Hierarchical TRIZ Algorithms

9th Installment-Jan 2006

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. Next month's installation will cover the seventh process step:

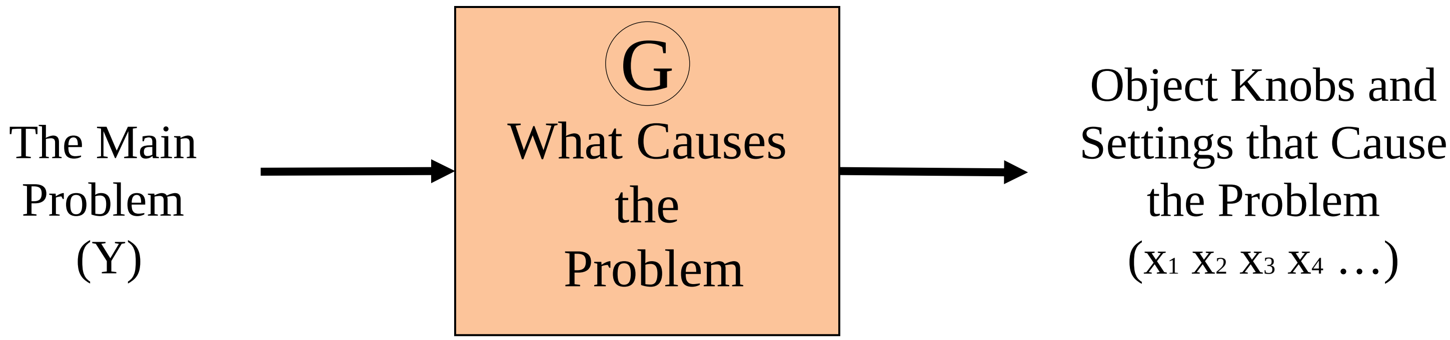
G. What Causes the Problem

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

H. Turn Object Knobs (Properties) **to Fix the 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

The previous chapter helped us to define the main problem that we are trying to solve or the improvement that the system requires. We called this the big Y or the *dependent variable* that we would like to improve.

$$Y$$

Let us go back to the example of the acid container in the previous chapter. Recall that we identified the dependent variable as "Cost of Replacement"

$$Y = \text{Cost of Replacement}$$

A common misstep in problem solving is to identify what you would like to improve and then start brainstorming solutions. For instance, we could easily jump to the conclusion that we need to change the material of the container to one that is not affected by the acids or to one that is less inexpensive. When we do this, we are taking a lot for granted. In effect, we may be attacking the symptoms of the disease while ignoring the disease itself. A good inventor or problem solver will always try to understand *what is causing the problem*.

In its simplest form, cause-effect analysis is the identification of the object knobs (object parameters, properties or attributes) that control the independent variable that we are trying to improve. We can write these attributes as the independent variables in the function which gives us Y.

$$Y = f\,(\,X_1\ \ X_2\ \ X_3\ \ X_4\ \ X_5 \ldots)$$

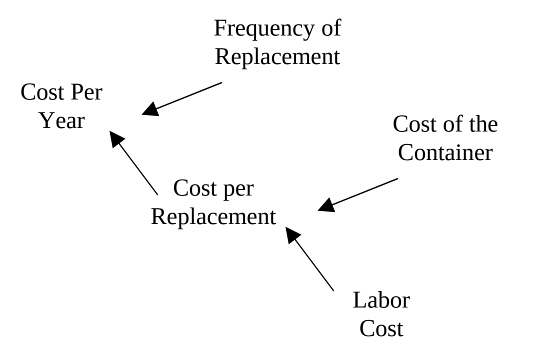
This equation can be read, Y is a function of, or is controlled by X1, X2 ….

We could state the acid corrosion problem in equation form.

$$\text{Cost per Year} = f\left(\text{Cost of the Container}\quad \text{Cost of the Container Material}\quad \text{Activity of the Acid}\ \ldots\right)$$

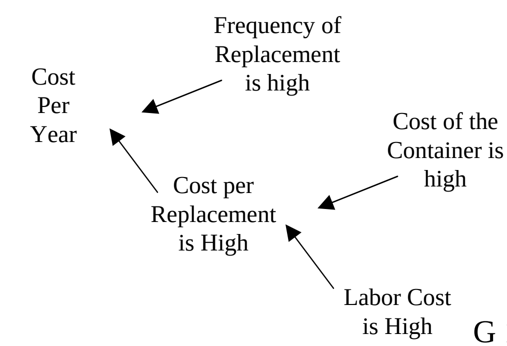
Let's assume, for the moment, that this function was created during a brainstorming session. When we stand back and look at what we have created, we may notice that the independent variables of the equation are not independent of each other. For instance, the cost of the container is related to the cost of the material. This relationship is not yet evident in the stated function.

We can write the function in a new form that takes into account the interdependencies. The act of doing this causes us to recognize new independent variables.



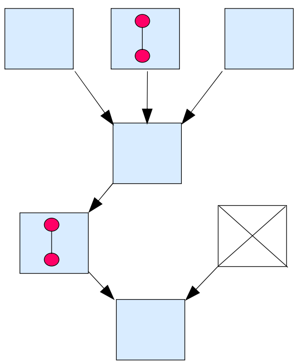
In effect, we have formed a cause-effect chain of dependencies which relate back to the original problem.

A further refinement of our understanding comes when we include the knob settings for each of the variables.



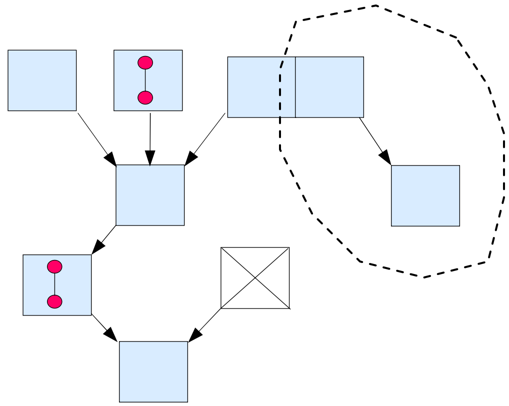
A further refinement comes when we recognize that many of the knob settings change over time and are controlled by something . Any time a knob setting changes over time, a function is involved. If we include these functions, and apply other tools that allow us look for more knobs involved with these functions we gain a yet deeper understanding of what is causing our problem.

These concepts are the beginnings of what will be described in this chapter as a cause-effect chart which takes the form shown below.



Each box in the chart represents a knob and setting or a function which leads to the problem that we are trying to solve. The functions are connected to each other by object attributes.

While setting up a cause-effect diagram, we will ultimately come to knobs which are not caused by anything else, but are design parameters such as the length of something. Here we learn a valuable lesson, requirements are not causes. The reason that such knobs have the settings that they do is because if they do not, something else will get worse. In effect, a contradiction is formed. In addition, an alternate problem path is created. We can solve the original problem by solving the alternative problem. This alternative problem path is illustrated in the next drawing by the added boxes.



This line of reason is very useful when we later look for solutions. First, we have observed the problem from all sides and have forced ourselves to discover all of the interrelationships that cause the problem. Secondly, many contradictions are already evident. Resolving any of these contradictions will fix at least two problems. One of which was not as evident.

The more one knows about the problem, the more useful this technique becomes. This becomes more evident when working with legacy problems that have languished for years. Usually, there is someone around that is a subject matter expert. All of the pieces to the problem are individually floating in the brain of this expert. Organizing this cranial information is an important step to solving the problem. It is common that such subject matter experts are also incapable of solving the problem. They are well aware of the conflicts and feel helpless to resolve them. Later steps in the solution process help us across this hurdle

If the problem is not well understood, finding the cause and effect relationships can be very time consuming. In effect, when we first start, we are usually putting down our theories. A cause-effect diagram is an effective way to document our theories. It also serves as a good thought process map to help us focus our energies on the most important tests to run, etc. A cause-effect diagram can be especially useful when working with teams of people.

It is important to add graphics to the diagram so that others can participate and follow it easily. Without such graphics, these diagrams can become chloroform in print. The reader will usually fall asleep before you can finish the story. The author has found that people untrained in the use of these cause-effect diagrams can come up to speed very quickly and make important contributions.

A problem may be extremely vexing because it is hard to tell what is causing it. A special section is included on what to do if the cause is hard to detect. If you belong to a large organization with lots of resources, you should likely perform screening tests on prototypes in which only one variable is changed at a time. These tests will help you to understand the relative importance of each knob.

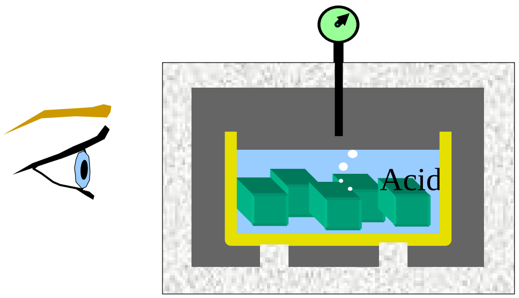
An additional benefit of this step is that sometimes we discover knobs that can be easily turned to solve the problem. Steps are given to find as many knobs as possible. These methods are referred to as “relative to” and the Table of Knobs which includes most of Altshullers “Standard Solutions”.

Some disciplines refer to this step as “Root Cause Analysis”. The name “Root Cause” implies that if we keeping asking why we will eventually come to *the* root cause. For those who are six-sigma minded, remember that there is a difference between problems which are special-cause and those with common-cause. Special cause implies that the output of a process is outside of the control limits and is therefore highly unlikely. For these problems, we can often find a single or a couple of *root* causes. However, for variation *within the control limits* there is a chain of causes. It is advisable to avoid the use of the term “Root Cause Analysis” when we are trying to understand a problem which is not special cause.

The output of this step is the knobs and settings and the key functions that cause the main problem. This output can be in the form of a cause-effect diagram.

Simplified

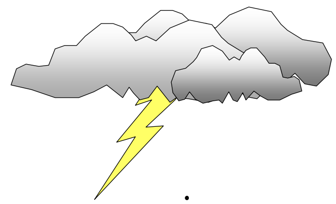
Observe The Situation / System



1. Watch people using the system. If possible, watch them in ways that will not influence how they use the system.
2. Look for unexpected characteristics of the system.

Brainstorm Object Knobs

$Y = f(X_1 \quad X_2 \quad X_3 \quad X_4 \ldots)$



What are the important object knobs that control the outcome that we are trying to improve?

Ask Why Several Times

Why ?
Why ?
Why ?
Why ?
Why ?

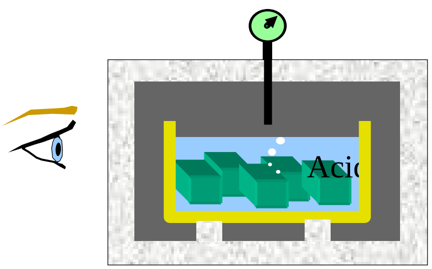
For each knob, ask why it has this setting.

- Ask why enough times to come to several design parameters.

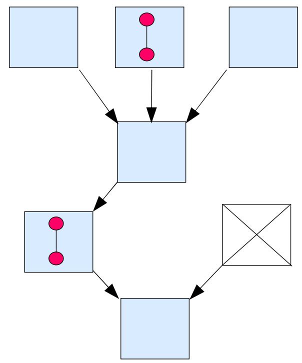
Detailed

Observe The Situation / System

Do not begin the process of cause-and-effect until you have had an opportunity to observe the situation yourself. While this may appear obvious to some, it is amazing how often the author has skipped this step, only to be embarrassed later by someone who performs this step and notices some important, but obvious fact about the situation.



Form Cause -Effect Chains

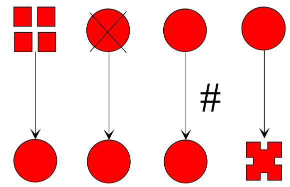


The cause-effect-chain is one of the most important tools for determining the knobs that lead to the disadvantage. Use of this tool will also help the problem solver to look at all sides of the problem. Become proficient at this step by using this tool often.

1. Most Problems can be traced to useful objects that do not perform their function as well as they should or also cause harm. What are these objects?
2. Create a Cause-Effect Chain to illuminate these objects with their attending functions and the object parameters which connect these functions

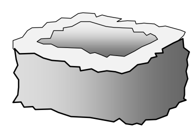
The process for creating a Cause Effect Chain for the acid bath is shown on following pages

Catch Missing Knobs --Table of Knobs



The first pass through the cause-effect chain will identify the more obvious knobs. Using this step and the following step will often allow the problem solver to discover new knobs which are not as obvious. Because others have not considered these knobs, they can sometimes be turned without harmful consequences.

1. Use the table of knobs to identify knobs (potential solutions) that might be otherwise missed

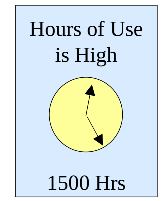


New knobs were found:
1. Acid contact area
2. Surface area of container

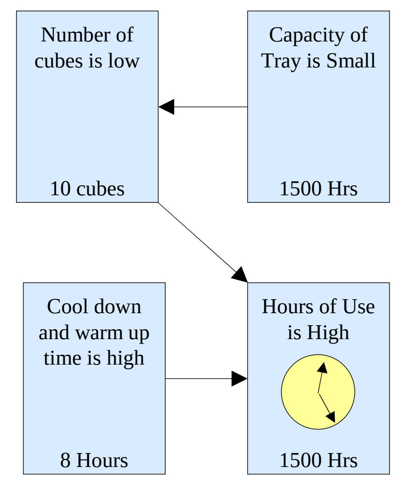
2. Remember, each discovered knob represents a possible solution

Catch Missing Knobs --Relative To

1. Every knob is measured relative to something. Consider changing that "something" instead.



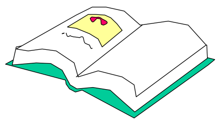
The hours of use are high: 1500
Question: High compared to what?
Answer: Number of Cubes and the total oven time. These are new knobs.



If It is Hard to Tell What is Causing the Problem

Form Theories

Subject Matter Experts

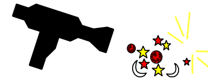


- Study what the **subject matter experts** have to say.
- Books, magazines, internet
- Talk directly to subject matter experts
- Ask **why** something happens. Then ask **why** that happens. **Keep asking why.**

Crime Scene Analysis

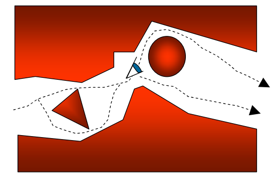
- Examine all objects carefully under a **microscope** or with the best tools available for causal evidence
- Draw**(real art)**what you see at macro and micro level. **Compare** to what you are looking at for differences
- **Verify** what you see with others
- All Evidence must be accounted for by theories.

Catch in the Act



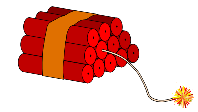
- Devise an experiment to **watch** the interactions. Consider slow motion, etc.
- Use *Redefine Informing functions* to find ways to look at what is happening (copies, etc.)

Empathy



- Put yourself in the place of the objects that you are investigating
- Follow through process from beginning to end

Subversion Analysis



- If you were a **Saboteur**, how would you cause the problem?
- Find an effect, no matter how weak, which could cause the phenomenon
- **Boost the effect** until it matches the evidence

Quantify Theories

$$E = mc^2$$

- Equations
- Models

Verify Theories

Perform "Screening" Experiments

- This is not the time for a DOE

Cause-Effect Chain Rules

Identify knobs and Settings Leading to the Main Disadvantage

1 Knob & Setting
Every box represents an a knob and a setting--**No exceptions**
Be Brief

2 Bad Setting
Every block describes a knob with a bad setting.

3 Quantify
Include knob settings to give relative importance of each leg

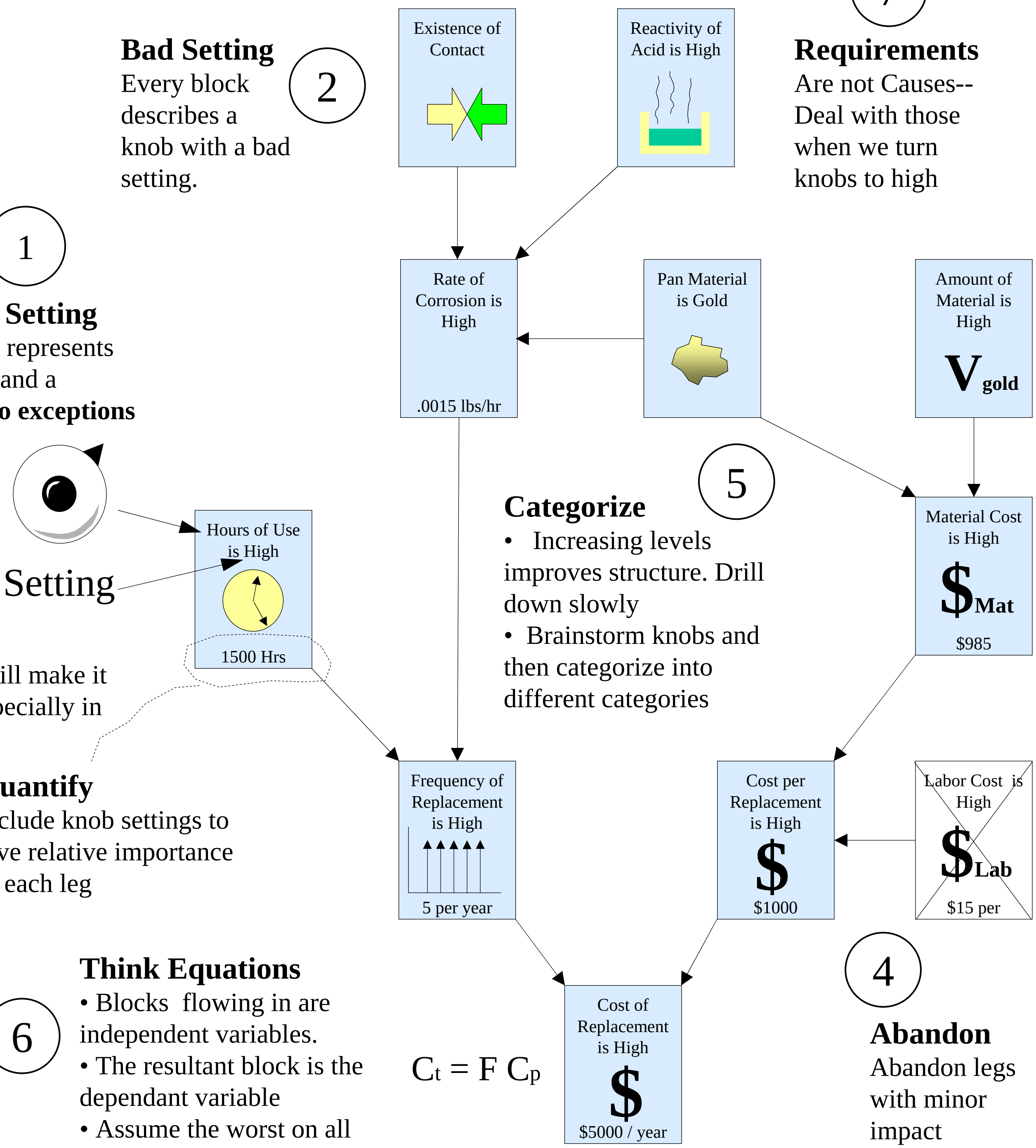
4 Abandon
Abandon legs with minor impact

5 Categorize
- Increasing levels improves structure. Drill down slowly
- Brainstorm knobs and then categorize into different categories

6 Think Equations
- Blocks flowing in are independent variables.
- The resultant block is the dependant variable
- Assume the worst on all in-flowing blocks

7 Requirements
Are not Causes--Deal with those when we turn knobs to high

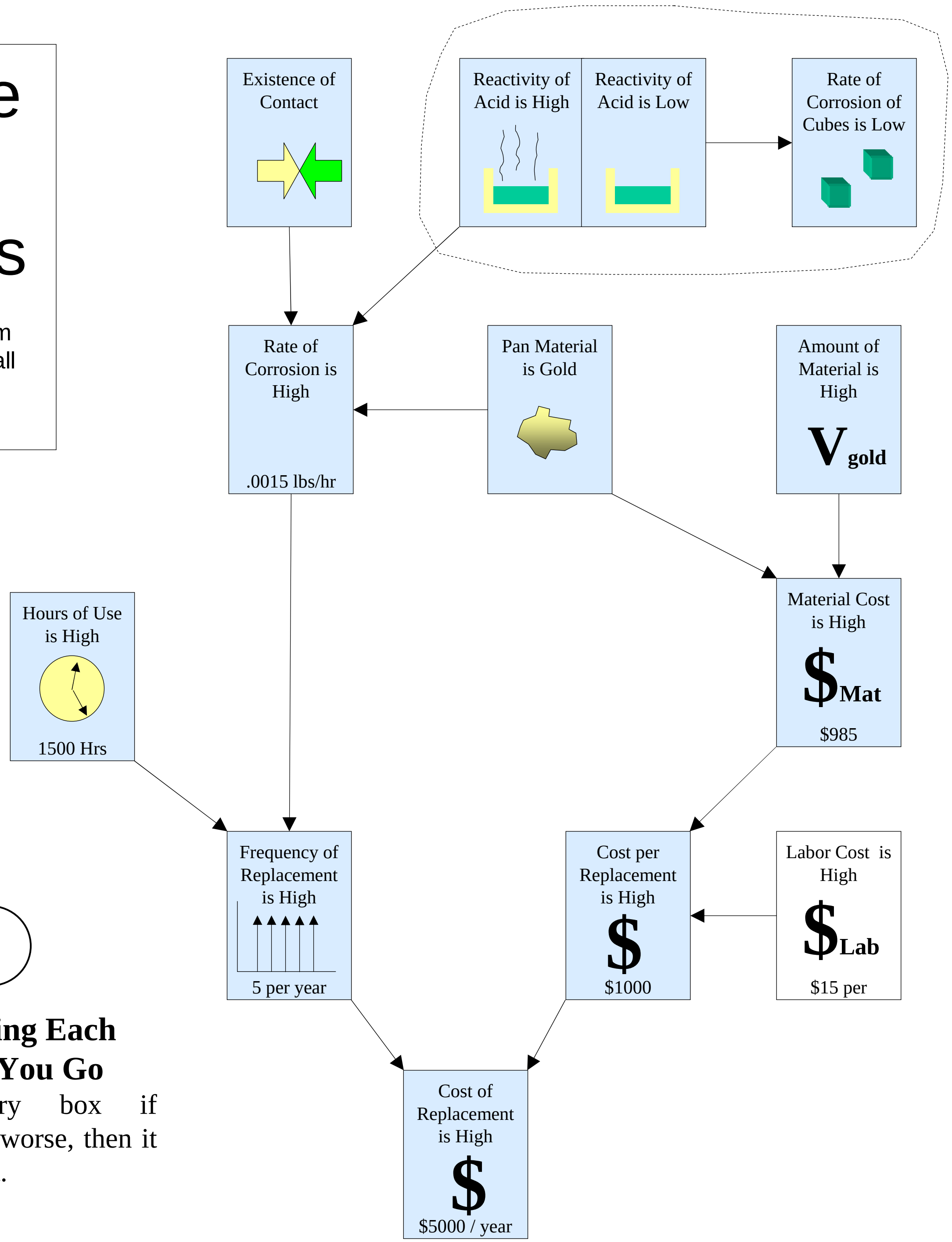
8 Draw Pictures
Drawing pictures will make it easier to follow, especially in group settings



$C_t = F\ C_p$

Alternative Problem Path Rules

Develop alternative problem paths, allowing one to see all sides of the problem



2

Requirements --Something Else Gets Worse

Some Knobs cause a problem when turned. Show both situations with the knob turned to opposite extremes and the effects that follow. These knobs are usually design features. **It is Easy to Spot this type of contradictions with the side-by-side boxes.**

3

Develop Alternate Problem Paths

These side-by-side boxes are the beginning of alternate problem paths. Develop these paths as far as you can in all directions. In the end, several disadvantages will be discovered, with common contradictions. These contradictions are "lynch pins" so to speak. Resolving these contradictions will result in solving several problems at once. It is likely that there are many alternative problem paths which result in many disadvantages.

1

Try Turning Each Knob as You Go

Consider every box if something gets worse, then it is a requirement.

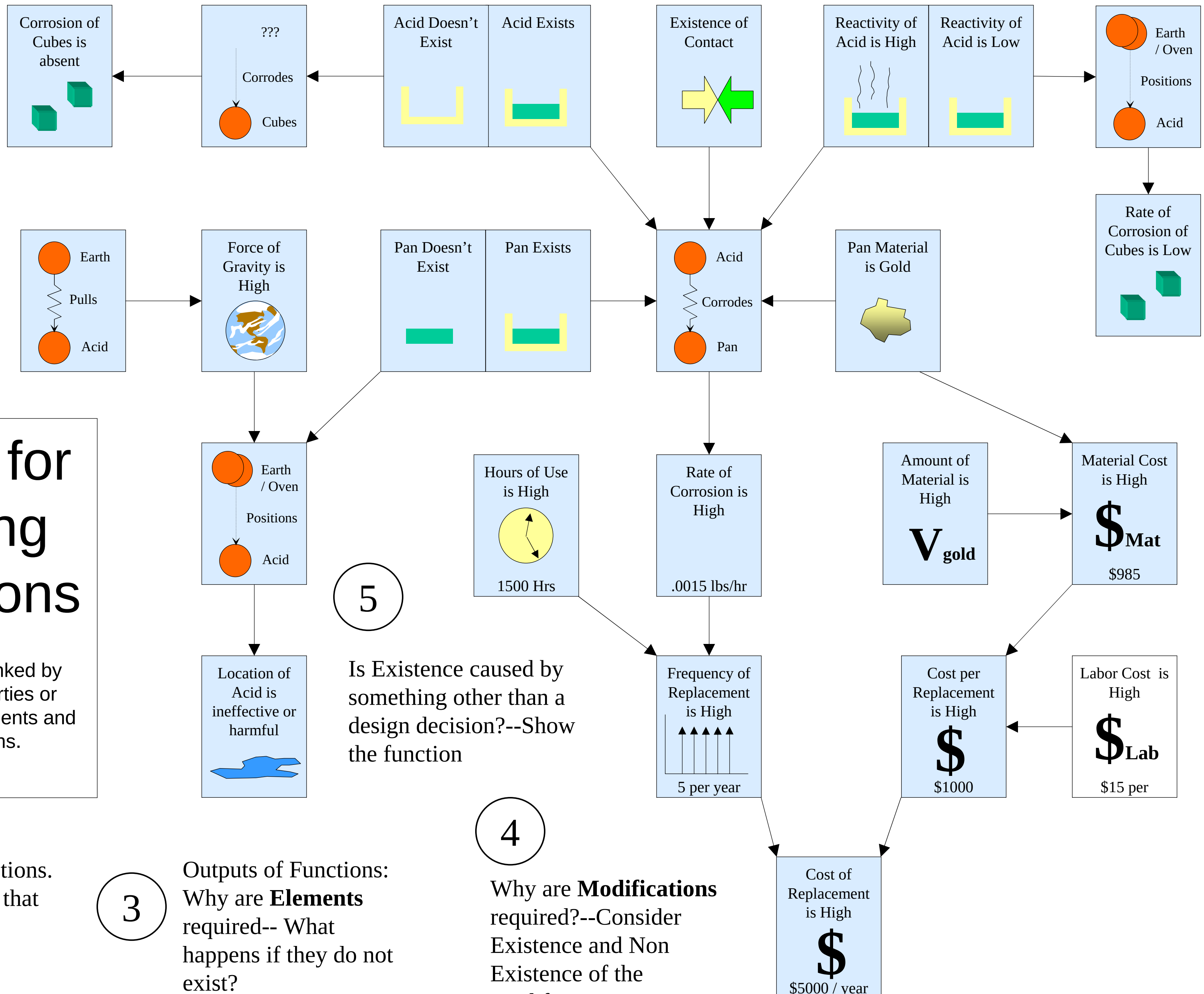
1

Look for object knobs caused by a function

- Not design features
- Not set or constant
- Are changed or controlled by something
- Caused by an interaction with something else

Rules for Linking Functions

Functions are linked by features, properties or knobs of the elements and modifications.



5

Is Existence caused by something other than a design decision?--Show the function

2

Insert functions. Be careful that they are described properly

3

Outputs of Functions: Why are **Elements** required-- What happens if they do not exist?

4

Why are **Modifications** required?--Consider Existence and Non Existence of the Modification