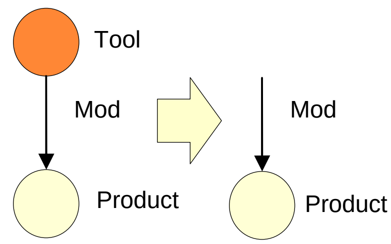
If a system is being simplified, the function may already come with a tool. If a new function is being created, the tool is not yet evident. We do not need the tool. It is a burden to our reasoning. We take nothing for granted and start with just the modification. For the moment, this is the most ideal form of the final result that we know. However, this will soon change as we consider other more desirable results.



For the moment, we must be unencumbered with a tool to perform the function. The tool almost always comes with undesirable functions or features. It may even be harmful to the product or other elements in the system. For now, we will forget it and just talk about what we want to happen.

Method

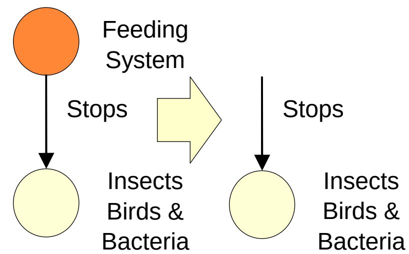
Write the function without the tool



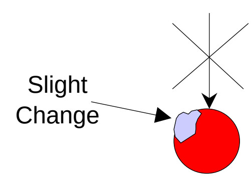
Example—Pet Feeding System

Write the function without the tool

I am interested in some sort of pet feeding system that protects the food from ants, roaches, birds and bacteria



L3-Modification Not Required



All useful functions can be thought of in a remedial or preventative context. This may not seem intuitive at first, but let us consider a couple of cases. A lawn mower cuts grass. Is this a remedial action? Yes, because it remedies the height of the grass. One could reason that if the grass were doing its job better, it would grow to an even height and then stop. While this may seem obsessive, it is nevertheless a very useful way to look at a situation from a new point of view. In order to accomplish this result a slight modification of the product is usually required. We might know why a modification is required if we have taken pains in our causal analysis to determine the need. Recall that we did this by considering the need for existence of objects. Objects are required to modify other objects. Once we understand why an object is required, then we also understand why the modification is required. The questioning of existence of objects usually begins an alternative problem path in the causal analysis diagram. When we consider non-existence of elements in the system (in the side-by-side box), we begin an alternative problem path which leads us to understand why an element was originally required in the system. It is possible to remove the need for the troublesome element and often other elements by resolving a problem elsewhere in the system.

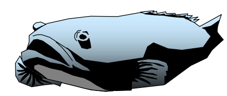
Recall that the non-existence of a function element is depicted in the causal analysis as a function box showing a function which has no tool. The tool was required to perform a function which no longer is performed because the tool is missing. One solution of the alternative problem path is to find a new way to perform the function of the missing object. This often leads to the consideration of how the function might be performed by existing elements, thus simplifying the system.

Method

Step 1: Why is the Function Required? What does it prevent? What does it fix? What does it make up for? Does it counter something? Follow this reasoning back through the causal relationships.

Step 2: A slight change to an object in the system (often the object that we are serving) removes the requirement for the main function and hence the objects that deliver the function. In other words, if something did its job better, then our system wouldn't be needed.

Example—the Scaling of Fish



Step 1: Why is the Function Required? What does it prevent? What does it fix? What does it make up for? Does it counter something?

Scaling removes scales and underlying tissue that may change the flavor during cooking and are also disgusting to certain cultures to eat. This is a remedial action.

Step 2: A slight change to an object in the system (often the object that we are serving) removes the requirement for the main function and hence the objects that deliver the function. In other words, if something did its job better, then our system wouldn't be needed

Consider changes to cooking methods that make scales a delicacy— Now the function of scaling is no longer required.

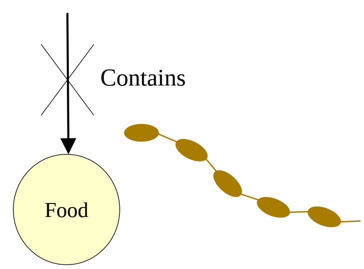
Example—Dog Food Bowl

Step 1: Why is the Function Required? What does it prevent? What does it fix? What does it make up for? Does it counter something?

Containing the food is required to keep it from getting dirty or wet.

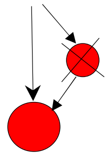
Step 2: A slight change to an object in the system (often the object that we are serving) removes the requirement for the main function and hence the objects that deliver the function. In other words, if something did its job better, then our system wouldn't be needed

The dog food requires no container because it does not come in independent pieces. For instance, the food is linked together or comes as one piece. Perhaps it just hangs on a roll.



L3-Remove Transmission or Transformation Elements

This tool comes from the Laws of Development of Systems and in its original form was called the Law of Energy Conductivity.[1] :



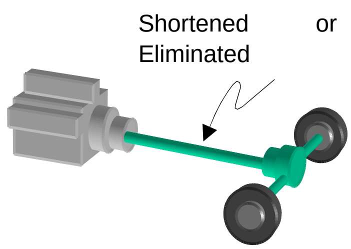
> A necessary condition for the life capability in principle of a technical system is the unhindered passage of energy throughout all parts of the system.

It follows that:

—Transmission paths are shortened and eventually eliminated

—Energy transformations are reduced and finally eliminated.

—Muscle and control elements use the same field.



When applying this law to the ideal product, it means that we should consider bypassing traditional or existing transmission/transformation elements and go directly to the object that requires modification. If the product of the function that we are considering is a transmission element, then we should consider whether it is required or if we can find some way to bypass it altogether or avoid the transformation of energy and use the energy more directly. Some elements masquerade as important functioning elements but are transmission/transformation elements instead.

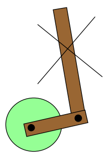
Method

Step 1: Is the product a transmission/transformation element? (Does the product transmit, transform or convert energy?)

Step 2: Bypass the element.

Example—Linkage Operated System

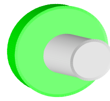
Many systems require rotary movement. Of these systems, a large number convert linear motion to rotary motion through a linkage. The actuators in these systems do not act directly on the working element.



Step 1: Is the product a transmission/transformation element? (Does the product transmit, transform or convert energy?)

The current system operated on a linkage assembly to turn an object.

Step 2: Bypass the element.



The new system directly rotates the element with a rotary actuator. The actuator works directly on the element of interest without the need for a transmission.

1 Creativity as an Exact Science—the Theory of the Solution of Inventive Problems, G.S Altshuller, Gordon and Breach, page 225 Some modern TRIZ theorists have expanded this Law and given it other names.

L3-Remove the Product

A product that does not exist does not need to be modified. If the product performs a useful function then that function must be performed by something else. The product can often be removed if it performs an auxiliary function. It is easy to lose track of whether the product is required in the first place. If the product is harmful or even a waste product (such as sawdust or leaves) wouldn't it make more sense to not have it around in the first place?

Method

Step 1: Does the product perform an auxiliary function or is it ever harmful or waste?

Step 2: Eliminate the product through the following methods:

--Method 1: Directly eliminate the product.

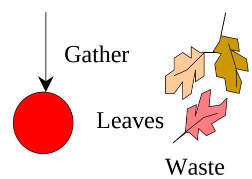
--Method 2: Eliminate the sources of the product.

--Method 3: Eliminate the path that the product moves to get to the location.

--Method 4: Absorb the product so that it is not harmful or wasteful any more. Consider using absorbent materials such as fabrics, powder or batting.

Example—the Collection of Leaves

The collection of leaves is a common problem.



Step 1: Does the product perform an auxiliary function or is it ever harmful or waste?

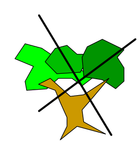
Unfortunately, it is considered waste in many areas. (Actually, it is nature's way of revitalizing itself. But, for this problem, we will consider it waste.)

Step 2: Eliminate the product through the following methods:

Method 1: Directly eliminate the product.

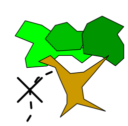
The leaves simply don't exist. Since we may not know how this occurs directly, it creates a contradiction: The leaves must and must not exist.

Method 2: Eliminate the sources of the product



Remove the tree. This may be a solution in certain cases. Again, it may lead to a contradiction: the tree exists and doesn't exist.

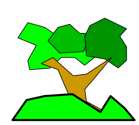
Method 3: Eliminate the path that the product moves to get to the location.



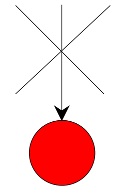
Remove the path to the ground.

Method 4: Absorb the product so that it is not harmful or wasteful any more. Consider using absorbent materials such as fabrics, powder or batting.

Something below the tree absorbs the leaves or at least hides them. Ground cover is often a good way to do this.



L3-Comes with Modification



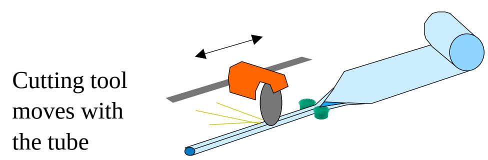
In certain situations, a modification can be performed upstream by the provider of the elements more conveniently than later. The product may be in a much more convenient form to perform the function. This is often true in a manufacturing environment such as during assembly. Pre-coated or pre-assembled parts can be more conveniently assembled. Forming and cutting operations can be more conveniently done when the material is in a more convenient form. Pre-modifying the product often leads to a contradiction. The modification must and must not be made.

Method

The product does not require the modification because it is already incorporated.

Example—Pipe Forming Machine

Pipe forming machines feed a flat ribbon into a forming machine that rolls the ribbon into a tube and welds it. The tubes are cut to length by a saw that moves with the formed tube while it is cutting to reduce the time to cut.

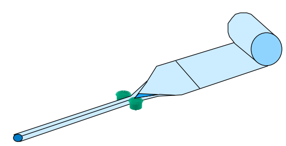


Faster and faster forming rates require the cutter to return more rapidly.

This results in many additional problems. Consider the ideal product. The tube must be cut before it is formed. This slows production (compared to a single ribbon) so the tube must be cut and not cut.

The product does not require the modification because it is already incorporated.

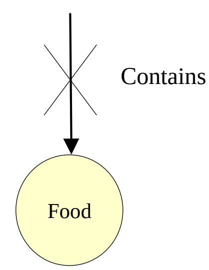
The tube is partially cut by stamping the tube before rolling. A hard twist fully cuts the tube.



Example—Pet Food Bowl

The product does not require the modification because it is already incorporated.

The food comes already contained. It matters not if the food is poured directly upon the ground. Neither the dog nor the food will sustain any injury.

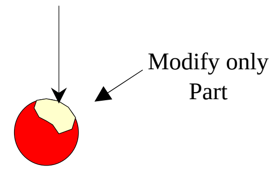


L3-Modify Minimum Part

If we have concluded that it is not possible to avoid the requirement for the modification, then we should consider modifying the least amount of the product as possible.

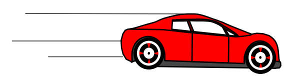
Method

What minimum part of the product must be modified? Produce a list of alternative products which are a minimized subset of the main product. Consider all subsets of the original product down to the molecular level.

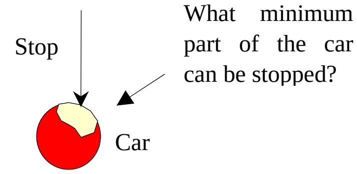


Example—Stopping a Speeding Car

Every year innocent people are hurt or killed during high speed chasses. About 40 percent of high speed chases end in crashes. How can the car be stopped?



What minimum part of the product must be modified? Produce a list of alternative products which are a minimized subset of the main product. Consider all subsets of the original product down to the molecular level.



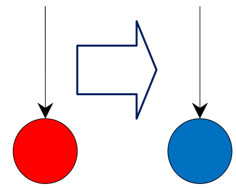
What if we only stop the driver, the tires, the drive shaft, the engine computer or carburetor, the tire, the electrical ignition spark?

L3-Different Product

Here we consider the possibility that the modification should be performed on something different. This could also spark the possibility that there is a better modification than the given one as well.

Method

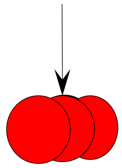
Is the modification being performed on the ideal product? Would something else be better?



L3-Natural Groupings

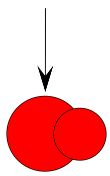
The seed for this tool comes from the standards involving multiple system elements.[2] [3] [4] [5] However, there is a twist to the idea. Simply increasing the number of product elements that are acted on is definitely an improvement over performing the functions on single product elements, but it is yet more useful when the products come in natural groupings. Such groupings often are dictated by nature or commonly accepted manufacturing conditions.

Multiple Products



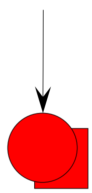
If we have concluded that the function is required, then let us get the most out of it that we can. Here we consider extending the function to as many elements as possible by looking for natural groupings. The evolutionary tendency of performing functions on multiple objects is to perform them in parallel. This can involve performing the function simultaneously on a grouping of objects, especially if these groups are natural groups such as a flock of geese, a mouthful of teeth, a pallet of objects, or a box of cereal. Extending the function to more of the same elements at the same time can reduce the overall amount of resources required. However, there are no guarantees that modifying the whole natural group will require fewer resources. At this point, we may not know how we may accomplish this feat, but we continue in hope of finding a physical phenomenon that can do this.

Biased Products



Biased products are products that are alike in function and other material ways, but in less significant ways different from each other. Nails come in different sizes. If a hammer can effectively drive a tiny nail and a large framing nail, it is more valuable to the user. A natural grouping of nails might be related to a certain type of construction job that requires a variety of nails. During this manufacture, it is desirable to perform the function on this group, at the same time or serially with the same system.

Diverse Products



Diverse products are products that are so different that, while they are associated with the same function, they are typically not associated with the same tool. Natural groupings of diverse products are objects that require the same function and are found together during a task or job. If possible we would like to perform this function on all diverse objects at the same time.

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2 STANDARD 3-1-1. System efficiency at any stage of its evolution can be improved by combining the system with another system (or systems) to form a bi- or poly-system. Notes: For a simple formation of bi- and poly-systems, two and more components are combined. Components to be combined may be substances, fields, substance- field pairs and whole SFMs. Example: To process sides of thin glass plates, several plates are put together to prevent glass from breaking.

3 STANDARD 3-1-2. Efficiency of bi- and poly-systems can be improved by developing links between system elements. Notes: Links between elements of a bi- and poly-system may be made either more rigid or more dynamic. Example: To synchronize a process of lifting a very heavy part by three cranes, it is proposed to use a rigid triangle synchronizing the cranes moving parts.

4 Inventive Principle #7—Nesting (Matrioshka): One object is placed inside another. That object is placed inside a third one. And so on. An object passes through a cavity in another object. Genrich Altshuller, The Innovation Algorithm page 287.

5 STANDARD 3-1-3. Efficiency of bi- and poly-systems can be improved by increasing the difference between system components. The following line of evolution is recommended: similar components (pencils of the same color) –->components with biased characteristics (pencils of different colors) –->different components (set of drawing instruments) –->combinations of the "component + component with opposite function" (pencil with rubber)

Method

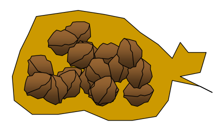
Step 1: Do the subjects that require the same function come in natural batches or groups? Do they come in large groups or in groups that are hard to separate? The subjects may be identical, similar in some aspect or completely different. The important question is whether they require the same measurement.

Step 2: Is it more ideal (or easier) to perform the function on the group simultaneously?

Example—Shelling Nuts

Step 1: Do the subjects that require the same function come in natural batches or groups? Do they come in large groups or in groups that are hard to separate? The subjects may be identical, similar in some aspect or completely different. The important question is whether they require the same measurement.

The nuts come in a bag.



Step 2: Is it more ideal (or easier) to perform the function on the group simultaneously?

In this case, it would much more ideal to shell the whole bag of nuts at once.

Example—Picking Fruit

In orchards, the fruit is often picked by hand. If this is automated, there is a problem. The whole tree should be picked at once, but there is a wide variety of fruit that must be picked. Some come off easier than others and they are at different levels of maturity.

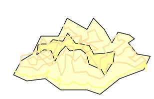
Step 1: Do the subjects that require the same function come in natural batches or groups? Do they come in large groups or in groups that are hard to separate? The subjects may be identical, similar in some aspect or completely different. The important question is whether they require the same measurement.

The fruit is at different levels of maturity and cling to the tree with different degrees of attachment. Also, there are a variety of fruit that might be picked.

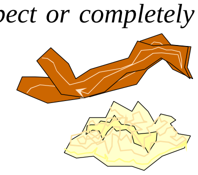
Step 2: Is it more ideal (or easier) to perform the function on the group simultaneously?

There is a large variety of fruit that this would apply to and the variation in attachment to the trees is also quite high. The ability to pick whole trees (a natural grouping) and the ability to apply this to fruit with a high variability of attachment strengths would be very useful in large orchards.

Example—Cooking Bacon



Step 1: Do the subjects that require the same function come in natural batches or groups? Do they come in large groups or in groups that are hard to separate? The subjects may be identical, similar in some aspect or completely different. The important question is whether they require the same measurement.



Eggs are generally associated with bacon.

Step 2: Is it more ideal (or easier) to perform the function on the group simultaneously?

Yes, Eggs can be included. The heat is there, but usually there is an over abundance of bacon fat. Remember that we have only considered the possibility of doing these together. In some cases, finding the means to do this is simple.

L2-The Ideal Modification

The Ideal Modification for Useful Functions

After focusing on the ideal product, the second part is the ideal modification. We ask "What do we really want to have happen and what are the attributes of the ideal modification?"

Since we have not yet decided what will deliver these idealized modifications to the product, we are actually composing a wish-list of what the ideal modification will look like. When we add real elements to deliver the modification, these elements often bring undesirable characteristics with them.

Since we are dealing with functions that are already useful, we would like to do the most good possible. It is easy to assume that because a useful function exists, that there is not a replacement function that is even better or that we might want to reverse things and perform the opposite function. The question is: What do we really want to have happen?

How do We Identify the Ideal Modification?

Let's refer back to the concept that Altshuller proposed for solving problems that require guesswork. Remember that a mathematical problem was proposed. How can we return with exactly six gallons of water if we have only a four and nine gallon bucket? Mathematical problems that normally require guesswork when solved forward are often more rapidly solved by starting with the solution and then working backwards. Altshuller proposed that, since solving inventive problems also requires guesswork, the solution will be more rapid and satisfying if we start with the ideal solution.

Altshuller proposed another, more important, reason for solving backwards. Solutions that start with mental pictures of existing machines are usually variations on these structures and end up more complex than they need to be. We must free our minds of these structures by starting afresh with an ideal solution. Altshuller called this preferred end state or solution the ideal machine.

The process of identifying the Ideal Final Result was begun when we considered the ideal product. Now we must consider what must ideally happen to this ideal product, *given that it still is required*. Since the final result is actually a modification to the product, we can continue to write about the ideal machine in functional terms.

At this stage, we will put together *several* versions of the ideal machine by describing the modification in ideal terms. We must remove our inhibitions and let it magically happen. Since there may be many ways to describe the modification that will give new insights, we consider a variety of ways to think of the modification that allow us to make better use of resources.

In the process of looking for the ideal machine, we will also consider the reverse modification[6]. It is easy to become locked into thinking of the function in the way that we always have. By asking what we are performing the function relative to, we see that there are other possibilities.

As a matter of practicality, the function should be described correctly in order to achieve the most good. Please refer to the chapter on writing functions if there are questions on how to write functions or deal with confusing functions.

Setting the Bar for How Well the Modification Must be Performed

6 Inventive Principle #13—Do It in Reverse: Instead of the direct action dictated by a problem, implement an opposite action (i.e., cooling instead of heating). Make the movable part of an object, or outside environment, stationary and stationary part moveable. Turn an object upside-down. Genrich Altshuller, The Innovation Algorithm page 287.

The next set of tools help us to decide the attributes of the ideal modification. At this stage, we continue our quest to identify several ideal modifications. If I could snap my fingers, how much modification do I really want? How well, how long, etc.

Since it is possible to overdo a modification causing other problems, we may need to constrain ourselves by asking this in a slightly different way. *What level of modification will give us a long-lasting solution?* By doing this, we recognize a truth: eventually the system will evolve to a point that it must be improved again. In the mean time, it will not be necessary to change this parameter or even consider it very much. This is different than the common way of changing systems where a parameter is just improved enough to get by. This leads to legacy problems that continue to crop up with the next version of a product.

It is important to note that insights derived at this stage have the ability to influence each other. Insights gained during one activity may be upset by insights gained in other activities. Consequently, it may be necessary to jump back and forth between tools.

L2-Method

Step 1: Write the modification in a variety of ways to see if any way is more ideal.

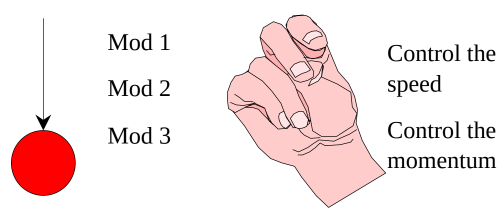
Step 2: Consider the inverse modification. Look at what the modification is being performed relative to and modify that instead.

Step 3: What is the ideal level of the modification? What is the ideal sequence? What is the ideal duty cycle? What is the ideal adjustability? What is the ideal use of energy? When should the modification be excluded?

Step 4: If the function carries a burden, consider how that burden can be turned into a useful function.

L3-Describe a Variety of Ideal Modifications

What are ideal final results? Describe this in a variety of ways. What would I want to happen if I could do it magically by snapping my fingers? We would like to consider several ways because each way may lead to a different physical phenomenon to accomplish the function (depending on abundance of system resources). Some of these ways may be more ideal than others.



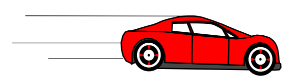
Method

Step 1: Are we changing or controlling? Which makes the most sense?

Step 2: Work backward by imagining several ideal final states. Using the longhand form of the modification, consider different ways to describe the modification. Consider moving from the macro world to the micro world (atomic level and beyond).

Example—Stopping a Speeding Car

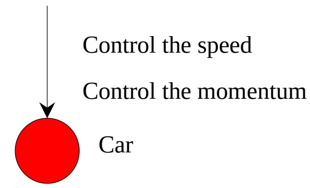
Step 1: Are we changing or controlling? Which makes the most sense?



In this case, we want to control the speed of the car to a set speed. This speed may not be zero and in fact, it might be dangerous to stop a car in the middle of fast traffic.

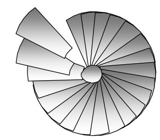
Step 2: Work backward by imagining several ideal final states. Using the longhand form of the modification, consider different ways to describe the modification. Consider moving from the macro world to the micro world (atomic level and beyond).

The different possibilities are shown in the figure to the right.



Example—Blade Loss of a Fanjet Engine

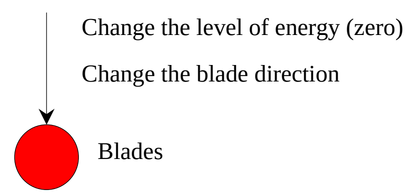
A jet engine fan loses some fan blades. This is sometimes referred to a blade-out condition. It can be caused when an object is ingested into the engine such as a bird. Each of the blades carries a tremendous amount of kinetic energy. When one blade goes, it often takes out other blades. The effect is explosive.



Step 1: Are we changing or controlling? Which makes the most sense?

In this case, we are changing. The blades start in one state and we must move to another.

Step 2: Work backward by imagining several ideal final states. Using the longhand form of the modification, consider different ways to describe the modification. Consider moving from the macro world to the micro world (atomic level and beyond).



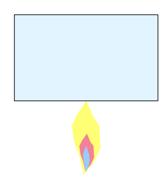
The different possibilities are shown in the figure to the right.

Example—Heating a Gas

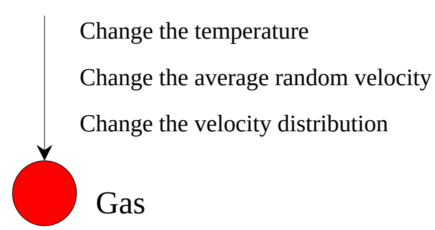
How can we describe the heating of a gas?

Step 1: Are we changing or controlling?

We have already described this as a change of state, thus we are changing rather than controlling.

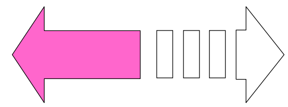


Step 2: Work backward by imagining several ideal final states. Using the longhand form of the modification, consider different ways to describe the modification. Consider moving from the macro world to the micro world (atomic level and beyond).



The different possibilities are shown in the figure to the right.

L3-Consider an Ideal Inverse Modification



Sometimes it is more ideal to do the reverse of the required action[7] *or modification. For instance, it may actually require fewer resources to move a person relative to a work object than it is to change the height of a heavy work object. In order to consider reversing a modification, it is necessary to consider what the action or modification is relative to. If two objects are moving relative to each other, it is usually easy to determine what the modification is relative to. With other modifications, it may take more thought.*

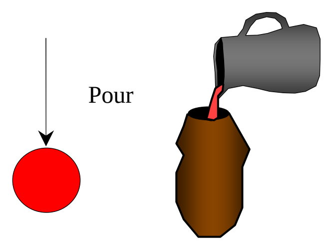
Method

Step 1: What object is the modification performed relative to?

Step 2: Invert the problem by modifying the relative object. (Make it the product).

Step 3: Go back and describe this in a variety of ideal ways.

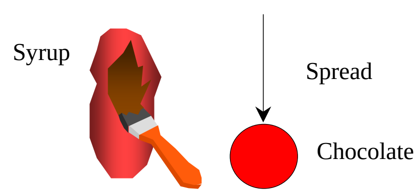
Example—Pouring Hot Syrup into a Chocolate Container



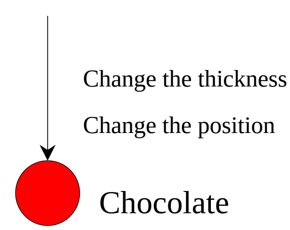
Step 1: What object is the modification performed relative to?

The pouring is relative to the stationary chocolate form

Step 2: Invert the problem by modifying the relative object. (Make it the product).



Thus, instead of pouring the syrup relative to the stationary chocolate form, we spread the chocolate relative to a stationary syrup form which has been frozen. Spread the chocolate onto the syrup.



Step 3: Go back and describe this in a variety of ideal ways.

Note that the variety of descriptions does not add a great deal to the understanding of how this function can be accomplished in this case.

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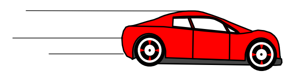
7 Inventive Principle #13—Do It in Reverse: Instead of the direct action dictated by a problem, implement an opposite action (i.e., cooling instead of heating). Make the movable part of an object, or outside environment, stationary and stationary part moveable. Turn an object upside-down. Genrich Altshuller, The Innovation Algorithm page 287.

Example—Stopping a Speeding Car

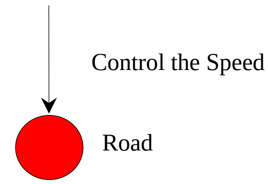
Step 1: What object is the modification performed relative to?



The slowing is relative to the road.

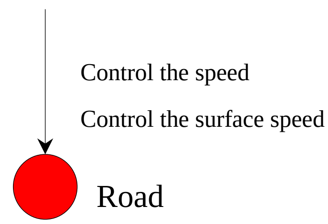
Step 2: Invert the problem by modifying the relative object. (Make it the product).

Thus, instead of stopping the car, we speed up the road so that the car and road are moving at the same velocity.



Step 3: Go back and describe this in a variety of ideal ways.

Note that this tends to describe some fashion of lubrication between the road and the tires which was not previously considered.



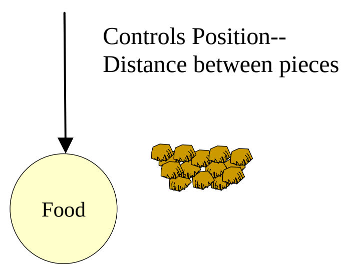
Example—Pet Food Container

Step 1: What object is the modification performed relative to?

The pet food is contained relative to the surrounding environment.

Step 2: Invert the problem by modifying the relative object. (Make it the product).

The food is positioned relative to the surrounding environment. Can we adjust the surroundings to accept scattered food?



Step 3: Go back and describe this in a variety of ideal ways.

If the food is scattered nobody cares because it just blends in with the surrounding.

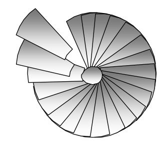
L3-What is the Ideal Level of Modification?

Determine the actual level of the ideal modification. This level usually involves a metric of some sort. As we begin to adjust the levels of the modification, we start to chip away at psychological inertia and gain insights. Perhaps what we are doing is not the correct function. Perhaps there are functions which are more ideal. (Note that these will give more knobs in causal analysis).

Method

If I could snap my fingers, what would the ideal level be?

Example—Blade Loss of a Fanjet Engine

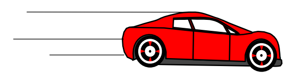


We continue our consideration of the loss of blades for a Fanjet Engine. We will only consider one of the ideal modifications that were named which is to change the energy level of the blade.

If I could snap my fingers, what would the ideal level be?

The energy should dissipate low enough as to never reach the cabin. Essentially, the blades have zero kinetic energy relative to the aircraft.

Example—Stopping a Speeding Car



If I could snap my fingers, what would the ideal level be?

Continuing with the example of a police officer stopping a speeding car, we realize that bringing the car to a complete stop may not be required or even desirable. It may be more desirable to control the maximum speed of the car. This allows us to control the situation better. For instance, if the car is already stopped, then we may want to guarantee that it is stopped for good. On the other hand, if the car is moving at a high rate of speed on a busy freeway, stopping the car might be dangerous to other cars. It may be better if the car were gradually slowed rather than stopped.

L3-What is the Ideal Sequence of the Function?

This method comes from considerations of harmonizing functions[8] or actions in a system.

> The law of harmonizing the rhythms of parts of the system. An essential condition for the living viability in principle of a technical system is the harmonization of the rhythms (frequencies of vibration, periodicity) of all parts of the system.

Considering the ideal sequence will continue to give us more insights into the ideal modification. As we consider when it should occur, it may affect what we believe the ideal modification should be. A powerful tool for investigating this is the process map. This can be accomplished in a variety of ways, including a storyboard or simply words in sequence. However it is done, it is nice to show the possibility of functions performed in parallel as this will be one of the considerations that we make.

Method

Create a process map of the sequence of functions. The subject function should show up as a block in the process map.

Step 2: Consider performing the function in different sequences. Move it earlier or later than currently performed. Try moving it so far forward that it is no longer during the

8 Creativity as an Exact Science—the Theory of the Solution of Inventive Problems, G.S Altshuller, Gordon and Breach, page 226.

normal process sequence. Consider moving it so far backward that it is no longer part of the ordinary sequence.

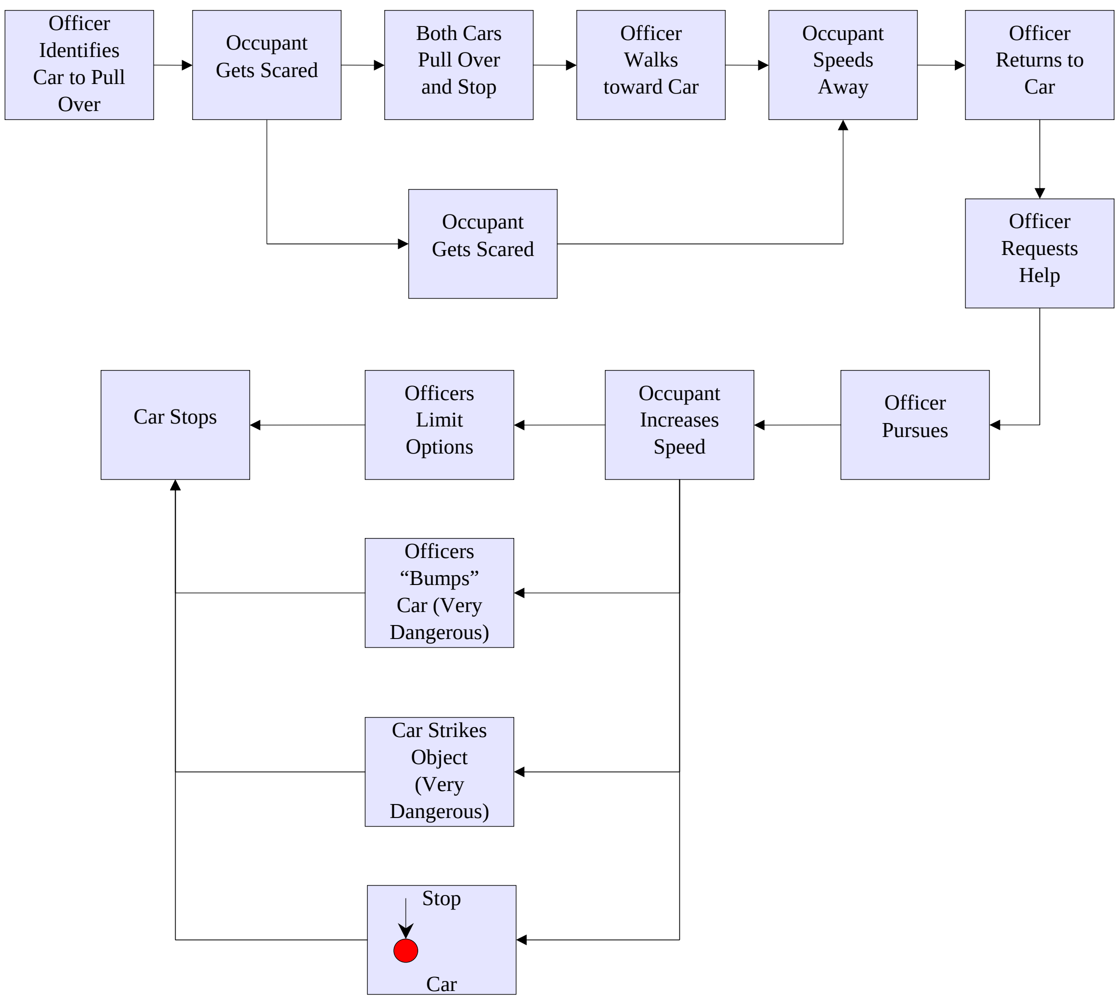
Step 3: Can the function be performed in parallel with other functions? Can the function be performed during other functions such as during transportation or while queued or waiting?. Can setup be performed at the same time as the operation? Rapid setup often implies the use of a previously placed tool. Could other tools help out at another time or sequence?

Step 4: Create a process map of the desired function and break it down into finer detail.

Step 5: Can the modification be broken into two (or more) stages? Does this allow for parallel processes to accomplish the main function, or does it allow for a more optimum sequencing of functions?

Example—Stopping a Speeding Car

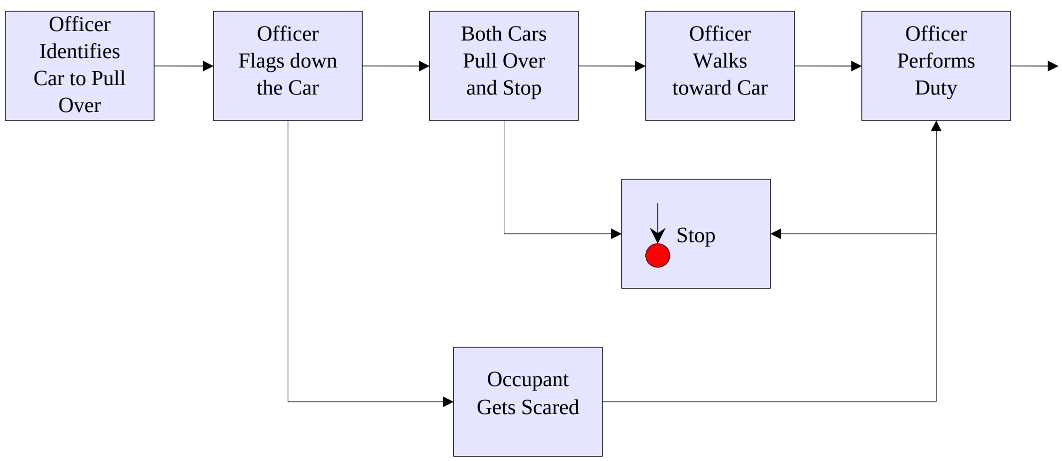
Step 1: Create a process map of the sequence of functions. The subject function should show up as a block in the process map.



If we start at the beginning of a typical car chase, the car has just been pulled over and the officer is walking to the other car. This is the most likely time for the occupant to become scared and to speed away or "bolt". Notice in the following process map that we could have used functional language throughout. Also, the ideal function is located wherever psychological inertia places it. That is fine to begin with.

Step 2: Consider performing the function in different sequences. Move it earlier or later than currently performed. Try moving it so far forward that it is no longer during the normal process sequence. Consider moving it so far backward that it is no longer part of the ordinary sequence.

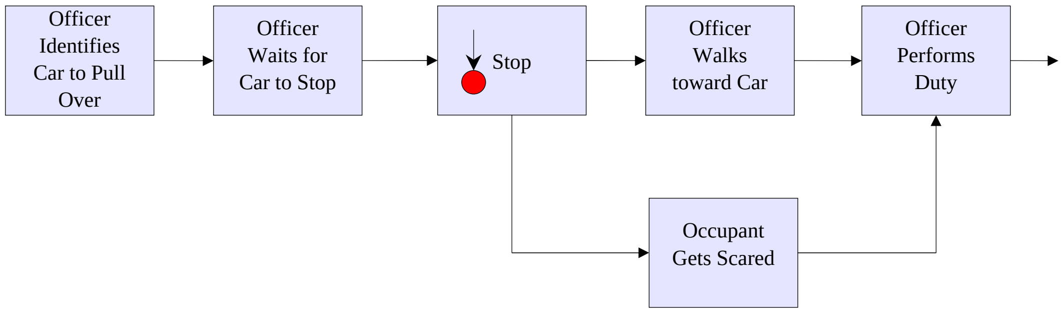
In this case, it probably does not make sense to stop the car until it has had a chance to pull over. In the less likely event that the car begins speeding away when the officer flags it down, then there may be a need to stop it at that moment. Now remember, it is possible to consider the more ideal situation where the occupant is not scared, etc. This all presupposes that we have already determined these other functions and are idealizing them on other paths. It also presupposes that we have considered other more ideal modifications and products and are working on this one specifically. The question that we are answering here is where is the most ideal place to put the function of stopping the car.



Another possibility is that the car bolts and the officer does not pursue at all! The car will be stopped later when it is safer, or the occupant will stop the car. The occupant can see that the officer is simply standing there and not pursuing. This allows for a less panicked state which keeps speeds lower. Perhaps the fact that officers will no longer pursue has become well publicized. And it becomes common knowledge that the car is being tracked by a high observer such as a surveillance craft or satellite. The occupant then has to pursue another strategy which usually involves abandoning the car. This puts the function of stopping the car far later than normal.

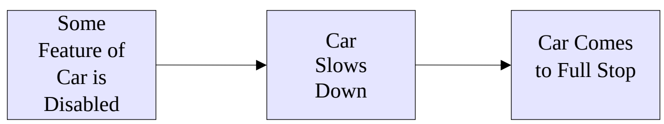
Step 3: Can the function be performed in parallel with other functions? Can the function be performed during other functions such as during transportation or while queued or waiting. Can setup be performed at the same time as the operation? Rapid setup often implies the use of a previously placed tool. Could other tools help out at another time or sequence?

This creates new possibilities, for instance, the car can be disabled while it is already stopping for a traffic light or stop sign. If this can be done safely, before the occupant is aware of what is happening. This precludes the problem of speeding away, but now this raises other problems such as how other drivers will react when a car is stopped.



There are also many people who would never consider speeding away and this becomes a needless embarrassment for them. It is also necessary to stop the car in such a way that the occupants and the car are out of harm's way. Such may not be the case if the car is stopped on a busy street. This highlights the fact that idealizing the system may cause other problems which can be avoided now (by choosing a different sequence) or later, by fixing the system.

Step 4: Create a process map of the desired function and break it down into finer detail.

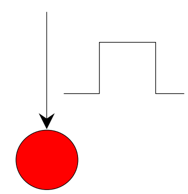


Step 5: Can the modification be broken into two (or more) stages? Does this allow for parallel processes to accomplish the main function, or does it allow for a more optimum sequencing of functions?

It may be that the car is not stopped, but first limited in speed to 25 mph. The car can now pull over and remove itself from traffic with the officer following. This brings up the idea that the more ideal possibility is to be able to limit the maximum speed of the car at a distance in such a way that the driver cannot tell the difference between this and a "malfunctioning" car.

L3-What is the Ideal Duration?

The ideal sequence is strongly influenced by the duration of the function. Likewise, duration of the function is strongly influenced by the sequence of the function.



Method

Step 1: If the modification were performed very rapidly, would other harmful functions be precluded?

Step 2: How much time do we have after it is normally performed that it would be allowable to continue performing the function? If the modification were performed very *slowly (hours, days, weeks, months, years) would this be harmful or could this actually help in the performance of other functions?*

Example—Stopping a Speeding Car

Step 1: If the modification were performed very rapidly, would other harmful functions be precluded?

Yes, if the car could be stopped instantly, before it was able to get out into traffic, many dangerous or harmful functions could be avoided.

Step 2: How much time do we have after it is normally performed that it would be allowable to continue performing the function? If the modification were performed very slowly (hours, days, weeks, months, years) would this be harmful or could this actually help in the performance of other functions?

Stopping the car permanently could be viewed as a punishment for trying to speed away. This might serve as a deterrent.

L3-What is the Ideal Duty Cycle?

Ideality requires that all objects perform as many functions as possible, as much of the time as possible. Systems that idle waste valuable resources. Consequently, it is important to consider idealizing the function by requiring the system to work all of the time.

Method

Step 1: Are there opportunities for the system to run all the time? Is this even desirable considering the current product? Ideally, objects in the system will be at full capacity[9].

Step 2: Are there other objects in the job that require the function? Should the function be reframed to consider these other objects?

Step 3: Should the modification be performed along the entire path, both coming and going? This usually applies to machines which have repetitive motions.

Step 4: Should dummy runs and downtimes be allowed?

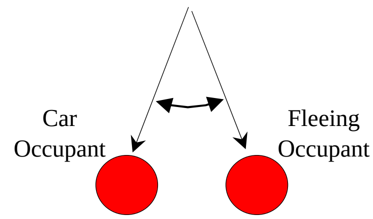
Example—Stopping Speeding Cars

Continuing with our example of stopping speeding cars, we ask whether the stopping system can be in operation at all times. Since the need to stop cars is not continuous, it would be necessary to re-describe the function in terms that can apply to objects other than cars.

Step 1: Are there opportunities for the system to run all the time? Is this even desirable considering the current product? Ideally, objects in the system will be at full capacity.

In the case of stopping speeding cars, there is no requirement to stop cars continuously.

9 Inventive Principle #20—Continuity of Useful Action: Carry out an action without a break. All parts of the objects should constantly operated at full capacity. Remove idle and intermediate motion. Replace "back-and-forth" motion with a rotating one. Genrich Altshuller, The Innovation Algorithm page 288.



Step 2: Are there other objects in the job that require the function? Should the function be reframed to consider these other objects?

Yes, it would be desirable to stop a human that abandons the car. If we redefine the problem as stopping the car occupants, whether they are moving or in a car, the system becomes much more ideal.

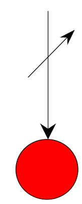
Step 3: Should the modification be performed along the entire path, both coming and going? This usually applies to machines which have repetitive motions.

In this case it probably does not apply except to say that the function of stopping the car's occupants should be possible regardless of which direction they are moving, even in reverse.

Step 4: Should dummy runs and downtimes be allowed?

I suppose that down times are allowed if all we are stopping are the occupants. It should not be necessary to have a test run before it is used each time to stop a car.

L3-What is the Ideal Adjustability and Continuity of Adjustment?



If we haven't already touched on this in some way, then we will deal with the subject of variability here. Lines of evolution suggest that the control of functions become more and more adjustable[10]. At first, the process is fixed. Next it becomes adjustable to at least discrete levels. Next, the adjustment must become continuous. Next, some form of control scheme is used to adjust the function for changing conditions. The first form of control often turns the function on or off. This is often referred to as "bang-bang" control. The next form of control is referred to as open-loop control. This means that a change is sensed somewhere and the mechanism that controls the function is given a set command that hopefully puts the output in the required realm. The next form of control uses feedback which continuously or discretely controls the function. Each level of adjustment and control increases the complexity of the system. It is important here to not go overboard in assigning an ideal level of adjustability. We can over-constrain the system. This sounds too much like a compromise, but here we will consider only an acceptable level of adjustment that will allow this system to operate for a long time without change. This is not much of a compromise.

Method

Step 1: Consider different and perhaps extreme operating environments. Decide whether or not it must be capable of adapting to these different environments.

Step 2: Consider adjustability to a variety of products. How much variation can we stand in the product? Consider biased products (objects which are of the same type, but have some differences in an important attribute like nails of various sizes or roses of different

10 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

shades). Consider objects with much greater differences such as the difference between edible plants.

Step 3 What granularity of adjustment is necessary? Can the adjustment be discrete? If so, what is the discrete step size?

Step 4: Does the adjustment need to be continuous or should it require continuous feedback[11]*?*

Example—Stopping a Speeding Car

Step 1: Consider different and perhaps extreme operating environments. Decide whether or not it must be capable of adapting to these different environments.

The car must be stopped in difficult weather conditions such as rain, snow, high heat, at night or day. The occupant must be stopped regardless of the position that they are in, either running or crouching low in the car. It must be capable of stopping the occupant regardless of obstacles that they hide behind such as seats, windows, car walls or trees and rocks once the occupant leaves the vehicle.

Step 2: Consider adjustability to a variety of products. How much variation can we stand in the product? Consider biased products (objects which are of the same type, but have some differences in an important attribute like nails of various sizes or roses of different shades). Consider objects with much greater differences such as the difference between edible plants.

The method of stopping must work regardless of the gender or size of the occupant. It must also work regardless of the equipment that they might be operating or carrying.

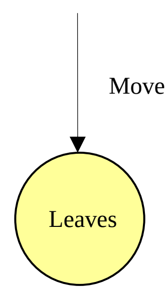
Step 3 What granularity of adjustment is necessary? Can the adjustment be discrete? If so, what is the discrete step size?

In this case, the adjustment could be fairly granular. We would like to limit the occupant or former occupant to a variety of speeds.

Step 4: Does the adjustment need to be continuous or should it require continuous feedback?

The adjustment could use some form of open-loop control if the officer provides the feedback. Some form of feedback may be necessary, however to reduce the concentration burden of the officer.

L3-What is the Ideal Use of Energy



Many modern conveniences save time at the expense of energy waste. We almost always use more energy than is required because energy is cheap. The unfortunate consequence is the cumulative energy and its costs. Considering the least energy that is required to perform the function will give the innovator a very different idea of what the ideal function is.

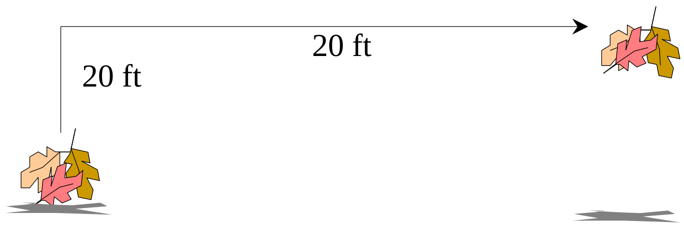
11 Inventive Principle #23—Feedback: Introduce feedback. If feedback already exists, change it. Genrich Altshuller, The Innovation Algorithm page 288.

Method

Consider the least energy required to perform the function.

Example—Leaf Blower

Consider the least energy required to perform the function.



In this case, the debris must be moved a horizontal distance of 20 feet and up 5 feet to be placed in a garbage can or storage receptacle. The least energy that is required to perform this function is the potential energy change. (Weight times the height). It is very small (and certainly much smaller than the energy which will be expended with a leaf blower).

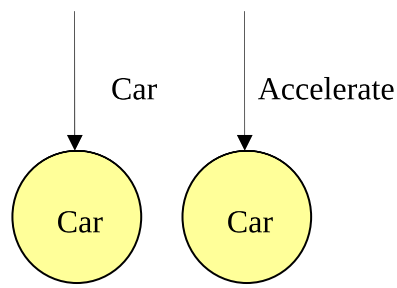
L3-Turning Function Burden to Blessing

Usually, we do not think of a raw function as having burdens. This usually occurs when the tool of the function is added. Unfortunately, there are burdens that are almost unavoidable. When we stop a car, the energy must be extracted. Regardless of the way that we do this, the energy must leave the car. This is a burden. We can turn this burden into a blessing[12] by using this energy to perform another function. Without deciding yet how this is going to happen, we are setting ourselves up to identify a physical phenomenon that can perform a second useful function with the energy that is removed from the car.

Method

Step 1: Identify unavoidable burdens which come with a useful function.

Step 2: Identify a second function which uses the burden to perform a useful function.



Example—Stopping a Car

Step 1: Identify unavoidable burdens which come with a function.

Energy loss comes with stopping any car.

Step 2: Identify a second function which uses the burden to perform a useful function.

This energy can be used to accelerate the same or a second car.

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12 Inventive Principle #22—Convert Harm Into Benefit: Utilize harmful factors - especially environmental to obtain a positive effect. Remove one harmful factor by combining it with another harmful factor. Increase the degree of harmful action to such an extent that it ceases to be harmful. Genrich Altshuller, The Innovation Algorithm page 288. The use of this principle is somewhat different here because we have to see past the useful function to the burdens that the useful function carries to find the harm.

L3-When Should It Be Excluded? (The Zero Function)

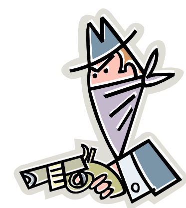
The zero function[13] is the intended absence of a function under certain conditions. We should have full control over the function when its existence would be dangerous or otherwise harmful.

Method

Step 1: Identify times when the primary functions are harmful.

Step 2: Consider providing the zero function and means for detecting and controlling the function during these times.

Example—A Safer Gun



Many are killed due to accidental handgun accidents. Children, in particular, are susceptible. Additionally, law enforcement officers sometimes become the victims of their own weapons.

Step 1: Identify times when the primary functions are harmful.

Harmful functions are most likely to occur when the gun is not in the hands of the owner. If a police officer is not in possession of his weapon, and a suspect has it, this is potentially very harmful.

Step 2: Consider providing the zero function and means for detecting and controlling the function during these times.

The Gun cannot shoot unless it is being held by the correct person.

Example—Stopping a Speeding Car

Is there a chance that we want to disable the possibility of stopping or controlling a speeding car?

Step 1: Identify times when the primary functions are harmful.

It may be harmful if the device can be used on a law enforcement vehicle. If the device is harmful to adults, children may be very susceptible to harm. Perhaps it cannot be used when children are present.

Step 2: Consider providing the zero function and means for detecting and controlling the function during these times.

The function will not be provided with children or law enforcement vehicles present.

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13 Greg Yezersky, General Theory of Innovation Feb 2006

L2-Potential Physical Phenomena

The Ideal Physical Phenomenon for Useful Functions

Now that we know *what* we want to do, we are prepared to talk about *how* we are going to deliver the function. We deliver functions with physical phenomena which are in turn delivered by the tool. The tool and the physical phenomena often come together, but for our purposes we will consider them separately as potential physical phenomena.

As taught in school, physical phenomena are a human abstract of fields and substances arranged in special architectures that do something recognizable. When we talk about buoyancy as a physical phenomenon, we are talking about several substances and several fields that interact to cause objects to float in their surrounding fluid. We recognize that this works in water and in the air. Buoyancy can be used to do things. It is a means to an end if we want. It is rare that only one substance and/or field is involved. For those who have learned physics, they recognize that the study of physics is primarily the study of physical phenomena. This is fortunate because it helps the user to understand how to calculate the effects of the associated parameters.

The decision of what physical phenomena to use to deliver a function is often ignored or taken for granted. Whenever we ignore or take for granted, we are assuming. Whenever we assume, we are subject to psychological inertia. We may not recognize that there are more ideal physical phenomena that can be used to deliver our modification to the tool. We may be ignoring free resources in the environment or in the job that can be used to simplify the system.

Even though, a physical phenomenon may not be ideal, we need to additionally consider whether the timing is right to change it. This decision should not be taken lightly as changing to a new physical phenomenon can lead to a lot of headaches. If it is not time to change, this whole section can be skipped.

There are many avenues for identifying physical phenomena. Many of physical phenomena are already in-use to perform the function. Some need to be transported from other industries. Once we have them, we need to sort through them to find the most ideal.

In the event that we cannot identify a good physical phenomenon to meet our needs, there is always the option to go searching for new phenomena. This should only be done if absolutely necessary as it requires the heart and soul of the researcher. Means are given to look for new phenomena. This is a new area for TRIZ and the methods are experimental.

Is it Time to Switch to a Different (more Ideal) Physical Phenomenon?

This decision has ramifications on the amount of work that will be required to make your product or service work. When you change to a new physical phenomenon, there are many unknowns. Perhaps you are lucky and you are involved with someone that is experienced in the new phenomenon. This makes the possibility of bridging to the new phenomenon much easier. Remember that the new product or service must compete with one that has been polished for many years. Changing to a new physical phenomenon can increase the required work substantially.

The Ideal Physical Phenomenon for Useful Functions

In this step, we consider which physical phenomena can perform the modification to the product that we desire. The decision of which physical phenomenon to use will come after seeing what resources are available. So, we are not making a decision at this point, but rather identifying potential physical phenomena. We create a fertile situation so that when the right tool is presented, we can see its merit. In effect, we are sensitizing our minds for the next step in which we consider the substance, object and field resources around us. Armed with the knowledge of what is possible, it will be easier to identify the value of a resource when we see it.

Some of the phenomena that we consider in this stage may seem a little wild or too weak to perform the function. Remember that there are ways to tame wild phenomena. Weak phenomena can often be boosted in latter stages of the algorithm. Therefore, it is important to keep an open mind to the possibilities.

The Ideal Physical Phenomena Must Have a Chance to Compete

The ideal resource is capable of holding its own. It must be abundant and capable of providing as many functions as possible. In the final set of tools, we consider which potential phenomena would be the most ideal. We "filter" for certain characteristics. What we have left over are the most likely candidates.

Discovering Completely New Physical Phenomena

The discipline of invention would be incomplete without the consideration of discovering new physical phenomena. These discoveries, while taking much longer to break through, have had profound impacts on all of technology. Discoveries such as the lasers, lithographic processes, and ultrasonic phenomena have transformed our lives.

A physical phenomenon is a unique combination of fields and substances which allows for the delivery of a function. The term "physical phenomena" is a human convention which allows us to create order from chaos. We classify what we are seeing in order to repeat it and use it for our purposes. Even the concept of a "field" (as used in the above definition) is a human convention. One might argue that 99% of all interactions in nature are the result of electron to electron interactions. Such a narrow definition of field limits classifications greatly. Here, we will consider fields to include the ones that we studied in physics courses.

Let's say that we were the first to discover capillary action. Perhaps we were the first to construct a glass tube and place it into a liquid. We might have seen the liquid move up the tube to a position higher than the liquid in the vessel that contains it. The liquid was modified. It changed its shape, height or relationship relative to the glass, etc. In other words, it performed a function because it modified one of the attributes of the liquid. The value of a physical phenomenon is that it is the means of delivering functions. In this context, the search for new physical phenomena is actually the search for new ways to deliver functions. (This logic is not perfect in that we may find a new way to deliver a function which involves an existing physical phenomenon.)

This search often begins with the thinking "If only I could find a way to…". Perhaps we search existing Libraries of Effects and physical phenomena as well as an exhaustive search of the internet. If nothing turns up and we are particularly serious about delivering this function in a new way, we may do something radical. We may begin an innovative quest….

The search *ideally* looks like this:

--I need to deliver a known function.

--I go and look in my own and other industries to search for a physical phenomenon to deliver the function and find that the available physical phenomena are not capable.

--I look for new phenomena that have not been used to deliver such a function. (Can't find any)

--I form a hypothesis for a new way to manipulate substances and fields that might deliver this function.

--I perform crude experiments that confirm (at least don't disprove) the hypothesis.

--I apply the new phenomenon to deliver the function and begin the process of working out the bugs—resolving contradictions, etc. Because this is a newly applied phenomenon, there are a lot of new problems to be solved which take a lot of time.

What often happens is different:

In the process of solving one problem (this problem may not be related to delivering a function), I may set things up (usually in an extreme way) that creates the conditions to discover a new phenomenon.

An unusual phenomenon is discovered.

This new phenomenon may not solve the problem that I am dealing with, so I now have a quandary: Do I continue working on the existing problem, or do I allow myself to divert to the new phenomena?

If I decide to divert to the new phenomena, what do I do with it? I could report it out in a technical journal for all to use. This is probably a good idea. I or someone else might recognize that there is a need for this new physical phenomenon. This is a classical solution in search of a problem. It is necessary to find potential functions that this phenomenon can deliver.

Methods are given which outline conditions under which new phenomena are often found. Some of these methods are directed towards discovering a new phenomena which can be applied to deliver the function of interest. Other methods merely create the environment in which a new phenomenon may be discovered.

Method

Step 1: Consider whether it is time to switch to a new physical phenomenon to deliver the function? Has the point of diminishing returns been reached? Do you see signs of extensive feedback in the main function?

Step 2: Consider physical phenomena from industries that perform similar modifications a lot. Look at the patent data base to see different physical phenomena. Consider how nature does it.

Step 3: Use the library of effects at: http://function.creax.com/

Step 4: Look at how nature does it at: http://asknature.org/

Step 5: Consider using a hybrid of the existing and a new phenomenon.

Step 6: Consider chaining physical phenomena.

Step 7: If a new phenomenon is required, then consider making the object of intelligent little people. What would they do to provide the modification?

Step 8: If a new physical phenomenon is required, then consider driving fields, order or other attributes to the extreme.

Step 9: Choose the most ideal phenomenon: one that makes use of abundant resources: requires the least contact or one that can provide multiple functions.

L3-(Switch?)—Review the Evolutionary History

Knowing the history of a product[14] helps to understand the main evolutionary trends. Each product has a main evolutionary tendency. The tendency of a system to stall along this evolutionary path is largely a function of the technical problems that directly conflict with this evolutionary tendency. You have already conducted a patent search within your industry so you have a lot of information about the history. This step can take a lot of time, but the information is extremely valuable from the viewpoint of continued steps. The inventor is becoming a true expert in this field.

Method

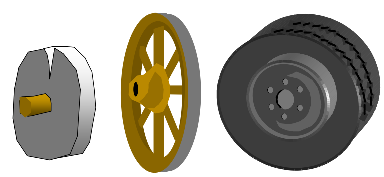
Step 1: From patents and literature, study the history of the functions that are typically involved in the job. What functions have been added over time? What main physical parameters have improved?

Step 2: From patents and literature, study the history of the technologies (physical phenomena) that typically deliver these functions. How have these technologies changed?

Example—Postal Services

Consider the transport of objects for pay such as postal services.

Step 1: From patents and literature, study the history of the functions that are typically involved in the job. What functions have been added over time? What main physical parameters have improved?



Things improved with postal services: The purchasing of service; delivery of object to point of use; the protection of objects (container movement); the tracking of objects and informing customer; the speed of movement of objects.

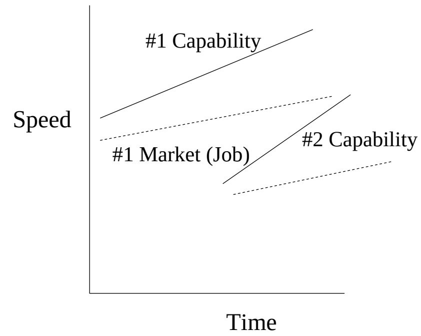
Step 2: From patents and literature, study the history of the technologies (physical phenomena) that typically deliver these functions. How have these technologies changed?

If we look at the actual physical means of delivering objects we see a continual transition to the fastest modes of general transportation: Runners→ Horses→ Carriages→ Wagons→ Trains or Boats→ Trucks→ Planes. With these transitions other improvements came in the form of speed, protection from damage and knowledge of object location.

14 The Innovation Algorithm by Genrich Altshuller page 215—While Altshuller's life was a study of the history of systems, this particular chapter shows the various stages of a technology. Altshuller made it a point to take an existing system and determine the evolutionary history of that particular system.

L3-(Switch?)—Plot the Course of Disruptive Technologies

We have already discussed disruptive technologies[15] in some depth. If you feel that a disruptive technology is threatening you, it may be wise to look at how rapid this encroachment is occurring. This analysis takes a great deal of time, so it is usually not useful unless an imminent threat is detected.



Method

Step 1: Each recognized market (job) is focused on a competitive parameter. Determine the competitive parameter. The progression of competitive parameters is as follows:

—Performance of the main parameter (speed, power, etc)

—Reliability

—Convenience

—Cost

Step 2: Plot this main competitive parameter for the most advanced leaders with respect to time for each market (job). This gives the capability curve.

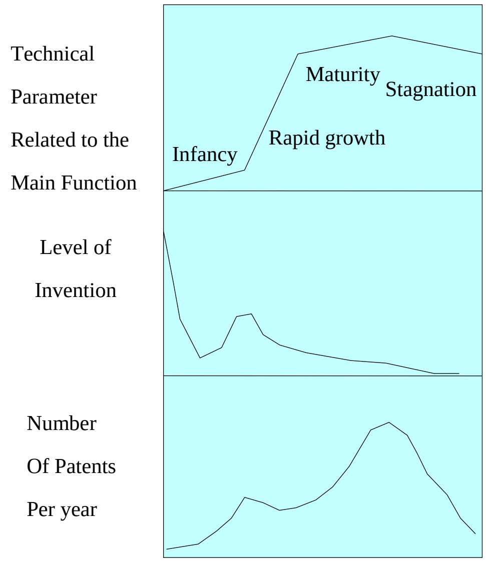
Step 3: Plot the average of the competitive parameter for all products for that market. This gives the demand curve for each market.

Step 4: If the capability of the lower performing market appears to be on a course to cross the demand line of the market with the upper capability, then it is imperative that you find a way to switch to the phenomenon used by the encroaching market. It may be necessary to spin off an independent group which is given proper resources and incentives to market this new technology. This may be difficult since the new market is likely to have developed new delivery channels. The more likely approach to overcoming a disruptive technology is to use a hybrid of the new and old physical phenomenon.

15 The Innovator's Dilemma by Clayton M. Christensen—Harper Business Essentials

L3-(Switch?)—Determine the System Maturity from Patents

The maturity of systems can be determined by several means. One means is by the study of patents[16]. This involves understanding the increase in performance of the main technical parameter related to main technical function, the level of invention and the number of patents over time. The method shown is very time consuming and should only be applied if other methods prove ineffective in showing the importance of switching to a new physical phenomenon.



Method for Examining System Maturity

Step 1: Identify the technical parameter related to the main function. Quantify how this has improved over time.

Step 2: Identify how the level of invention has changed over time. The level of invention is typically high when changing to a new physical phenomenon. It peaks again during the period of rapid growth as resources are made available from sales.

Later, it levels off as system resources are exhausted.

The levels of invention are as follows:

1. No resolution of contradiction.

2. Resolves contradiction with small change.

3. Resolves contradictions with a major change. Uses a technology from the same field.

4. Resolves a contradiction. Complete change in physical phenomenon. This is usually a technology from another field.

5. New Physical Phenomenon. Has ability to change the super-system to which it belongs.

Step 3: Quantify the number of patents per year.

L3-(Switch?)—Is it Time to Switch to a New Physical Phenomenon?

The main reason that we would like to know the system maturity is because it is particularly important to determine whether there is a need to change to a new physical phenomenon to perform the main modification of the system product. A new physical phenomenon typically brings fresh resources which allow continued evolution of the

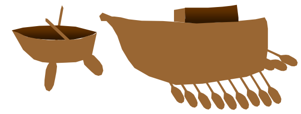
16 Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller. Gordon and Breach. Page 207

function or the job that is being performed. Unfortunately, it typically involves unknown risks and unfamiliarity of the side effects of the new phenomenon. An additional shortcoming of going to a new physical phenomenon is that the customer has come to accept certain levels of performance which will almost certainly not be achieved unless the transition is brought about through the use of hybrid phenomena which will be described later.

Required Conditions for a New Phenomenon

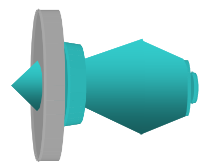
If several of the below conditions are present then consider a new physical phenomenon to deliver the main modification.

Condition 1: The super-system has become very specialized.



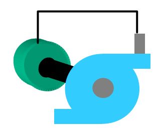
In the beginning, row boats were very crude and usually created from single trunks of trees. As time went on, they evolved to specialized uses including fishing, transportation of goods and conducting warfare. These variations became very specialized with warships having multiple levels of oars.

Condition 2: The super-system has reached the point of diminishing return. Are the main technical parameters improving very slowly?



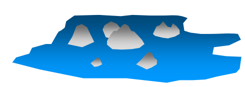
An example of a system that has reached the point of diminished return is the fanjet engine. The amount of fuel burned per unit of thrust is improving in the single digit range. This is largely due to the high degree of regulation in the airline industry for the sake of safety. Improvements are absorbed slowly so as to ensure that unintended effects are minimized.

Condition 3: Automatic feedback is used to perform the main super-system function[17]. By the point that systems are using extensive feedback, we can usually assume that the system is running out of resources. This is because the use of feedback is costly, and indicates that costly improvements are required to bring minor changes to performance.



A fanjet engine is again a good example of feedback which is employed in almost every major function on the engine.

Condition 4: Multiple conflicts must be resolved for large improvements. (Many rocks appear when we begin to drain the pond). It is typical that products and services will be filled with compromise "solutions". Between major improvements in the product, there is a tendency to ignore risks and to live with compromises. As time goes on and the product becomes specialized, these compromises mount up until changes in the operating environment expose multiple compromises.



Going back to our example of the aircraft engine, temperatures are always increasing within the engine to increase engine efficiency. This increase in temperature exposes the weakness of multiple components.

17 17 SECRETS OF AN INVENTIVE MIND: HOW TO CONCEIVE WORLD CLASS PRODUCTS RAPIDLY USING TRIZ AND OTHER LEADING EDGE CREATIVE TOOLS by James Kowalick

L3-(Switch?)—Can Line of Evolution be Used Instead?

Until you have reached the end of a line of evolution, it is hard to know if you have more unused resources.

Method

Review Lines of evolution below to see if there are still unused resources.

Path: Linear→Curved in plane→Curved out of plane

Structure: 1-Dim→2-Dim→3-Dim

Segmentation: Monolith→Parts→Powder or Mist→Mixed Media

Voids: Monolith→ Cavity→ Voids→ Porous[18] *or Capillaries→ Structured Capillaries→Dynamized*[19] *Voids*

Surface Structure: Smooth→Protrusions→Rough→Activated Surface

State: Solid→Liquid→Gas→Plasma→Rarified Gas→Vacuum

Degrees of Freedom: Fixed→Joint→Multiple Joints→Flexible

Adjustability[20]*: Fixed→Adjustable→Continuously Adjustable→Feedback*[21]

Continuity of Adjustment: Invariable→Stepwise Variable→Continuously Variable

Oscillation[22]*: Continuous→Pulsed→Oscillating→Resonating→Standing Wave*

18 Inventive Principle #31—Porous Material: Make an object porous, or use supplementary porous elements (inserts, covers, etc.). If an object is already porous, fill poured in advance with some substance. Genrich Altshuller, The Innovation Algorithm page 289.

19 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

20 Inventive Principle #15—Dynamicity: Characteristics of an object or outside environment, must be altered to provide optimal performance at each stage of an operation. If an object is immobile, make it mobile. Make it interchangeable. Divide an object into elements capable of changing their position relative to each other. Genrich Altshuller, The Innovation Algorithm page 288.

21 Inventive Principle #23—Feedback: Introduce feedback. If feedback already exists, change it. Genrich Altshuller, The Innovation Algorithm page 288.

22 Inventive Principle #18—Mechanical Vibration: Utilize oscillation. If oscillation exists, increase its frequency to ultrasonic. Use the frequency of resonance. Replace mechanical vibrations with Piezo-vibrations. Use ultrasonic vibrations in conjunction with an electromagnetic field. Genrich Altshuller, The Innovation Algorithm page 288.

L3-(Ideal Phenomenon)—Analogous Products—Patents Outside Your Industry

An analogous phenomenon[23] produces the same result that we want on other objects. This can be transferred to our situation with satisfying results. We look at analogous products first because we will soon be looking at existing products and patent searching and we would like to cover the range of analogue products when we do that. In other words, we would like to perform the product and patent searches once and use the information that we gather there for further steps.

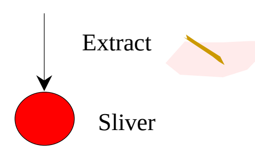
Method

Step 1: Identify an analogous product. What other types of objects require the same modification?

Step 2: Identify the common tool for modifying this product and the minimum feature required for the modification. Search for patents related to the modification of this analogous product.

Step 3: Transfer this feature to the new situation. Consider combining this with the existing tool or transferring the minimum amount of the tool.

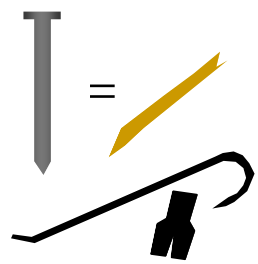
Example—Removing a Sliver



We would like to identify a new physical phenomenon for extracting slivers.

Step 1: Identify an analogous product. What other types of objects require the same modification?

A nail is analogous to a sliver.

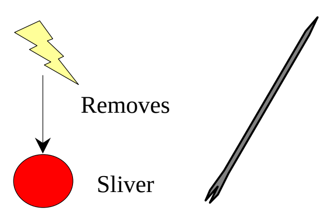


Step 2: Identify the common tool for modifying this product and the minimum feature required for the modification. Search for patents related to the modification of this analogous product.

A crowbar is used to extract nails. The feature that performs this modification is the claw.

Step 3: Transfer this feature to the new situation. Consider combining this with the existing tool or transferring the minimum amount of the tool.

A mini-crowbar is created for extracting slivers.



23 No specific reference is given for this tool. The author has heard rumor that there might be a table of analogous phenomena in existence somewhere in the world. It is not necessary to have a table to use this method, but would be helpful if such a table existed.

L3-(Ideal Phenomenon)—Analogous Products—Mega Trend

If we look in industries that perform a function on a massive scale[24], we can often discover the evolutionary trend for this function along with physical phenomena which are used to accomplish it. It is even possible to identify physical phenomena by using the patent database.

Method

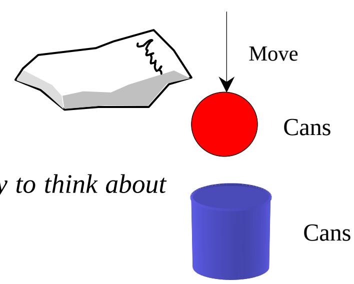
Step 1: Identify analogous products in leading industries. These are objects which require the same function that you are considering. It may be necessary to think about the modification differently.

Step 2: Identify trends for performing the function where a large amount of this product requires the same modification? Consider looking at patents for this analogous product. Can you identify the evolutionary trend?

Step 3: Apply this to the product that you are considering.

Example—Moving Large Amounts of Packaged Materials

We would like to move sacks from a truck shipment to a location on the factory floor. Typically, this is done by hand, unloading one at a time.

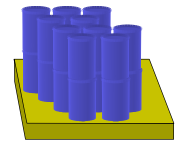


Step 1: Identify analogous products in leading industries. These are objects which require the same function that you are considering. It may be necessary to think about the modification differently.

Cans are an analogous product.

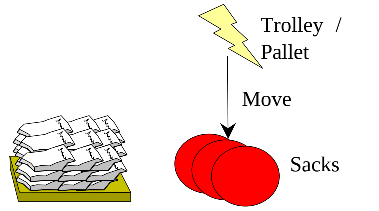
24 The Innovation Algorithm by G.S. Altshuller, Technical Innovation center. First Edition 1999 page 174. Used as part of ARIZ 71. "Compare the by-pass problem with a tendency (a direction of evolution) in a leading industry."

Step 2: Identify trends for performing the function where a large amount of this product requires the same modification? Consider looking at patents for this analogous product. Can you identify the evolutionary trend?



The Cans are moved on pallets as large groups. As more and more things are moved, they seem to be moved in large groups rather than one-by-one.

Step 3: Apply this to the product that you are considering.



L3-(Ideal Phenomenon)—Identify the Competitive Alternative through Observation and Questioning

Here we learn about potential physical phenomena from competitive alternatives. Competitive alternatives are any systems that can potentially compete with the system that you are simplifying or creating. A newspaper is competition for the television. Car or truck transportation is competition for airline travel.

The competitive alternative is what people currently use and what they would use if they didn't have what they are currently using. Remember that this is not necessarily what you would consider to be direct business competition. For a pet watering bowl, the competitive alternative might be a large bucket. In the early stages, Southwest Airlines did not compete against other airlines; they were in competition with traveling by car.

It is very tempting to go on personal experience to answer this question, but this is a trap. Often, inventors assume that they are like everyone else. There is wisdom in going to the battle to see how it is really being waged. There is no substitute for this. Don't be satisfied with talking to a few people.

Method

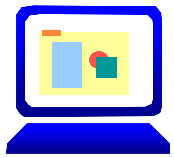
Step 1: Observe what the target market currently does to satisfy this function. If possible, go and watch before talking. By observing you get to the truth. What people do and what they say that they do are often two different things.

Step 2: Ask how they satisfy this function and what they would do if they didn't have what they currently use. This may give some valuable information into the history of the function. They will often offer what they did way back when...

Step 3: Identify what "extreme users" currently do to satisfy this function and what they would do if they weren't using their current means. Extreme users often have a range of experience with uncommon ways to satisfy a function.

Step 4: Ask everyone that you interview where they go for the source of items and products that they need to do these jobs. This will set you up for the next step.

L3-(Ideal Phenomenon)—Internet Product Search



Learn from the competitive alternatives (Remember that these may not be direct competitors). What jobs do they do? What functions do they perform? What Physical Phenomena delivers the functions? If you are searching for an unrecognized market and you find a major competitor then go back to the drawing board.

Method

Step 1: Use an internet search-engine to determine what products are offered.

Step 2: Refine the search by noting and using nomenclature and names that are common to the industry.

Step 3: Consider cheap competitive alternatives.

Example—Stopping a Speeding Car

Step 1: Use an internet search-engine to determine what products are offered.

"Stop-Sticks" are found on police equipment websites. They are a triangular shaped device that cost $380 per set and can be deployed by throwing them into the road way. The occupant has little time to react and often rolls over them. The sticks can immediately be pulled back to allowing pursuing law enforcement cars to pass unharmed. As an added feature, the stop sticks are replaced if damaged for up to 4 years.

It takes a fair amount of training to use them. If they are thrown too early, the occupant has time to swerve, potentially into the officers throwing them. A "marker" is used on the side of the road to time the throw. When the fleeing car passes the marker, the stop sticks are thrown out. One tricky feature is that the officer needs to be close enough to throw the sticks, which may put them into a dangerous situation. They come with 80 ft of cord to pull them out of the path or into the path of cars. This does not mean that the officer can be 80 feet away when throwing the stop sticks. An interesting feature of these stop sticks is the number of police officers killed while deploying them. The most common fatalities have to do with drivers swerving to avoid the sticks and striking officers. Others have been killed while trying to retrieve them. Sadly, they are sometimes killed by the pursuing police car. They may try to retrieve them to keep pursuing law enforcement cars from also running over the stop sticks.

Another tricky feature is that pursuing officers are often very close behind the speeding car. It is difficult to convey at what point the sticks may be thrown out. The police car may also try to swerve to avoid them which endanger officers trying to deploy them.

Another problem reported is the use of stop sticks on people that were not breaking the law.

Another competitive alternative is tire spikes—these range from $400 to $800. These spikes spread out to as long as 25 ft. They are capable of piercing truck tires. The tines can be replaced in seconds should they become damaged. The spikes enter the tires and break free from the retainer. They are hollow and slowly deflate the tire to avoid dangerous blowouts.

Another competitive alternative is the X-Net. This is a netting covered with spikes. The spikes attach to the wheels and the net is wound onto the wheel thus stopping it. It is purported to be capable of stopping vehicles in excess of 10,000 lbs.

Step 2: Refine the search by noting and using nomenclature and names that are common to the industry.

Stop Tech Ltd. is the company that makes Stop Sticks.

Step 3: Consider cheap competitive alternatives.

I could not detect any cheap alternatives. Big rocks would be too dangerous, especially for pursuing police officers.

L3-(Ideal Phenomenon)—Observe Existing Products

With an internet product search under your belt, you may be able to identify local products that you can observe first-hand. While competitive alternatives can be anything that others would use if they were not using our system, there may be obvious competitors in the market place. Let's go to the store to see what these products and services are.

Method

Step 1: Go to a store that would sell products that deliver the required modification.

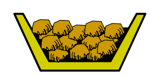
Step 2: Note brands and producers. Do the producers sell more than one product? Who are the main producers?

Step 3: Look for product trends.

Step 4: Read the labels. What do they claim?

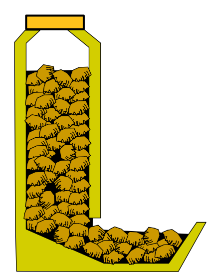
Example—Pet Food Container

Step 1: Go to a store that would sell products that deliver the required modification.



I am interested in containers that serve pet food, so I go to a pet store or the pet section of a department or grocery store.

Step 2: Note brands and producers. Do the producers sell more than one product? Who are the main producers?



I note that there are three main manufacturers that sell products in the category that I am interested in.

Step 3: Look for product trends.

The trend is to combine the food bowls with large storage containers and to keep the food at a level that is comfortable for the pet.

Step 4: Read the labels. What do they claim?

One claims to slow down bugs.

L3-(Ideal Phenomenon)—Use a Known Disruptive Technology

This tool is especially important to consider when targeting a market segment that is already consuming and in which you are trying to sustain the momentum.

It is easy to get caught up in calling any great innovation a disruptive technology, but be careful how this term is used. Disruptive technologies[25] are products and services that are typically disruptive to a business practice. Ultimately, they are so disruptive that many great businesses can no longer compete.

> *The ones that you typically have to be concerned with are those that may disrupt your business. For instance, they do not give the margins that you have come to expect. They do not intersect your supply chain. They do not satisfy the same levels of performance that your main customers have become accustomed to. They require new vendors. Often, a disruptive technology will require a whole new business model. This is the most disruptive of all. As management considers these technologies, they will seem distasteful and will reject them because they feel that they are doing this in the best interest of their company. Remember, they are held captive by their largest customers. Few resources are left over for other customers and disruptive technologies.*

These disruptive offerings are generally initiated in industries that are not your own, but may be closely adjacent. They satisfy someone that is not currently purchasing from you, so they seem innocent. They usually do not perform at sufficient levels to attract the attention of your main customers. This is because they are designed to perform the same functions that your products perform, only for other markets. As these offerings increase in performance, eventually, they will have the capability of satisfying low-end customers in your market. Again, this seems innocent as these low end customers are not important to your business as you move up-market to gain higher and higher margins. Slowly, these offerings will gain in performance as they are fueled by the cash coming into these markets until you find that they are cutting into your mainline customers. Often, it is too late at this point because of the resources required to change over. Developing a whole new supply chain is very impractical. History has shown that it is nearly impossible to copy a disruptive technology at this point. Vendors are often locked up while supplying the new supply chain. Consumers have loyalty to the early products.

> *You might ask why we are not intent upon creating technologies which are disruptive to our main competitors. While it is possible to create technologies that are disruptive to other's businesses, this strategy can only work if your company is open to destructive creation of products and to the creation of new business models, usually in completely separate business units than your legacy products. In order to disrupt existing competition, you will ultimately cannibalize yourself. Remember that these are your competitors and you are competing for the same market. If the market of your competitor begins to move to your new product, they must also stop buying your legacy product. Most companies will find that it is usually better to try to satisfy a market that will not likely compete with your market. If you pick a non-consuming market to satisfy, there are many opportunities to create new offerings. The need to compete is virtually eliminated. You would only do this out of spite for the competitor which is not really a good business practice and will generally take you nowhere.*

If you are still determined to create a disruptive business for your competitor, there are more hurdles. This disruptive technology will need to compete against your biggest customers for resources. It will also be necessary to

25 The Innovator's Dilemma by Clayton M. Christensen—Harper Business Essentials

change long-held company values at the highest levels of the business. It is hard to admit that your business strategy and company values are wrong. In order to make this kind of change a lot of people have to be aligned and committed. If they are not convinced, they will likely revolt in passive ways that are hard to detect and counter. A better approach than directly disrupting your business would be to start a new business built on a learning approach with its own resources. This business will create its own business model and supply train from scratch.

Finally, if you are still determined to create a disruptive technology within an existing business, you must recognize that, the business needs to have an offering which can stand on its own in some market. This is a large challenge on its own as most offerings fail due to all of the market conditions.

In summary, it is usually not a good practice to try to create a disruptive technology (disruptive to you) within an existing business and customer base. The more likely place to create disruptive technologies is with new business startups. These have the ability to recognize market segments that are not being served.

The reason for considering this step here is that others may be encroaching on your market and it is necessary to consider the physical phenomena that this disruptive technology is using. We do this because there is a way out of this trap and that is hybrid phenomena. Hybrid phenomena are the combination of two phenomena in such a way that the performance gained by one phenomenon compliments the other. In this way, the new phenomena can be used to better satisfy the existing market. This would be difficult to do if we made a sudden jump to the new phenomenon. When this occurs the performance is usually less than what the existing market expects. According to evolution of systems, when we move between physical phenomena, there is usually a transitional state through hybrid phenomena. A recent example of this is hybrid electric and petrol fueled vehicles.

Checking for disruptive technologies amounts to looking for analogous functions in closely adjacent markets and then looking for how those functions are delivered. There are usually people in the business that have seen technologies that they would like to bring into the business. They may sense that these technologies will one day compete with them or that they could be exploited with current customers, but there is little support within the businesses. History has shown that many toppled businesses have seen these disruptors coming but were unable to respond adequately. The typical response is to try to force these disruptive technologies into existing markets with disastrous results. The new phenomenon is not capable of delivering the performance that the existing market has come to expect. As mentioned, the strategy that typically works is to strive for a hybrid technology that enhances the current technology. Once established, the new phenomenon will begin to take over from the existing phenomenon, all the while satisfying existing customers.

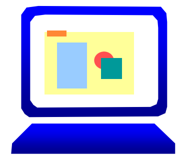
Method

Step 1: Identify technologies that exist in adjacent markets that seem to be threatening the existing business. These may be low cost alternatives or alternatives that use a different physical phenomenon to deliver the function.

Step 2: Identify the physical phenomenon that is used to deliver the function. It is likely that this will later be considered for a hybrid physical phenomenon to satisfy the target market.

L3-(Ideal Phenomenon)—Patent Searching and Study

One of the best times for performing a patent search is when you are searching for physical phenomena to deliver a function. During this particular step, we will be considering searching for physical phenomena inside the given industry. Later, we will be searching for patents outside the industry as we identify analogous situations. Not only will we better understand the possible physical phenomena that can be used, it is inevitable that other types of valuable information will be gathered along the way.



6,543,345

5,678,432

3,234,211

Most people wait too long in the inventive process to perform a patent search. It is usually done after much time and expense to develop their invention. Often they find that someone has already patented their idea or that more useful and elegant concepts are available. This can be quite a blow! Waiting too long occurs for a variety of reasons:

First, people get excited about an idea and they want to develop it without delay. It is easy to get very excited about what the future will bring. Wealth and fame are at your fingertips! There is no time to waste! The idea must put on the market before someone steals it or you lose your drive! This fear is usually unfounded and based on the idea that if we had the idea then the conditions are ripe for someone else to have it. Be patient, there are many inventions to be had if this one doesn't pan out.

Secondly, considering a patent search can invoke fear. It is like knowing that you should see the doctor while fearing that he will give you bad news. It is easy to this put off, but, like going to the doctor, the time investment is small compared to the time that can be wasted by not acting. It typically takes a Saturday morning to do a thorough patent search which is a small investment compared to the typical development time for an invention. Even though the resulting information can be somewhat deflating, it is better to start with a realistic view.

Thirdly, a patent search can appear to be beyond our capabilities. After all, people are employed full time to do patent searches! Again, this fear is unfounded. It is important to remember that you have several advantages that professional patent searchers do not have. You are motivated by the prospects of your idea. (A patent examiner is employed for money and is obligated to perform to certain minimum standards). You are not constrained by time and can afford to search to the bitter end. (Not all patent examiners are thorough and there may be time constraints on some examiners). You are more familiar with the technology than they are. (They do not have the time to become expert at the technologies that you are interested in). With a little practice, this overwhelming task can become natural and commonplace.

Forth, understanding patents is difficult. Admittedly, patents have their own language. In this language, there is no legal prohibition to making up words! Patents can seem very stiff and…legal. Remember that it is in the favor of the legal profession that they look this way. We can easily convince ourselves that only patent attorneys can read patents. On the contrary, anyone can thoroughly understand a patent if they are willing to take the time. They have a repeatable structure, so you can learn the parts of the patent that you need to go to for specific information. Remember that it is much easier to learn to read patents when you are motivated by an idea. This will force you into the patent. Read it, digest it, and diagram it. Soon, you will be speaking "patenteze". Reading and understanding your first patent may take you a half day, but the next patent will go much faster.

Fifth, some feel that seeing what others have done will keep them from looking "outside the box". Sure, there is a possibility that this can temporarily happen, but remember that this whole book is about making us uncomfortable inside the box. There are multiple opportunities to kick ourselves outside. Also, lots of additional information is learned along the way that strengthens our general understanding of physics. Understanding a broad spectrum of physical phenomena will make you a better inventor! Where we get *into trouble is by studying only certain areas of physics deeply. Remaining "specialists" can have a constraining effect on our imagination.*

It is ok that you do not understand everything about patents when you begin your search. True, like first time car drivers, it is impossible to know what you do not know, but you have to start somewhere. If you make mistakes, remember that there is a world of potential inventions out there. Dive in and you will find that you have more capacity than you thought!

There is a wealth of information in patents that is often overlooked. Patents are structured so that others can duplicate the results of an invention. Consequently, it is necessary to give away many details. Most patents begin with a description of the typical approaches that are already available. This sets the stage for why their idea is an improvement. It usually gives the history of the problem (and sometimes the industry) and also a look at alternative physical phenomena that have been used. Following this section is a description of the invention and why it is an improvement. This gives details into new physical phenomena that may have been used. It may describe how various object attributes affect the operation of the product. You may also be able to detect how the inventor overcame various contradictions. Clearly articulating the contradiction that was solved helps an inventor explain why their invention is "non-obvious to those experienced in the art". This is the main hurdle that is required to get a patent. Next is a detailed description of the architecture of the invention. This gives valuable clues concerning the details of the physics. Finally, the claims section gives an idea of the scope of what the patent examiner thought was allowable to claim for the invention.

Unless you are having problems with your computer, it takes about two hours to prepare for your first patent search. Mostly, this involves setting up links in your browser and a patent viewer. The patent viewer is important because looking at pictures conveys information much more rapidly than reading patenteze. Here is how to setup your computer browser with the necessary bookmarks to do a basic patent search:

Step 1: Go to www.uspto.gov. This is the official patent website for the US government. If you take the time to familiarize yourself with this site, you will discover that a lot of effort has been made to make patent search and application easier for individuals. All of the forms are available for self-application. There seems to be a bias towards helping individuals over corporations. You will particularly notice this if you submit a patent for consideration (this is called prosecuting a patent). People at the patent office sometimes bend over backward to help individuals, especially ones that have never been through the process before.

Step 2: On the home page, go to "Patents". You will find this on the left-hand side. If you click on this, a drop down will show you several links. "Search Patents" is down the list a little. Go to this and bookmark it with a memorable name. You can also find this at http://www.uspto.gov/patft/index.html. This page is the main page for beginning patent searches. It allows for a variety of patent search formats.

Step 3: Download the patent viewer for viewing patent drawings. As mentioned, viewing the patents will really help in understanding them. To access the viewer, go to http://www.uspto.gov/patft/help/images.htm. The program that you download for viewing patents is dependent upon the operating system and internet browser that you use. Follow the instructions and links for your particular operating system. If you are like most people and use the windows operating system and Internet Explorer for your browser, you can go to http://www.alternatiff.com/install/ to directly download the viewer. Remember to bookmark this page in case you need to reload the patent viewer for some reason. You will know that you have succeeded when the text appears at the bottom of the page informing you that it is installed.

Step 4: Bookmark the definition of classifications and give it a memorable name. It is located at: http://www.uspto.gov/web/patents/classification/selectnumwithtitle.htm. Each patent is assigned a patent classification. Having a link to the classifications helps the searcher delineate between classifications. When you get to this page, you will notice that there is a numbering system which starts with items such as "apparel".

Remember that this is a very old system of classifying patents that was based upon products that were available when it was started. Scroll through this list and look for more modern classifications to appear. Click on any one of the definitions. This will take you to sub-classifications. Patents are usually assigned a classification and at least one sub-classification. When you select one of the classification numbers, you finally arrive at the definitions.

Step 5: Bookmark the index of classifications and give it a memorable name. It is located at: http://www.uspto.gov/web/patents/classification/uspcindex/indextouspc.htm. When you have an invention with a common name, you can find the classification by going to this index. Everything is listed in alphabetical order. For instance, if you are working on an improvement for hand shovels, you can go to shovels and find that there are a variety of objects which are referred to as shovels. There are hand shovels, power shovels, crane shovels, loading shovels, plow shovels, etc. This is important to know because many of these systems provide exactly the same function as the one that you are considering. In effect, they provide analogous functions in different industries. It is possible that they use physical phenomena and lines of evolution that are different from your industry. These can be put to work in your situation. Also, when you later identify other analogous products, you can readily find the patents for these products by using this index.

Step 6: Bookmark the Advanced Search page and study the examples for Boolean searches. (Note that you can search for phrases in parentheses.)

Now you are ready to perform the actual patent search.

Method

Step 1: Search for patents directly related to the modification that you would like to perform

Step 2: Using Advanced Search, search for key words in the abstract or body of the patents.

Step 3: When you finally find a patent which is close to the intended subject, identify the classification.

Step 4: Search by classification, making use of the Definitions and Index of Classifications. Make sure that classification includes possible patents that cover the field that you are interested in.

Step 5: When you find good representative patents, note and view all patents cited.

Step 6: Now search these patents and continue the process until no new patents regarding your area of interest show up.

Step 7: Search patents for physical phenomena that are unusual to your industry.

L3-(Ideal Phenomenon)—Evolution of Field Phenomena

Examine the Table of Fields shown in orange. Note that the top fields are the most abundant fields and the bottom fields are typically the least abundant. In general, systems tend to use the top fields first for muscle and then the lower fields for sensing and control. Later, the lower fields may become more abundant. When they are both abundant and controllable it makes sense that systems evolve toward the bottom fields. By examining the fields currently being used by your system, or similar systems, you can guess the fields that might be used next. Standard Solutions includes the replacement of poorly controlled fields with more easily controlled fields.[26] The Inventive Principles suggest the replacement of mechanical systems[27] with systems that use other than mechanical fields.

Elastic Stress	Gravity	Friction	Adhesion			
Buoyant Force	Hydrostatic Pressure	Jet Pressure	Surface Tension			
Centrifugal Force	Inertial Force	Coriolis Force				
Oder & Taste	Diffusion	Osmosis	Chemical Fields			
Sound	Vibrations & Oscillations	Ultrasound	Waves			
Thermal Heating or Cooling	Thermal Shocks	Information				
Corona Discharge	Current	Eddie Currents	Particle Beams	Nuclear Forces		
Electrostatic Fields	Magnetic Fields	Electromagnetic Fields				
Radio Waves	Micro Waves	Infrared	Visible Light	Ultraviolet	X-Ray	Cosmic

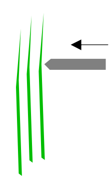
Method

Step 1: What fields are currently being used to deliver this function?

Step 2: What are the next fields that will likely be used?

Example—Lawn Mower

Step 1: What fields are currently being used to deliver this function?

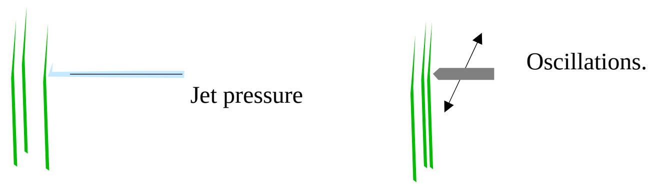


Currently, the blade is cut by a mechanical high-pressure field that makes use of the grass's inertia.

26 STANDARD 2-2-1. Efficiency of a SFM can be improved by replacing an uncontrolled (or poorly controlled) field with a well-controlled field, e.g. by replacing a gravitation field with mechanical field, mechanical field with an electric, etc. Notes: In certain situations, controllability of a field may be improved not only by replacing a given field with another one, but also by modifying the present field along the following line: Permanent field -> monotonically changing one -> pulsed one -> variable one -> variable in frequency and amplitude -> etc. Example: Instead of a metal blade for non-uniform metal cutting, a water jet can be used.

27 Inventive Principle #28—Replacement of Mechanical System: Replace a mechanical system with an optical, acoustical, thermal or olfactory system. Use an electric, magnetic or electromagnetic field to interact with an object. Replace fields that are Stationary with mobile. Fixed with changing in time. Random with structured. Use fields in conjunction with ferromagnetic particles. Genrich Altshuller, The Innovation Algorithm page 289.

Step 2: What are the next fields that will likely be used?



L3-(Ideal Phenomenon)—Library of Effects

The Library of Effects[28] is a table of physical phenomena that can be used to deliver functions. Once we know the modification that we desire, we can find a similar function in the table. Usually, this is a generalization of the desired function. The table usually gives many physical phenomena that can deliver the desired modification to the product.

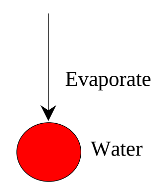
Method

Step 1: Convert given function to a Generalized Function.

Step 2: Find phenomena in the Library of Effects. Go to one of the sources for the library of effects. Some commercial software have this library. A scaled-down version can be found at: http://function.creax.com/

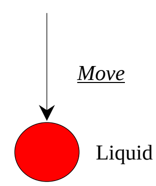
Step 3: Locate the generalized function and then consider all of the physical phenomena that can be used.

Example—Clothes Dryer



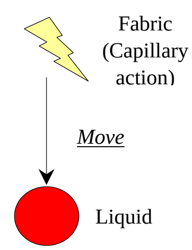
The function of the air in the dryer is to evaporate water.

Step 1: Convert given function to a Generalized Function.



The generalized function is to move a liquid.

Step 2: Find phenomena in the Library of Effects. Go to one of the sources for the library of effects.



Step 3: Locate the generalized function and then consider all of the physical phenomena that can be used.

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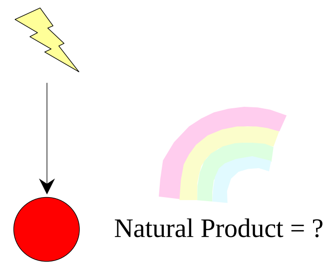
28 A Library of Effects is one way to describe a table of physical phenomena. In Creativity as an Exact Science—the Theory of the Solution of Inventive Problems, G.S Altshuller, Gordon and Breach, page 309, a table is introduced called THE APPLICATION OF CERTAIN PHYSICAL EFFECTS AND PHENOMENA IN THE SOLUTION OF INVENTIVE PROBLEMS. This table is now referred to in a number of ways, but is generally a table describing physical phenomena that can be used to deliver a desired function.

L3-(Ideal Phenomenon)—Analogous Products—Bio-mimicry

Nature has developed many analogous phenomena that can be employed to perform functions. The name for this search is commonly referred to as bio-mimicry[29]. The concept of analogous phenomena starts with an analogous product. Identifying objects in nature that require the same function will begin to lead the seeker to new physical phenomena.



Method

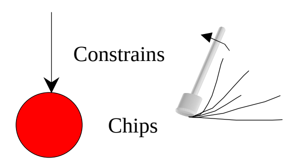
Step 1: Identify analogous products in nature. What objects in nature require or have this same function imposed? You might have to consider variants of this function. (Look for primitive natural analogies).

Step 2: Identify the natural Tool/ Effect.

Step 3: Transfer the Effect/Tool to the new situation.

Step 4: Consult the website-- http://asknature.org/ with a specific function.

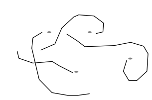
Example—Catching Chips



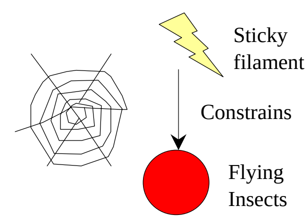
When we grind an object, small chips are ejected. We would like to constrain these chips.

Step 1: Identify analogous products in nature. What objects in nature require or have this same function imposed? You might have to consider variants of this function. (Look for primitive natural analogies).

Flying Insects are often caught in webs.

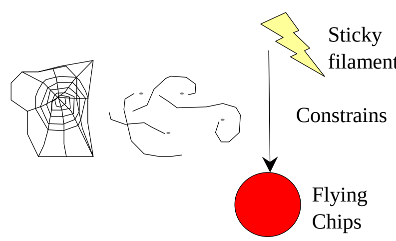


Step 2: Identify the natural Tool/ Effect.



As stated, the insects are often caught in webs.

Step 3: Transfer the Effect/Tool to the new situation.



A sticky filament will catch the flying chips.

Step 4: Consult the website-- http://asknature.org/ with a specific function.

We are looking for the function: "capture". Here are just a few of the following ways that nature does this.

--Wiry tangles capture fog: lichens

29 Otto Schmitt, is credited with creating the term bio-mimicry.

--Bristles and barbs capture minute foods: Calanoid copepods

--Bio-inspired adhesive tape

--Elaborate stigmas capture pollen grains: grasses

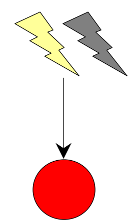
L3-(Ideal Phenomenon)—Transition to Use of Bulk Properties?

Systems may transition to a new physical phenomenon by moving to the micro-level.[30] In other words, the bulk properties of the material are mobilized to provide the required functions.

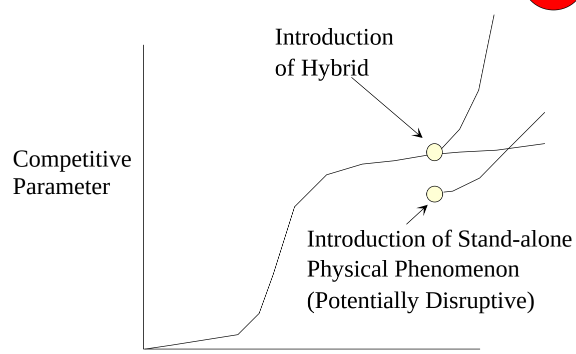
Method

Step 1: Can the bulk properties of the materials be used to perform the required functions?

L3-(Ideal Phenomenon)—Hybrid or Stand-Alone Phenomena?



Trying to satisfy an entrenched sustaining market will be unlikely with a completely new physical phenomenon as some very important competitive parameter will almost certainly be compromised. The sustaining market will demand that we not depart from the performance that they are used to, although the s-curve of performance is flattening. New markets will be much more forgiving and may even welcome the weaknesses of the new physical phenomenon as strength. The new Phenomenon will gather strength as a hybrid and eventually replace the old phenomenon or it will gather strength as a stand-alone phenomenon in the new market. Clayton Christensen[31] points out, it is possible that the new stand-alone phenomenon will develop along its own s-curve and eventually become a disruptive technology, taking away market share from the existing sustaining markets. Also, if the existing phenomenon is in the rapid growth part of the S-Curve, it will be difficult to catch up. Greater resources will keep the performance ahead of the new phenomena.



Instead of jumping to the new phenomena entirely, it is

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30 STANDARD 3-2-1. Efficiency of a system at any stage of its evolution can be improved by transition from a macro-level to a micro-level: the system or its part is replaced by a substance capable of delivering the required function when interacting with a field. Notes: There is a multitude of micro-level states of a substance (domains, crystal lattice, molecules, ions, domains, atoms, fundamental particles, fields, etc.). Therefore, various options of transition to a micro-level and various options of transition from one micro-level to another, lower one, should be considered when solving a problem. Example: Instead of a micro-screw, a microscopic table can be positioned by fixing it on a metal rod that is subjected to a thermal field. The rod expands and contracts relatively the value of the temperature due to the effect of thermal expansion.

31 The Innovator's Dilemma by Clayton M. Christensen—Harper Business Essentials

possible to gain the rapidly developing advantages of the new phenomena or technology by creating a hybrid[32] of the new and old phenomenon. This tool if extremely useful when you are working with a demanding sustaining market and the resources of the current phenomenon are becoming limited. This is a way to move to the new physical phenomena while increasing (rather than sacrificing) performance, as is often the case when jumping to a new effect.

Method

Step 1: If the market is a recognized and mature market then consider a hybrid of the old and new phenomenon.

Step 2: Begin with a common physical phenomenon that is normally used to deliver the modification.

Step 3: Identify another phenomenon which performs the same modification.

Step 4: What is the feature of the new tool which would extend the capability of the first tool?

Step 5: Identify the cheap tool which should deliver most of the function.

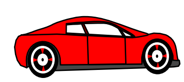
Step 6: Combine both phenomena into a hybrid. A new capability should emerge. Try combining both as whole tools. Try transferring just the desirable feature. Consider having the two physical phenomena interact with each other.

Step 7: If the market is an emerging or unrecognized market then consider using a completely new physical phenomena in which the native weaknesses of the physical phenomena are considered to be a strength.

Example—Transition to Electric Car

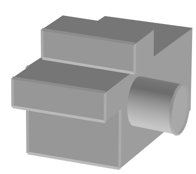
It is time to transition to a new phenomena for car propulsion.

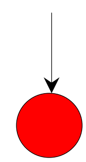
Step 1: If the market is a recognized and mature market then consider a hybrid of the old and new phenomenon.



Jumping entirely to a fully electric car would sacrifice too much with a mature market. Consequently, the decision is made to consider a hybrid car—Gas and Electric.

Step 2: Begin with a common physical phenomenon that is normally used to deliver the modification.

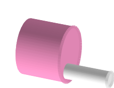




Moves

Internal Combustion Engine

Step 3: Identify another phenomenon which performs the same modification.



Electric Motor

32 STANDARD 3-1-3. Efficiency of bi- and poly-systems can be improved by increasing the difference between system components. The following line of evolution is recommended: similar components (pencils of the same color) –->components with biased characteristics (pencils of different colors) –->different components (set of drawing instruments) –->combinations of the "component + component with opposite function" (pencil with rubber)

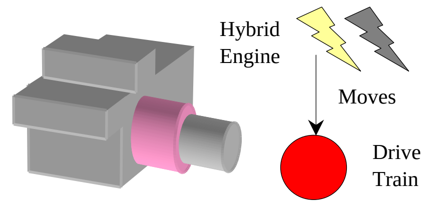
Step 4: What is the feature of the new tool which would extend the capability of the first tool?

Torque at low speeds

Step 5: Identify the cheap tool which should deliver most of the function.

The Internal Combustion Engine

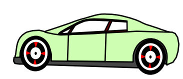
Step 6: Combine both phenomena into a hybrid. A new capability should emerge. Try combining both as whole tools. Try transferring just the desirable feature. Consider having the two physical phenomena interact with each other.



The electric motor is coupled to the driveshaft of the internal combustion engine.

Step 7: If the market is an emerging or unrecognized market then consider using a completely new physical phenomena in which the native weaknesses of the physical phenomena are considered to be a strength.

Imagine that the market is not a mature market. This means that it is still small. Let's consider an Electric Car for Teen Drivers



— Extremely safe enclosure

— Limited speeds

— Restricted driving range

— Full entertainment system

L3-(Ideal Phenomenon)—Merge or Interact With Multiplied Tools

If you are aware of a physical phenomena which can perform the function there is a possibility that a completely new physical phenomenon can be identified by multiplying the common tools and then making the multiplied tools interact with each other.

Method

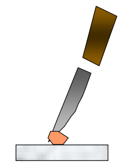
Step 1: Identify an object related to a physical phenomenon that is similar to the one required.

Step 2: Multiply the system. Start with two.

Step 3: Can these tools be merged or interact together to create an unexpected capability? Try different orientations.

Step 4: Consolidate[33] Elements if Possible

Example—Common Knife

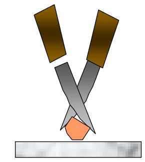


Step 1: Identify an object related to a physical phenomenon that is similar to the one required.

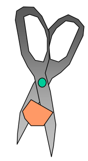
Consider a knife.

Step 2: Multiply the system. Start with two.

Now we have two knives.



Step 3: Can these tools be merged or interact together to create an unexpected capability? Try different orientations.



Try merging the knives. The knives become scissors.

Step 4: Consolidate Elements if Possible

L3-(Ideal Phenomenon)—Chaining Physical Phenomena

As a fallback to creating a completely new physical phenomenon, consider the possibility of chaining physical phenomena[34] to deliver the function. This is especially true if substances and fields can be consolidated[35].

Method

Step 1: Some software is capable of chaining physical phenomena to deliver a function.

Step 2: If software is not available, chain a final and starting physical phenomenon together with connecting phenomena. This may be done by trial and error.

L3-(Discovering Phenomena)—Intelligent Little People

One of the most important tools of investigation is empathy. This is the ability to become a part of the system that we are investigating and to see it from this unique perspective. The principle of empathy is very powerful, but has a few limitations. First, we provide only one perspective from which to view the problem. Secondly, we must exist in order to view the problem. In other words, we cannot dissolve or disappear. Third, there is just one of us to

33 Inventive Principle #5—Consolidation: Consolidate in space homogeneous objects, or objects destined for contiguous operations. Consolidate in time homogeneous or contiguous operations. Genrich Altshuller, The Innovation Algorithm page 287.

34 Invention Machine Software provides for chaining physical phenomena or Effects to deliver the desired function. This ability is added to their library of effects (physical phenomena).

35 Inventive Principle #5—Consolidation: Consolidate in space homogeneous objects, or objects destined for contiguous operations. Consolidate in time homogeneous or contiguous operations. Genrich Altshuller, The Innovation Algorithm page 287.

interact with the system. If there were more of us to interact, this would open up new possibilities. These difficulties are largely overcome by using the principle of little intelligent people[36].

Method

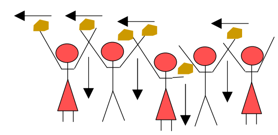
Step 1: Envision the system as composed of intelligent little people who can work together. They also have the capability to disappear and reappear if necessary. What do they do to accomplish the desired result? How do they intelligently act together?

Step 2: Consider possible physical phenomena that can accomplish this cooperation.

Example—Self cleaning air filter

Step 1: Envision the system as composed of intelligent little people who can work together. They also have the capability to disappear and reappear if necessary. What do they do to accomplish the desired result? How do they intelligently act together?

The little people pass the particulates from one to the next while allowing air to flow.



Step 2: Consider possible physical phenomena that can accomplish this cooperation.

A separate liquid moves along the surface due to a mechanical action. The liquid acts to trap and carry the particles. Lungs clean themselves using this same action.

L3-(Discovering Phenomena)—Drive Measurement and Detection to the Extreme

One might argue that "new" physical phenomena are going on around us all the time. Unfortunately, we are not capable of detecting it, because it is beyond the normal range of human sensing. For example, without special filters, it would be impossible to detect the polarization of a ray of light.

In order to see what is going on around us, we must look with a new perspective; we must use tools which are capable of detecting modifications to substances and fields in places and under circumstances that are extreme. Extreme circumstances would include extremely small, extremely hot, extremely cold…

Whenever you drive anything to the extreme, you will likely see or experience new phenomena. Being able to see smaller things or further into space, or probe areas of the micro and macro universe or into extremely unusual environments will likely uncover unusual physical phenomena.

Method

Step 1: Identify an attribute that you would like to detect to the extreme.

Step 2: Create a measurement system that can detect to this level (see measurement and detections).

Step 3: Measure to the extreme and see if what is observed matches theory.

36 Creativity as an Exact Science-The Theory of the Solution of Inventive Problems by G.S. Altshuller. Gordon and Breach page 104

L3-(Discovering Phenomena)—Bio-Mimicry

The biological kingdom performs countless functions at large scales and small. The diversity of functions and physical phenomenon are great. What if we could train ourselves to see things in a new way and ask ourselves hard questions? Why are eagle claws always sharp? How do bird feathers hold their shape? How can a bumble bee fly? When we are searching for new ways to deliver functions, we can look to nature to see how it delivers these functions and duplicate what it does. Nature has developed many analogous phenomena that can be employed to perform functions. The study of nature to determine how its secrets can be used to deliver useful human functions is called Bio-mimicry[37.]

Method

Step 1: Identify analogous products in nature? (Look for primitive natural analogies).

Step 2: Identify the natural Tool/ Effect.

Step 3: Transfer the Effect/Tool to the new situation

Step 4: Consult the website-- http://asknature.org/ with a specific function.

L3-(Discovering Phenomena)—Analogous Phenomenon

This approach asks, can a physical phenomenon which delivers an analogous function be delivered with fields that are native to your situation.

Method

Step 1: Identify the product and modification that you want to deliver.

Step 2: Identify analogous products which use a different phenomenon to deliver the function?

Step 2: Identify the fields and substances that deliver the function to the analogous function.

Step 3: Transfer the phenomenon to your situation using the fields that are native to your situation.

Example—Concentration of Light

Step 1: Identify the product and modification that you want to deliver.

I would like to concentrate light. I want to push photons closer together and pack them very tightly.

Step 2: Identify analogous products which use a different phenomenon to deliver the function?

An analogous product is the concentration of gas in a cylinder.

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37 Otto Schmitt, is credited with creating the term bio-mimicry.

Step 2: Identify the fields and substances that deliver the function to the analogous function.

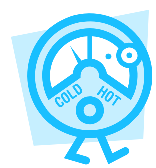
A piston is used to concentrate the gas particles.

Step 3: Transfer the phenomenon to your situation using the fields that are native to your situation.

Mirrors are "effectively"brought close together very rapidly. Is it possible to create structures that can change the distance between reflective bodies rapidly enough to avoid reflective losses through too many reflections?

L3-(Discovering Phenomena)—Drive Fields to the Extreme

Another way to find new physical phenomena is by looking at physical phenomena that have been driven to the extreme. There are different ways to drive a phenomenon to the extreme. We may pair a field with a substance that is particularly susceptible to the field. We may drive the field to an extreme level. We may create a very precise degree of order to the substances or to the fields. We may drive a physical attribute of one of the substances to the extreme. In each case, we will likely discover that nature behaves in unusual ways. These unusual responses can often be used to deliver functions. Nicola Tesla was legendary for driving fields to the extreme. No electrostatic field was ever high enough for him; he always kept pushing and as a result, discovered new phenomena and fundamentally new ways to deliver functions.



Method

Step 1: Identify fields in the Table of Fields (Appendix). These fields will be applied to a substance at the same time.

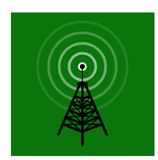
Step 2: Drive the field to the extreme. This might be extreme intensity or for very short durations.

Step 3: Look for new phenomena.

L3-(Discovering Phenomena)—Drive Order to the Extreme

Whenever order is driven to the extreme, new physical phenomena are discovered.

Method

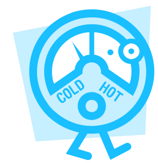


Step 1: Where there is little order, drive order to the extreme and look for new physical phenomena.

Step 2: Where there is great order, drive chaos to the extreme and look for new physical phenomena.

L3-(Discovering Phenomena)—Drive Attributes to the Extreme

Whenever physical attributes are driven to the extreme, new physical phenomena are observed.



Method

Step 1: Take any given physical phenomenon.

Step 2: Take an attribute of an Element within that physical phenomenon and consider means in which this can be driven to the extreme.

Step 3: Drive this attribute to the extreme and look for physical phenomena.

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L2-Tool Resources

The Ideal Tool for Useful Functions

With potential physical phenomena in mind to deliver the function it is time to identify a tool which can deliver the physical phenomenon. We ask ourselves what the ideal machine should be, and then we tell ourselves that we will achieve this result without the use or addition of any object or substance to the system. This is often possible when we can get an object to perform more functions than it normally would. It is also possible if we can eliminate objects and allow something in the system to take over the function.

Up to this point, we have avoided adding any object to the system. If we have reached this point and still need to add an object, then we must do it in the most ideal way possible. We would like to perform our function without adding any objects. If possible, existing objects and ambient fields should perform the modification. If this is not possible, only then do we consider adding objects. The best situation is a small change to the product that allows an ambient field to perform the function. According to the law of increasing ideality, the value of any object increases when the number of functions that the object does is increased and the number of harmful factors decreases. In general, this means that we would like to get the most functions possible out of each object. Each tool should take on as many functions as possible.

Parasitic Tools

Parasitic tools use something which already exists in the system, super-system or environment to perform the function. When this occurs, it is actually possible to get something for nothing.

L2-Method

Step 1: Make a list of resources.

Step 2: Consider that the object requiring the modification performs the modification on itself.

Step 3: Consider whether the function is already performed by something in the system or the environment, even poorly. Could this resource be boosted?

Step 4: Consider using a similar tool which is in the system or the environment.

Step 5: Consider merging with the super-system in order to achieve the modification.

L3-List of Resources

In preparation for considering changing elements or adding substances and fields to the system, it is good to know what substance and field resources we have available. In this step we consider ordinary elements about us that might be pressed into service [38] to deliver the required physical phenomena. This method is especially effective with low level fields such as elastic fields, gravity, pressure, etc.

38 Inventive Principle #6—Universality: an object can perform several different functions ; therefore, other elements can be removed. Genrich Altshuller, The Innovation Algorithm page 287. Most courses on TRIZ suggest creating a list of objects in the system or environment that can be pressed into service to perform a useful function.

Method

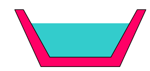
Step 1: Make a list of adjacent elements, especially those which were not considered in the super-system functional models.

Step 2: What fields are associated with these objects?

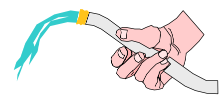
Step 3: Consider ways in which elements on the list might be pressed into service to perform the required modification.

Step 4: Consider decomposing elements into new components.

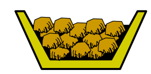
Example—Pet Feeder—How can we stop insects?



Step 1: Make a list of adjacent elements, especially those which were not considered in the super-system functional models.



Pet Food—Water Bowl—Water Hose—Water in Water Bowl—Food Bowl—Cement or Ground.

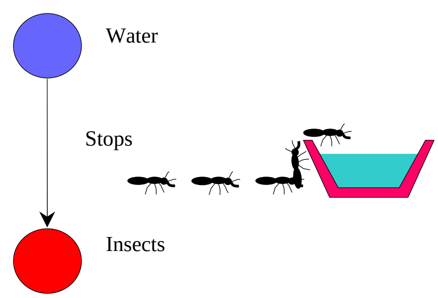


Step 2: What fields are associated with these objects:

—Surface Tension—Water Bowl

—Mechanical fields—Food Bowl & Water Bowl

—Water Pressure—Water hose



Step 3: Consider ways in which elements on the list might be pressed into service to perform the required modification.

The water stops the crawling insects.

Step 4: Consider decomposing elements into new components.

L3-Use of Cheap Abundant Substances

When a function can be delivered at low cost, the value of the system increases. If there is a way to use a cheap abundant substance, try to use it. If the phenomenon is weak, it may be possible to boost the phenomenon later.

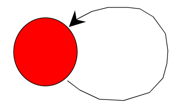
Method

Consider the following list of cheap substances:

Powders— Foams— Voids— Water— Ice— Steam— Hydrates— Air— Nitrogen—Carbon Dioxide— Oxygen— Corrosion— Decay— Sand— Soil— Rocks— Waste—Waste Water— Sawdust— Waste Glass— Waste Gases— Waste Paper— Garbage—Yard Waste— Industrial Wastes— Hybrid Substances— Disassociated Forms of Any of the Above— Products of Interactions— Starting Materials— Final Products— Semi-Finished Elements

L3-Self- Service

The product in question has native fields associated with it. Can we make some small change to the product so that it performs the modification on itself[39]? (It is likely that energy will still need to come from outside).



Method

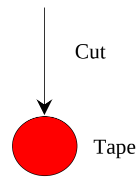
Step 1: Search the Table of Fields (in the Appendix) for fields that are always associated with the product?

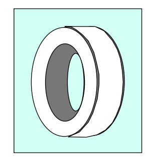
Step 2: What Effect or Physical Phenomena can be used to deliver this function?

Step 3: In following steps we can try to boost this function.

Example—Cutting Tape from a Roll

Consider the example of a roll of tape that must be cut. Normally it is cut by a blade supported to the base element. Let us begin with the tape alone and the modification "cut".

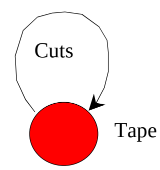




Step 1: Search the Table of Fields (in the Appendix) for fields that are always associated with the product?

We should consider Adhesive Fields & Mechanical Fields.

Step 2: What Effect or Physical Phenomena can be used to deliver this function?



The Creation of directed forces by use of adhesive forces

Step 3: In following steps we can try to boost this function.

The adhesion between layers must create forces which grossly overpower adhesion of the tape material to itself.

Some readers may be confused with this example as it does not seem to indicate a particular solution, but the possibility of a solution. This is as it should be in this case. Whenever we idealize functions, we are creating new candidate systems. At this point, we do not know whether they will work or not. Most of these examples discuss new systems that seem like they could work out. This one appears to be questionable. Remember that when we have a new candidate system, it may have many weaknesses. It is now our opportunity to turn this "sows ear" into a "silk purse". We do this by going back to reviewing the related requirements and following through the causal analysis, etc. again. Eventually, we will continue past this point in the algorithm by focusing on the object attributes and contradictions which need to be solved. Remember that in Idealizing Functions, we are creating Ideal Final Results for ourselves. We may not yet know how to realize them.

39 Inventive Principle #25—Self-service: An object must service itself and carry-out supplementary and repair operations. Make use of waste material and energy. Genrich Altshuller, The Innovation Algorithm page 288.

L3-Already Poorly Performed by Native Fields

Sometimes, a function is already performed by some natural phenomenon but it is done very poorly or even harmfully. With a little help, we can boost these functions until they become useful[40].

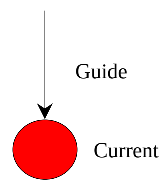
Method

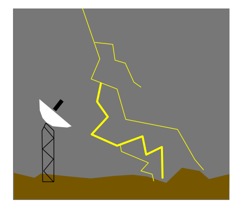
Step 1: Is the function already delivered by a super-system tool, even poorly?

Step 2: What physical phenomenon is employed to poorly deliver this function?

Example—Protecting a Radio Tower from Lightning

A classic TRIZ example is the radio tower which requires lightning rods to protect it. We must guide the current, but we would like to do this by using native fields.

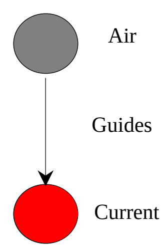




Step 1: Is the function already delivered by a super-system tool, even poorly?

Yes, the air guides the current poorly. The charge comes to the ground in concentrated form

Step 2: What physical phenomenon is employed to poorly deliver this function?



To initiate this, the air must be locally ionized. The air then becomes conductive. As the current is conducted, there is a self concentrating effect caused by many moving charges traveling in the same direction.

In following steps we can ask what modifications to the fields or the tool allow the function to be boosted. These modifications may require the small addition of substances or structures which react strongly to the native fields.

40 STANDARD 5-2-1. If a field has to be introduced in a SFM, one should use first of all the present fields for whom the media are those substances that form the system or its part. Note: The use of substances and fields which already present in the system improves the system's ideality: number of functions performed by the system increases without increasing the number of used components.

STANDARD 5-2-2. If a field has to be introduced in a SFM and it is not possible to use the fields which already present in the system, one should use the fields of the external environment. Note: The use of external environment fields (gravitation, thermal field, pressure...) improves the system's ideality: the number of functions performed by the system increases without increasing the number of used components.

STANDARD 5-2-3. If a field has to be introduced in a SFM but it is impossible to use the fields which already present in the system or in the external environment, one should use the fields for whom the substances present in the system or external environment can act as media or sources. Notes: In particular, if there are ferromagnetic substances in a system and they are used for mechanical purposes, it is possible to use their magnetic properties in order to obtain additional effects: improve interactions between components, obtain information on the state of the system, etc.

L3-Abundant Native Fields

Most objects are awash in native fields. These fields do not remain constant throughout the product life cycle. By identifying the fields all around the product, we locate tool resources that can perform the function. The solution standards give several practical suggestions for introducing fields which are native to the system or the environment.[41]

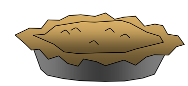
Method

Step 1: Process Map the product life through relevant life stages.

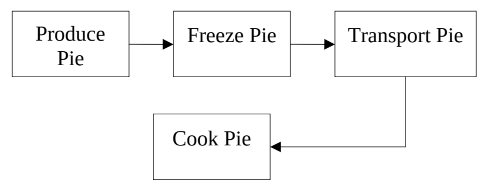
Step 2: Look through the Table of Fields at the end of this appendix. Identify which native fields the product experiences at each process step. Which of these native fields perform this function even poorly?

Step 3: What Effect or physical phenomena can be employed to deliver this function?

Example—Cutting a Pie before Consumption

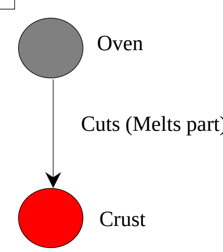


Step 1: Process Map the product life through relevant life stages.



Step 2: Look through the Table of Fields at the end of this appendix. Identify which native fields the product experiences at each process step. Which of these native fields perform this function even poorly?

Thermal fields can deteriorate the crust. I suppose that this is a useful variant of cutting



Step 3: What Effect or physical phenomena can be employed to deliver this function?

Melting or Chemical Reaction are possible physical phenomena. In the next steps we can try to boost this function.

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41 STANDARD 5-2-1. If a field has to be introduced in a SFM, one should use first of all the present fields for whom the media are those substances that form the system or its part. Note: The use of substances and fields which already present in the system improves the system's ideality: number of functions performed by the system increases without increasing the number of used components.

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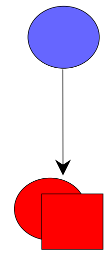
L3-Nearby Similar Tool



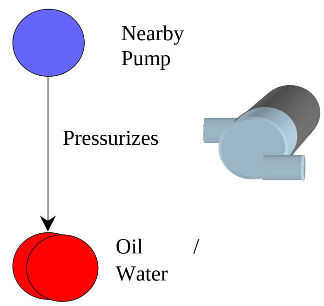
Depending on how systems evolve, it is common that several elements in the system perform the same function. These objects may perform the same function on different or biased products[42]. Sometimes, this tool can be pressed into service to perform the function on both products.

Method

Step 1: Identify a similar tool nearby which performs the same function.

Step 2: Combine and consolidate[43] both elements into one system.

Example—Air Pump



The pressurization of air is required.

Step 1: Identify a similar tool nearby which performs the same function.

There is an oil pump nearby which performs the function.

Step 2: Combine and consolidate both elements into one system.

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42 Inventive Principle #6—Universality: an object can perform several different functions ; therefore, other elements can be removed. Genrich Altshuller, The Innovation Algorithm page 287.

43 Inventive Principle #5—Consolidation: Consolidate in space homogeneous objects, or objects destined for contiguous operations. Consolidate in time homogeneous or contiguous operations. Genrich Altshuller, The Innovation Algorithm page 287.

L3-Simplified Copy of the Current Tool

Use of the current tool can be overkill, especially if the tool is a human. A simplified copy[44] can often perform the same function as the full tool.

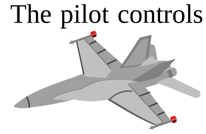
Method

Step 1: What part of the current tool performs the function?

Step 2: Can a copy of the tool perform the function?

Example—Dangerous Missions

Jets are often required to perform dangerous recognizance missions. The pilot controls the sophisticated aircraft. The pilot is capable of performing unexpected maneuvers during combat or if failures occur, but during a recognizance mission, these functions are rarely required.

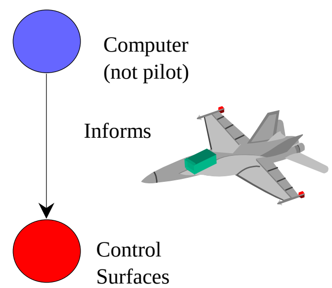


Step 1: What part of the current tool performs the function?

The brains and hands of the pilot perform the current function.

Step 2: Can a copy of the tool perform the function?

A computer performs the function of the pilot.



L3-Merge with the Super-System

Sometimes, it is the most advantageous to give up functions of the system and turn them over to the super-system. Note that this is an exception to the rule that the slave must not serve the master. There are some conditions where integration yields much higher performance than modularity.

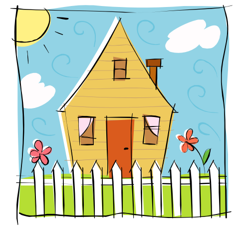
Method

Step 1: Look for functions performed in the super-system that are identical with functions performed in the system.

Step 2: Transfer these functions to the super-system.

44 Inventive Principle #26—Copying: A simplified and inexpensive copy should be used in place of a fragile original or an object that is inconvenient to operate. If a visible optical copy is used, replace it with an infrared or ultraviolet copies. Replace an object (or system of objects) with their optical image. The image can then be reduced or enlarged. Genrich Altshuller, The Innovation Algorithm page 288.

Example—Refrigerator Combines with Home



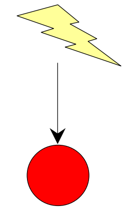
Step 1: Look for functions performed in the super-system that are identical with functions performed in the system.

Both the house and the refrigerator have insulation. The function of insulation is to reduce the flow of heat.

Step 2: Transfer these functions to the super-system.

The Refrigerator merges with the home. The House provides the insulation for the refrigerator. Now the insulation has essentially become quite thick, thus making the system more efficient.

L2-Ideal Tool(s)

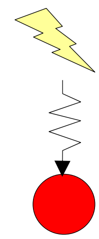


In choosing the ideal tools to perform the function, there are a number of considerations to keep in mind. We would like the tool to be as ideal as possible, but what does this usually mean? In this section, we look at ways to tell if a tool is more ideal. We do this with an understanding that all tools will bring burdens for the system. We just want the lowest burden possible.

Abundance

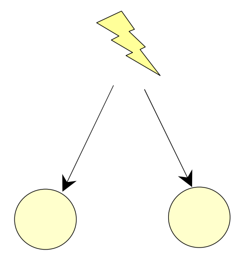
The availability or abundance of resources to deliver the physical phenomena must be high. Objects and resources are already present in the environment that can help deliver the physical phenomena. We do not determine in this section whether a sufficient abundance exists. This will occur in the next section. That is why this section deals with possible physical phenomena.

Inherent Harm (Contact)



Some tools, with their attending physical phenomena require the addition of harmful interactions. This is especially true with physical phenomena that require contact. If physical phenomena are present which do not require contact and the resources for providing this physical phenomena are abundant, then consider these over those that require contact.

Multiple Functions including Passive Control and the Anti-Function



A more ideal physical phenomenon is capable of performing multiple functions. The value of objects in a system is dependent upon two things, the number of useful functions that they deliver and the burdens that they create. In this case, we are considering the number of functions that they deliver. It is only possible to consider multiple functions if other functions in the system are already required. There is no reason to create functions to perform in order to allow a physical phenomenon to perform more functions. The secondary function that the phenomenon performs may be a supporting function but more ideally, it should be a primary function that acts directly on the system product.

In the case of measurement, it would be more ideal if the physical phenomenon could both sense and control. If sensing and actuation are required in the same system, then it is ideal to perform both functions with the same subject. It is therefore necessary that the physical phenomenon is capable of delivering both.

The evolution of systems predicts that systems will eventually take on the anti-function in order to provide more value. The anti-function is often provided by the super-system already, but it is often forgotten because it may occur much later than when the product or process is applied. But what does this mean when we refer to measurement? Whenever measurement occurs, there is a disturbance to the system. If you dip a thermometer into a hot liquid, the liquid must change the temperature of the thermometer in order for it to register. For every action, there is an equal and opposite reaction. While the thermometer is being heated, the liquid is being cooled. While most measuring instruments are designed to disturb the system as little as possible, a very accurate measurement of the system may require that the disturbance be undone, preferably at the same time that the measurement is taken.

Scalable

A more ideal physical phenomenon is capable of being scaled to the level necessary to meet increasing and decreasing demands.

Relative Risk

When we move to a new phenomenon to deliver a function, we are taking upon ourselves unknown risks. Therefore it is important to come to an understanding of this new phenomenon as rapidly as possible and make sure that the risks are localized to one or two major risks.

Self-Service

If possible, we would like to add no elements to the system. If possible, the function should exist but no objects and substances should be added. "Self-service" is one way to achieve this. Sometimes, this is accomplished by native fields in the environment or the system.

L2-Method

Step 1: Abundance: In order for the physical phenomenon to have any chance, it should be abundant in the system. Identify abundant fields—these are usually associated with abundant physical phenomena. Filter the potential phenomena (previous steps) to allow only those which are abundant.

Step 2: Self Service: Can the function be performed without the addition of any new element or with the minimum substance?

Step 3: Inherent Harm (Contact): Filter the physical phenomena that you are considering for contact.

Step 4: Multiple Functions: Search for additional functions within the system that the physical phenomenon could deliver. Look for opportunities to use passive feedback from physical phenomena that can both sense and actuate. If necessary, can the physical phenomenon deliver the function and the anti-function?

Step 5: Scalable: Is the physical phenomenon capable of being scaled to larger or smaller scales?

Step 6: Familiarity and Localization of Risk: Become as familiar with the phenomenon as rapidly as possible to determine the inherent problems and risks. The drawbacks should be localized to one or two areas.