Hierarchical TRIZ Algorithms

6th Installment--Oct 2005

Hierarchical TRIZ Algorithms is a how-to TRIZ book. It is designed to assist both beginning and advanced users. Each month, the TRIZ-Journal will publish another chapter of the book. This month's installment includes the Fifth step of the 10 step algorithm (shown on the cover):

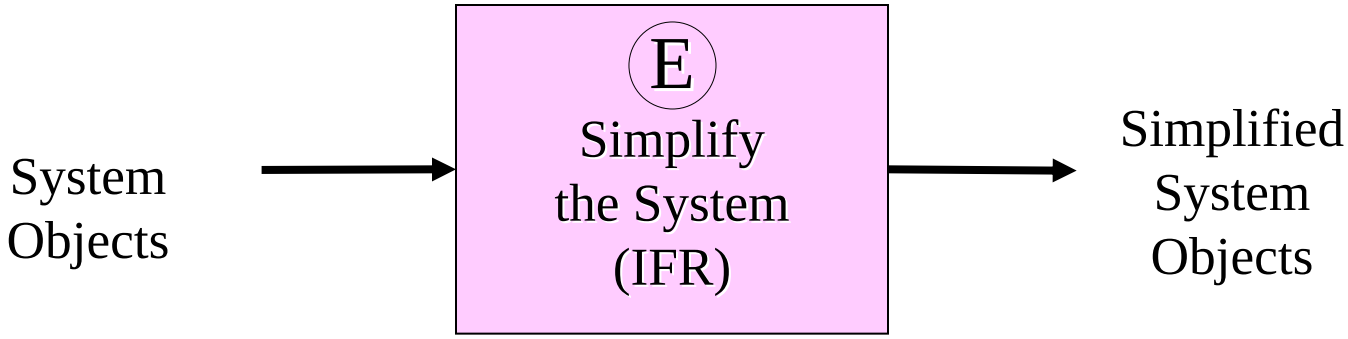
E. Simplify the System

Next month's installation will cover the sixth process step:

F. What is the Main Problem?

In all, there will be 12 installments. Should you decide to purchase the most current edition of the complete book contact the publisher at:

http://www.3mpub.com/TRIZ/



Introduction

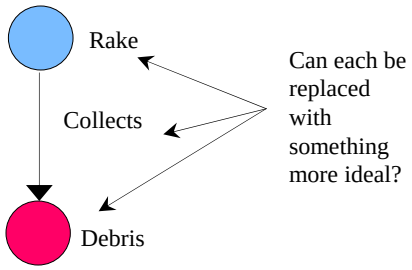
With the system objects known, there is now the opportunity to increase the system value for the target market. This usually involves reducing the cost and complexity of the system. In virtually any instance, the value of the system will increase if the system is simpler. Simple solutions are one of the hallmarks of TRIZ. Most people will look at a TRIZ solution and ask: "Why didn't I think of that?" Once the product or solution is seen, it is difficult to remember how difficult the situation was!

This step begins with a detailed functional model of the system. This is necessary to see each of the parts, at once, and to identify elements with similar functions which can be combined. Next, we discover the parts of the system that have intrinsically low value. Typically these parts do not operate directly on the system product and they often cost a lot. These elements are prime candidates for removal from the system.

The steps that follow are suggestions for simplifying the system in big jumps. One of the most important of these suggestions is to identify and remove remedial or preventative functions. Virtually any useful function can be viewed as a remedial or preventative function. We simply ask ourselves the question "What does this function fix or what does it prevent". If we can find the reason that the function is required, then we can work to idealize this new offending function. What remains after this simplification process can yet be greatly simplified by considering the Ideal Final Result (IFR).

The Ideal Final Result (IFR) is a classical TRIZ tool used to guide the inventor to a system which is much simpler. All functions which must be performed are performed without the addition of any substance or element. They magically happen. While this may seem quite impossible, there *are* ways in which we can come close to achieving this ideal. For instance, if we can get another object in the system to perform the function, then we have effectively accomplished the IFR. As a matter of practicality, a small change may be required to so that this other object can take over the function.

While the classical concept of the IFR is very elegant, the practical implementation can be difficult. Smaller thinking steps may be required. This can be accomplished by considering the IFR in functional terms, using functional language. This is done by looking at each part of the function in question and asking "Can I replace this with something more ideal?"



As we consider idealizing each function in the system, the method of attack will change depending upon the type of function that we are considering. For *useful functions*, we begin by asking what the ideal product would be.

The answer to this question may seem strange at first, but the most ideal product is one that does not require the modification in the first place! If the modification *is* required, we ask what the most ideal modification is. Next, we ask what the most ideal physical phenomena would be and finally, what objects will deliver this physical phenomena without the addition of substance or elements. For Harmful Functions, the initial focus is on the tool and modification. How can we make this harmful phenomena deliver a useful modification? How can the harmful object be eliminated? For Informing Functions, the initial focus is on the tool or the object parameter which requires detecting. What physical phenomena are availaable for detecting and finally the objects which make use of this physical phenomena

Where did the concept of functional IFR come from? The functional IFR is a restructuring and reinterpretation of the parts of the "Standard Solutions" that deal with eliminating, redefining or replacing function parts (object resources). When combined with the classical concept of the IFR, this part of the change process becomes more powerful. This is the opportunity to greatly reduce the system penalties by decreasing the number of elements and allowing elements to take on more functions. This process of simplification can continue until the system is simplified out of existence!

Beyond this step, it is assumed that the main system elements are in place and we will only reluctantly add more elements.

Simplified

Consider adding, removing or replacing objects which do not perform their function as well as they should or that cause harm. If components are added, it is to simplify the overall system.

Eliminate Remedial or Preventative Actions and Harmful Objects

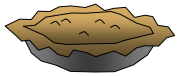
In the end, most problems can be traced to useful objects that do not perform their function as well as they should or also cause harm.

- Ask why harmful or remedial objects are required.
- Ask why several times until you uncover key reasons or key problems
- Solve these problems to remove the remedial or harmful objects

22 Turn Harm to Benefit

- Make Lemonade from Lemons by making adjustable or reversing fields-Harmful Object performs useful function

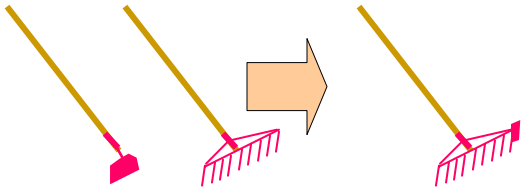
25 Self-Service



Oven heat cuts pie

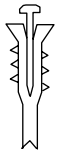
- Slight change to product allows ambient fields to do job

5 Combine Elements with Similar Functions



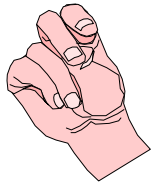
- Identify objects which are normally related to the target job and which have similar functions.
- Can these objects be combined with your product?

6 Universality



- Look around and list other objects which are normally related with the target job.
- Can these be combined with your product?

Ideal Final Result (IFR)



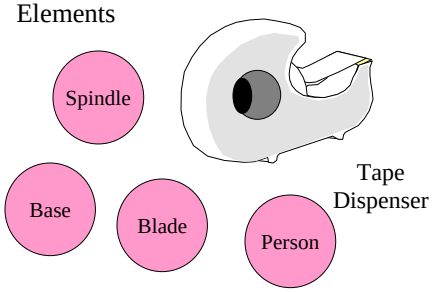
If I could snap my fingers…

Continue this process until the function is present, but no objects exist to perform the function.

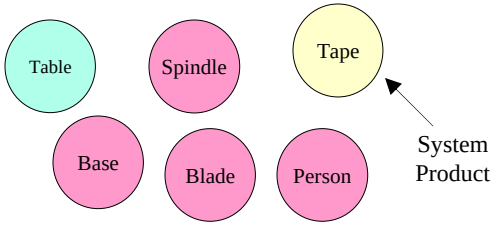
Detailed

Create a Functional Description of the System

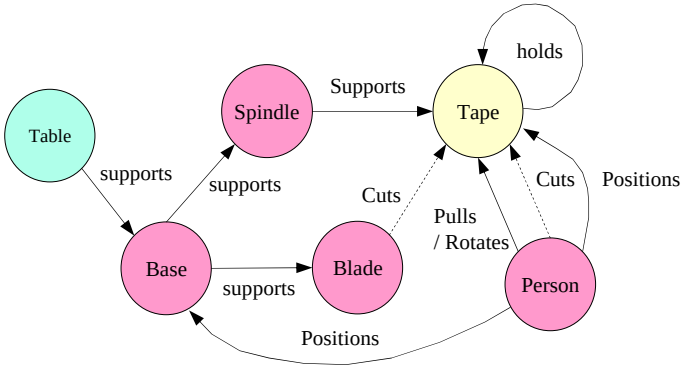
1. Break the System Down Into Functional Elements



2. Add Super-System Elements
- Super-system elements include, but are not limited to elements related with the job or task
- Generally, you do not have the authority to eliminate super-system elements, though they do not have to interact with the system
- Include only those that interact with the system
- Identify the system product. This is the element that the system modifies or serves



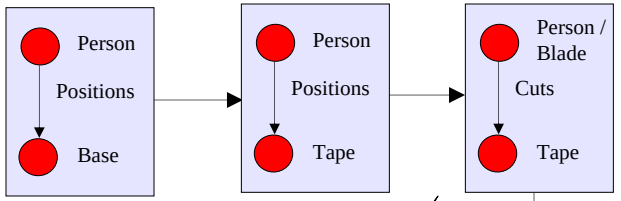
3. Introduce Modification Links
- Include useful, flawed and harmful links (harmful not shown below)
- Verify that all rules for forming functions have been followed.



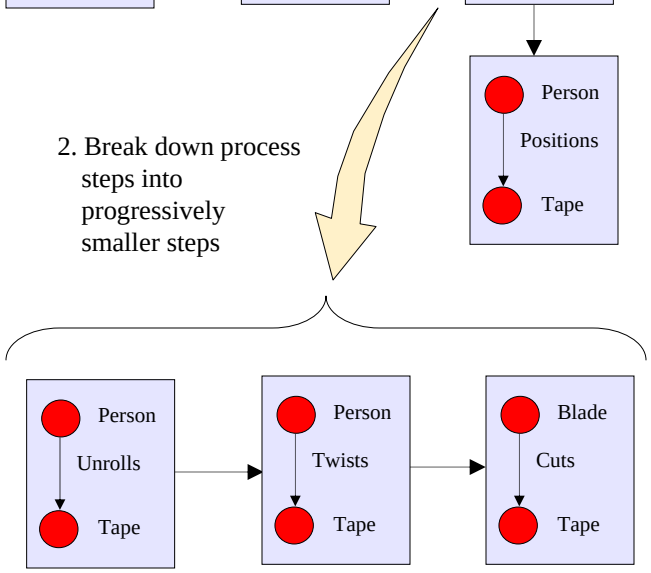
The functional diagram gives a snapshot of all the elements and their modifications, without reference to time or reason for existence. Cause and effect can be inferred where modifications are passed on. (supports--->supports--->supports)

(OR) Create a Functional Process Map

1. Describe each step of the process in functional terms



2. Break down process steps into progressively smaller steps

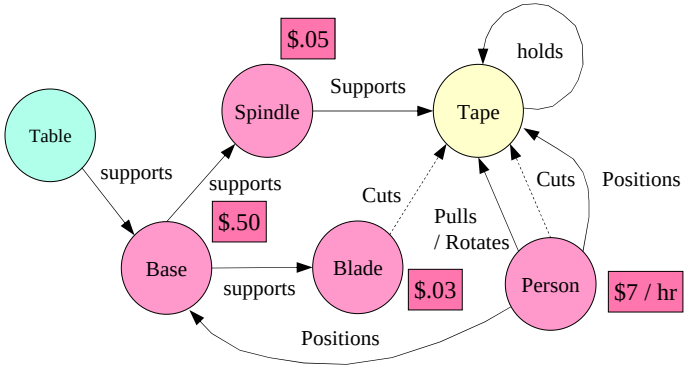


The value of a process map is mostly found in the ability to break a process down into increasingly finer steps. Do not pay great attention to all of the knobs in this step. A process map gives a snapshot of the sequence of functions, without reference to causality and may not include all of the possible elements of the system or super-system.

Simplify the System

Replace Low Value Elements

1. Identify the cost of each element



2. Calculate the cumulative function rank of each element by adding up the rank for each function that is performed by the element according to the following rule.

Function Rank:
Basic or Productive = 3
Auxiliary or Enabling = 1
Harmful =0

Base: 2 auxiliary functions
= 2 x 2 = 4
Blade: 1 basic function
= 1 x 3 = 3
Spindle: 1 basic function
= 1 x 3 = 3
Person: 3 basic and 1 auxiliary function
= 3 x 3 + 1 = 10

3. Calculate the value of each element

$$\text{Value} = \frac{\text{Cumulative Rank}}{\text{Cost}}$$

Base: 4 / .5 = 8

Blade: 3 / .03 = 100

Spindle: 3 / .05 = 60

Person: 10 / ?? Difficult to say

4. Identify the elements with low value. These elements are candidates for elimination or combination with other elements.

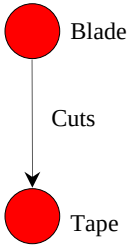
The base has the lowest value and is a good candidate for elimination

5. Press other objects nearby to perform the function of these low value elements.

Based upon this and the previous step of removing remedial objects, the person will replace the function of the base.

Remove Remedial Objects

1. Almost any useful function can be thought of as fixing a problem that something else causes. For instance, a function is required because something else does not do its job well enough or because another object is harmful.



Consider cutting the tape as a remedial action

It "fixes" the tape length which is too long

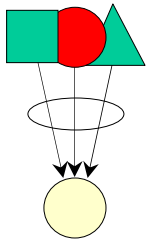
2. Ask why the remedial action is required. Then ask why several more times until you uncover key reasons or key problems

The tape is long for a couple of reasons:
- It can be produced in a compact roll
- Once the tape is pulled from the roll, the end is easy to find

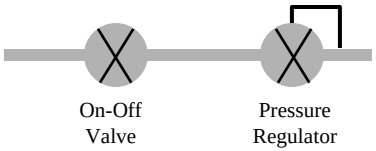
3. Identify the key problems that must be solved to remove the remedial or harmful objects.

The roll of tape does not require a tape dispenser if small pre-cut pieces could be formed into a compact shape and the tape ends could be easily found and pulled off

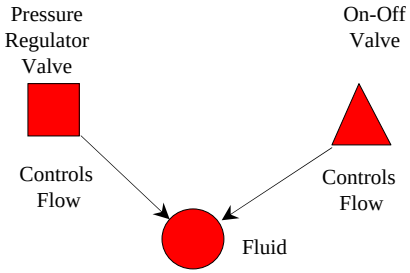
Consolidate Elements with Similar Functions on Same Product



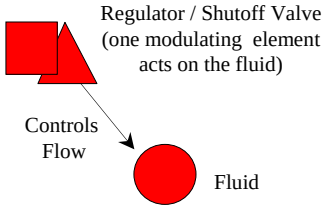
Let us consider a typical fluid handling system that controls the pressure and shuts off flow.



1. Identify Elements with similar functions on the same product

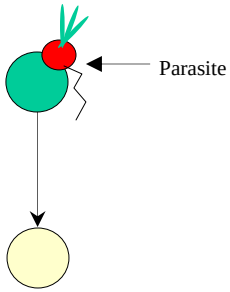


2. Can the similar functions be performed by one or fewer elements?

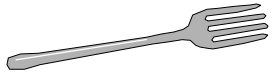


3. Consider different configurations. **New capabilities may emerge**

ASIT Parasite Tool

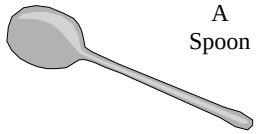


1. Choose a low value object



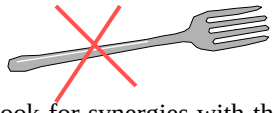
A Fork

2. List objects in the environment with similarities to the chosen object



A Spoon

3. Pick a part of the main object (preferably one of the more important ones) and eliminate it. One of the similar object takes over this function.

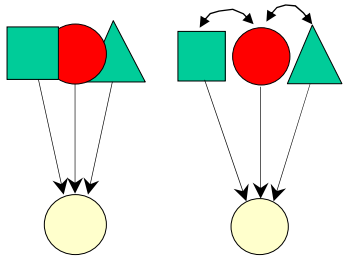


The Handle

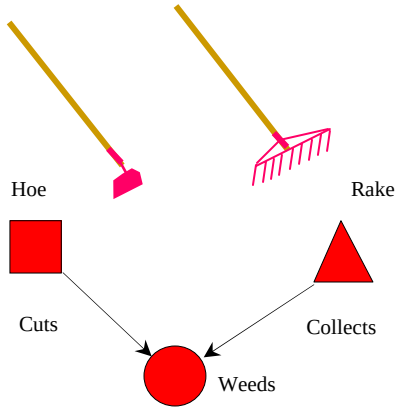
4. Look for synergies with the product in the environment.

A spoon with a Fork Parasite

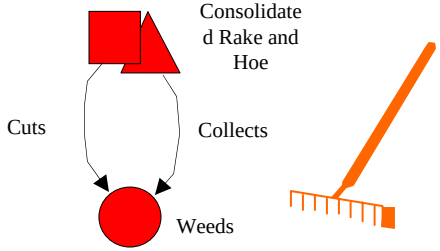
Consolidate Elements with Different Functions on Same Product



1. Identify tools that perform **different functions** on the same product?

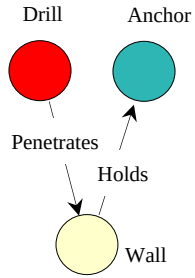


2. Consolidate these tools or make them interact. Look for an **unexpected capability**

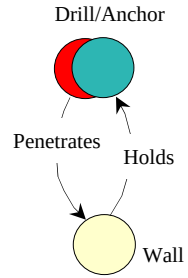


Combine Elements of Contiguous Operations

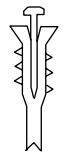
1. Identify Contiguous Functions (One follows the other in time)



2. Consider ways to combine and consolidate the elements elements?

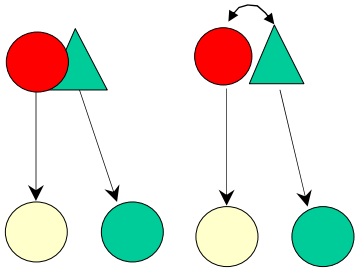


3. Look for **unexpected capabilities**



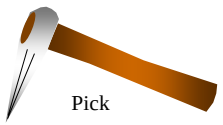
Drill and Wall Anchor Combined (Can be inserted with common screwdriver)

Consolidate Elements with Similar Structure



The energy source, transmission or controls of a system can often be consolidated. Consider a hammer and a pick. While neither perform the exact same function, they both share common elements that could be consolidated into one.

1. Identify an element, preferably a low value element?



2. Identify a second element with similar structure. (Same power source, transmission and control)

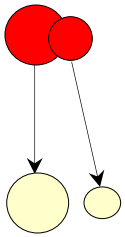
3. Identify the minimum working element of both elements.

4. Combine or interact the working elements while consolidating the power source, transmission or control.

4. Especially consider **interacting with humans** in the super-system

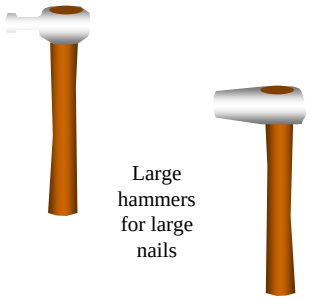
6. Look for **unexpected capabilities**

Consolidate Biased Tools

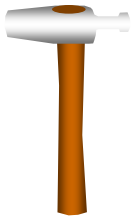


Biased objects are objects that are substantially the same but have one main difference. A bag of marbles will have marbles of different colors. A library will hold books made of different materials. There is often the need to operate on all elements in the super-system, or to extend the functional range of the tool.

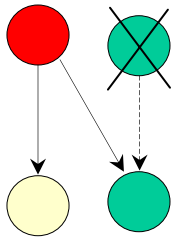
1. Are there other tools in the super-system that operate on products that are **slightly different from each other** (biased)?



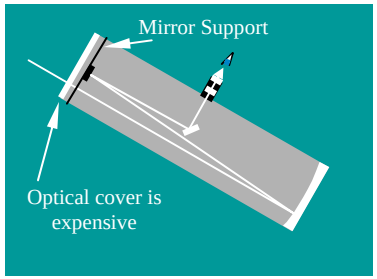
2. Merge or interact with these and **consolidate.**



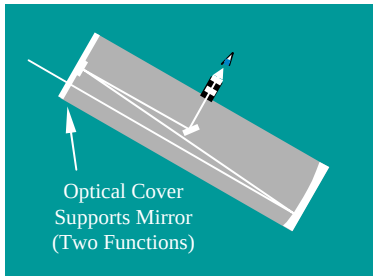
Reduce Penalty of Expensive Parts



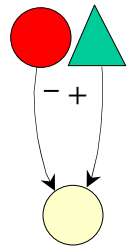
If elements are costly, and there seems no way around this, then look for ways to increase the number of functions performed by the costly element. This can decrease the overall cost. An example of this is a telescope for children's class rooms. The mirror needs to be protected from dust. Optical grade glass can form a cover, but it is too expensive.



1. Take over the function of something else, even if it is only serves as a structural element.



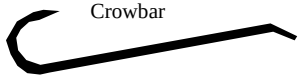
Merge Anti-Tools



Evolution of systems dictate that functions will eventually be combined with the anti-function. The tool to perform the anti-function of your tool may already exist in the super-system. Look carefully for it.

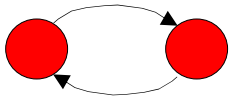
1. Identify a tool within the system

2. What effect/tool exists in the system or environment or could be used to perform the anti-function



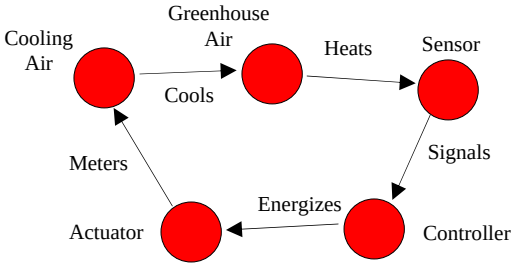
3. Can this anti-tool be merged with the system? Look for **unexpected capabilities.**

Change to Passive Control



The highest form of control is passive control. Systems ideally use one field for operation and control. Consider consolidating the sensing, control and actuating elements into one element that does all of these functions. What this means is that the substances involved are capable of sensing a field and then use the field to create muscle force to actuate. These fields are usually towards the top of the Table of Fields. The system is usually operated close to a critical point. (Close to tripping, close to melting, etc.). Consider the cooling system for a greenhouse.

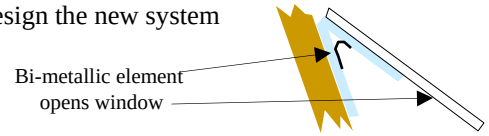
1. Identify the existing control system



2. Identify a physical phenomena which uses the same field (that is being controlled) for sense and actuation.

Use of Bi-metals

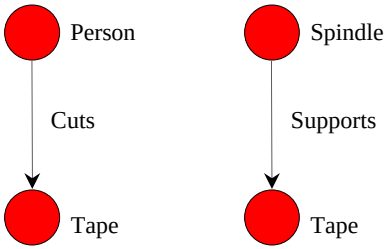
3. Design the new system



4. Move the critical point (small changes in input cause large changes in output) to the desired control point.

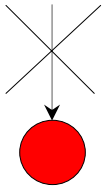
Transform Remaining Functions to the **Ideal Final Result (IFR)**

1. Consider each function of the system in turn. Begin with those **closest to the system product** or functions which **involve human intervention.**



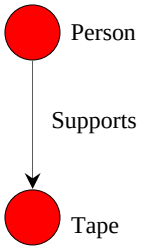
2. Use the **Appendix--Idealizing Functions** to idealize useful, harmful or measurement functions

Comes that Way

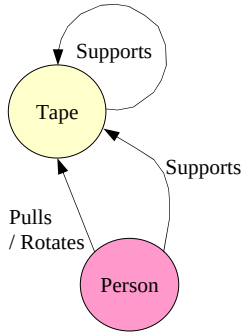


The Tape comes cut so that the blade is not required

Adjacent Elements

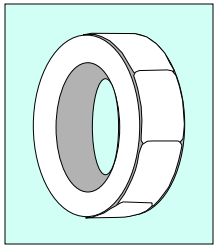


3. With each step, make modifications to the system model reflecting the changes.

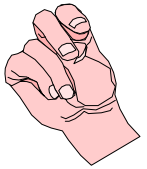


The tape must support itself without the spindle or its own roll. The person which is applying the tape is all that is required to take the tape from the roll

4. **Make drawings** depicting the new system.



5. Continue this process of simplification as long as possible. Remember that the cost of the system is dramatically decreased with each part that is removed. Every part removed is a part which does not require a drawing, analysis, procurement, assembly and cannot wear out.



Continue to create the ideal system. . . .If I could snap my fingers…

6. This new system will likely have disadvantages or problems that will be considered later.

The tape sticks to itself so that it is difficult to pull off only one piece

- The tape is thin and sticks to the other pieces, making it difficult to separate from the roll.