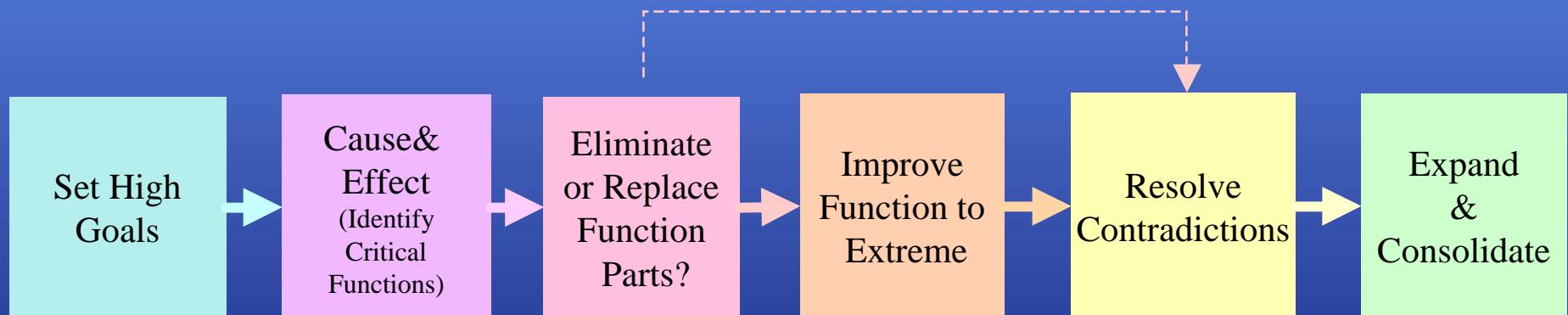


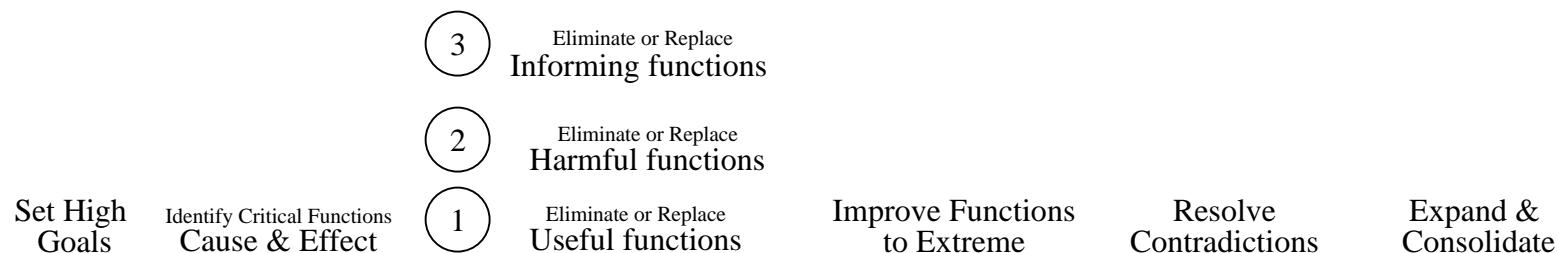
# Breakthrough Thinking

A Linear Sequencing of TRIZ Tools



# 6 Tab Positions

## (Line up with Process Boxes on Front Cover)



Expand & Consolidate
Resolve Contradictions
Improve Functions to Extreme
Eliminate or Replace Parts? Informing Functions
Eliminate or Replace Parts? Harmful Functions
Eliminate or Replace Parts? Useful Functions
Identify Critical Functions Cause & Effect
Set High Goals

Note: A small mark is placed at the bottom of each divider sheet to indicate where the tab is located. For better results, print divider sheets and tabs on card stock.

←  
**Tab Labels**  
(Sized for Avery ®  
Self-Adhesive Tabs)

# Set High Goals

## Choose Or Create Subject System



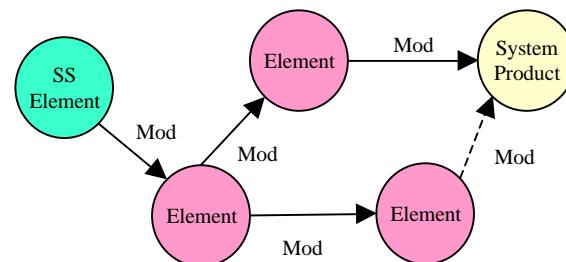
- Be as **specific** as possible.
- The system may already exist but in highly flawed form

## Determine Customer Requirements & System Disadvantages

# VOC

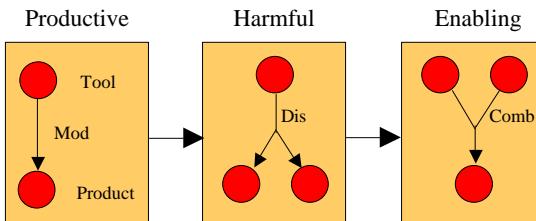
- Identify Customers and Potential Customers? Who is really going to want this?
- Identify system **disadvantages** from the viewpoint of the Customers
- Capture **Customer Requirements**. May use QFD
- Identify the Super-System.
- What does the Super-System want right now?
- Place yourself in the **future**. What will the Super-System want then?
- Gather **costs and penalties** associated with disadvantages
- Determine whether problem is **worth pursuing**

## Model the Current Technical System



- Identify System Elements
- Identify the main system product (what the system modifies)
- Identify super-system elements. Super-system elements cannot be eliminated. Consider only super-system elements which directly interact with the system elements. This bounds the system and sets limits over what can and cannot be changed.

## Or Model the Current Process



- Identify Process Steps as:
  - Productive--Modifies the final product
  - Enabling--Does not modify the final product but makes it possible
  - Corrective--Removes some unwanted aspect of previous steps
  - Harmful--Unintended Function that harms

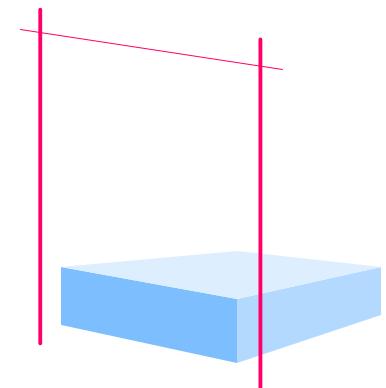
## Determine Element Or Process Step Values

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

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

- Identify elements or steps with low value. These elements are prime candidates for elimination later.

## Set a High Bar



- **System Ideal Final Result:** What do I really want to have happen at the system level? At the Super-System Level?
  - How much must it **cost**?
  - Set **High Goals and Difficult Constraints** that will galvanize the effort

# Identify Critical functions Cause & Effect

# Form Theories

## Do your Homework



- 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** until you get to the root of the problem

## Crime Scene Analysis



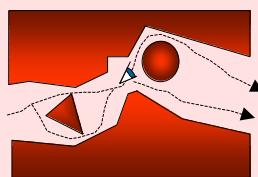
- Examine all objects carefully under a **microscope** or with the best tools available for causal evidence
- Draw(**real art**)what you see at macro and micro level.
- Compare** to what you are looking at for differences
- **Verify** what you see with others
- All Evidence must be accounted for by theories.

## Catch in the Act



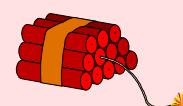
- Devise an experiment to **watch** the interactions. Consider slow motion, etc.
- Use *Redefine Informing functions* to find ways to look at what is happening (copies, etc.)

## 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 $E = mc^2$

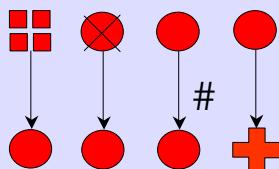
### Experiments

- Equations
- Models

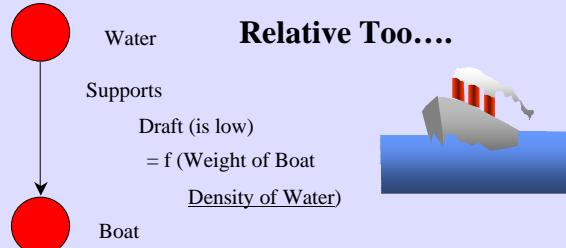
## Catch Missing Causal / Controlling Variables

### Intuition

#### Table of Controlling Variables



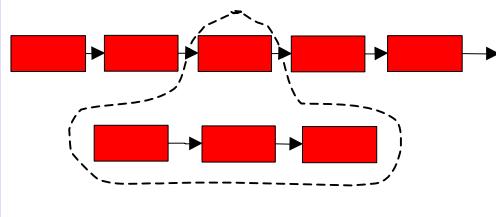
#### Relative Tool....



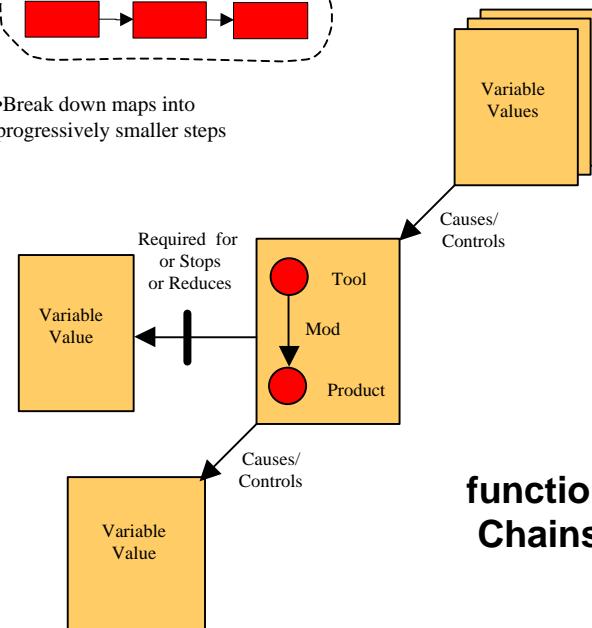
• Every Controlling Variable is measured relative to something. Consider changing that something...

## Link Causal Relationships

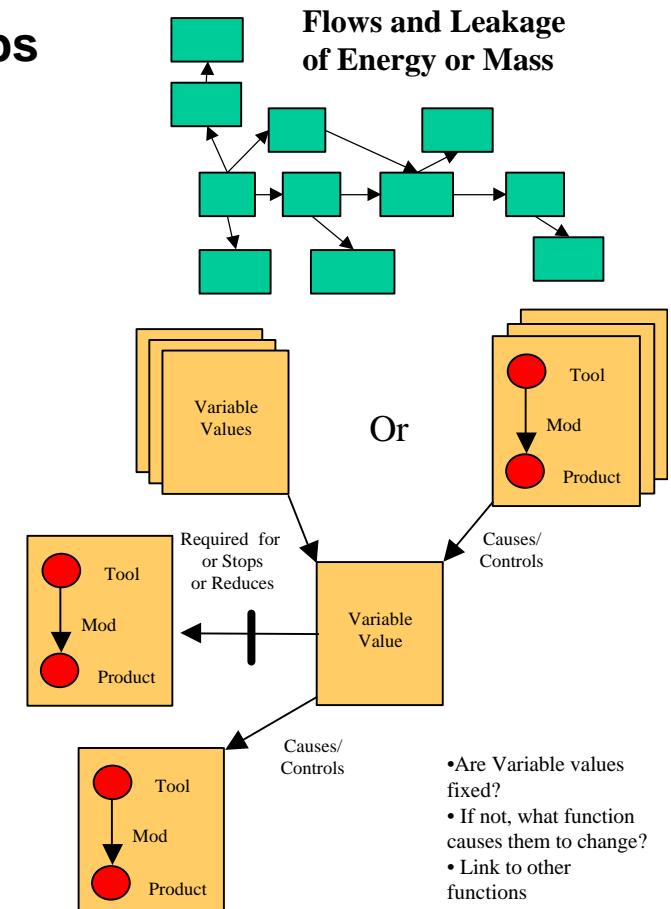
### Flow of Goods & Information



• Break down maps into progressively smaller steps

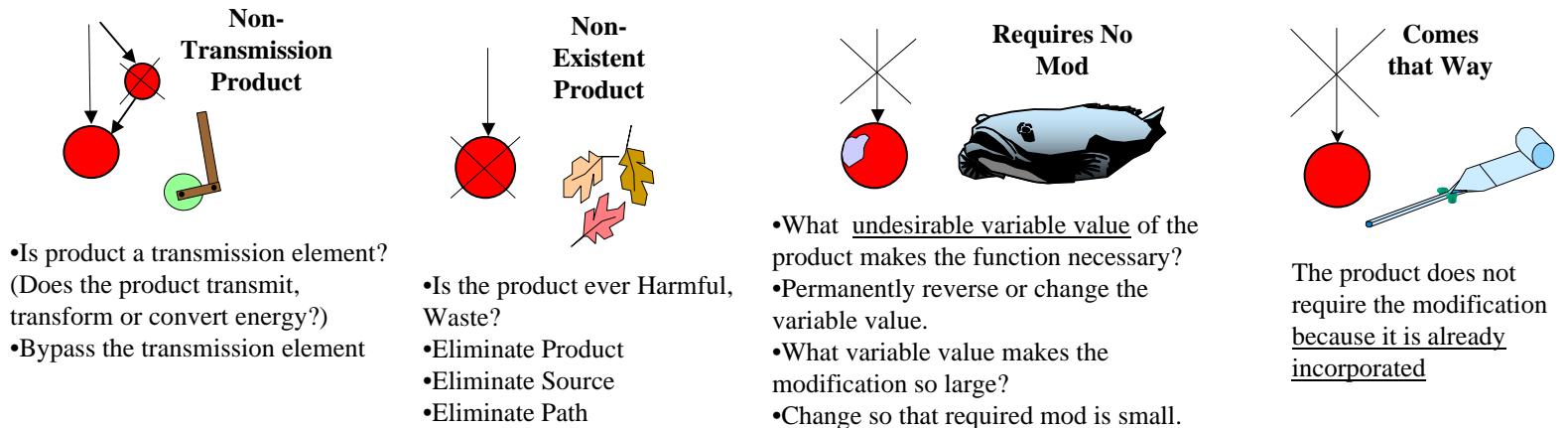


### function Chains

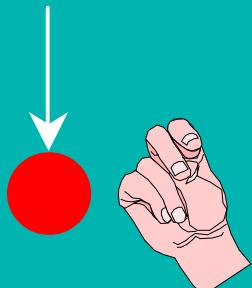


# Eliminate or Replace Function Parts? Useful Functions

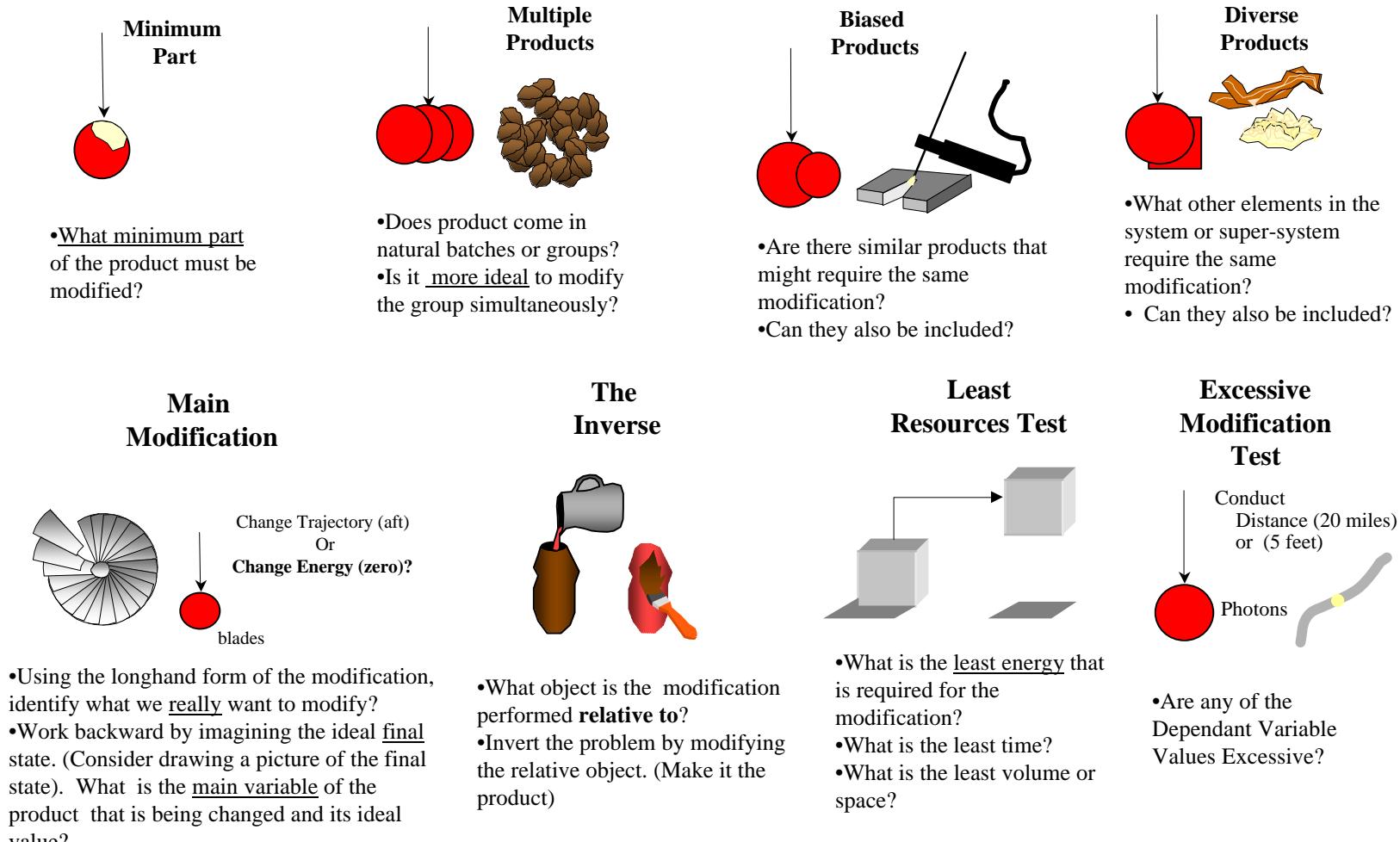
## Ideal Product ?

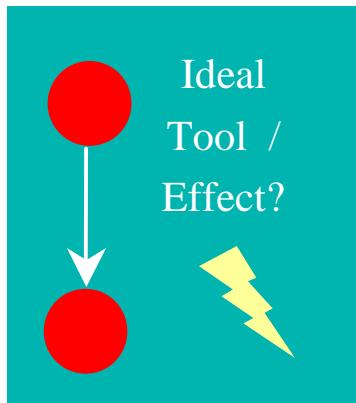


## Ideal Modification?



If I could snap my fingers...



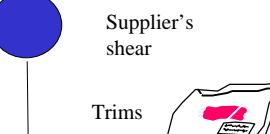


- Process Map beginning to end of life
- What fields does product experience during life?
- Which of these fields perform this function to even poorly?
- Modify the Product to improve the function.
- Model with intelligent little people
- Can the former tool be combined with product?



- Is the function now delivered by a super-system tool, even poorly?
- Look through the Table of Fields and identify native fields.
- Which of these perform the function, even poorly?
- Modify the field or tool to improve the Function.

### Comes that Way



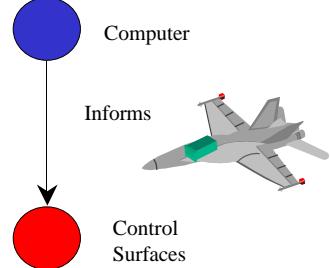
Trims



Wires

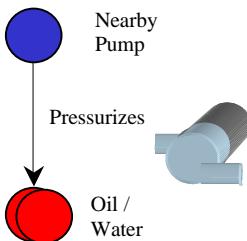
- Continuation of *Comes that Way* for the ideal product
- What tool is best suited for this modification?

### Copy Current Tool



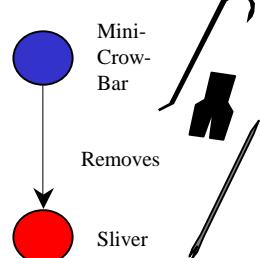
- What part of the current tool performs the function?
- Can a copy of the tool perform the function?

### Nearby Analogous Tool



- Identify nearby analogous product
- Identify the Tool
- Combine and Consolidate

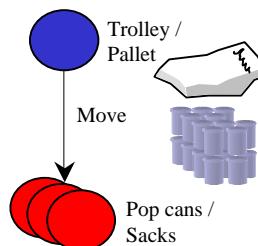
### Analogous Tools



Sliver

- Identify an analogous product
- Identify its tool
- Identify minimum tool variable
- Transfer Effect/Tool to new situation
- Combine w/ existing tool
- Transfer **minimum** amount of tool

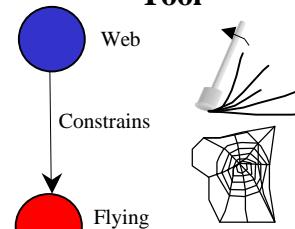
### Mega-trend Analogous Tool



Pop cans / Sacks

- Identify analogous products in leading industries.
- Identify trends for performing the function?
- What is considered the ideal Product, Modification and Tool?

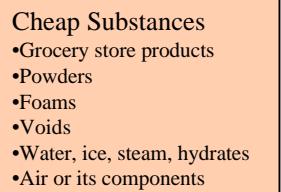
### Natural Analogous Tool



Flying Insects / Chips

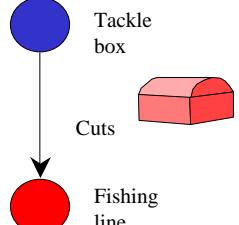
- Identify analogous products in nature?
- Identify the natural Tool/ Effect?
- Transfer the Effect/Tool to the new situation
- Look for primitive natural analogies?

### Cheap Abundant Substances



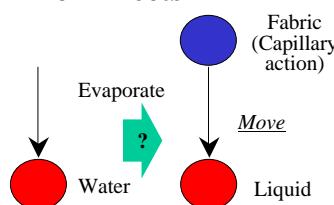
- Look around for cheap abundant substances.
- Could any of these be coaxed to perform the function?

### Adjacent Elements



- Consider a simple modification to an adjacent element.
- Especially effective with low level fields such as elastic, gravity pressure, etc.

### Table of Effects

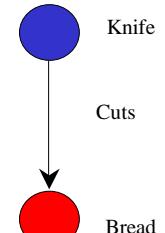


- Convert to General Function
- Find Effect in Table of Effects
- Find tool to deliver Effect

### Patent Data Base

## US Patent Data Base

### Current tool



- Can the current tool deliver the ideal modification?

Elastic Force Internal & External

Gravity

Friction

Adhesive

Centrifugal Force

Inertia of Bodies (Note Direction)

Coriolis Force

Buoyant force

Hydrostatic Pressure

Jet Pressure

Surface Tension

Odor & Taste

Diffusion

Osmosis

Chemical Fields

Sound

Vibrations & Oscillations

Ultrasound

Waves

Corona Discharge

Current

Eddie Currents (internal and skin)

Particle Beams

Thermal Heating or Freezing

Thermal Shocks

Nuclear Forces

Electrostatic Field

Magnetic Field

# Table of Fields

Electromagnetic (Voltage)

Information

Radio Waves

Micro-waves

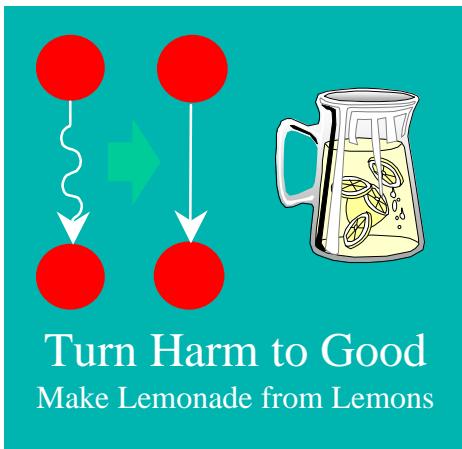
Infrared

Visible Light

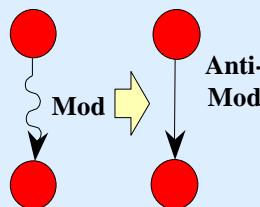
Ultra-violet

X-Ray

# Eliminate or Replace Function Parts? Harmful Functions

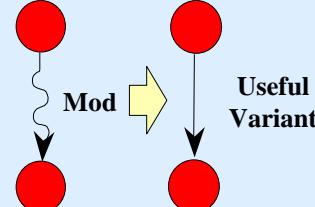


### Identify the Anti-Function



- Carefully identify the harmful function and its **anti-function**
- Verify that this is the most ideal form of the modification.

### Identify a Useful Variant



- Identify all useful functions performed **on the Product**
- Is the harmful function a **useful variant** of any of these useful functions?
- Is the function **useful in any context**? (Somewhere on the product or in the system a useful form of the function is being performed, but unnoticed).

### Reverse the Fields or Action



- Reverse the fields to perform the **Anti-function**. Boost the anti-function.
- What constitutes the reverse of the current action?
- What is the action performed relative to? Change that instead.

### Make Adjustable



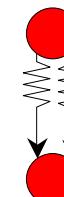
- If the harmful function could be **adjustable**, could it perform the anti-function, the useful variant or a useful function on another system product?
- Find **controlling variables** of the harmful function that can be made adjustable and boost them

### Work With



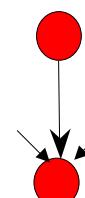
- Is the anti-function performed **with** the harmful function but **not in equilibrium**? Boost the anti-function.
- Is the harmful function useful any place on the product or on other elements **to the least degree**? Boost this function.

### Incorporation



- Can the flaw, caused by the harmful modification be incorporated **aesthetically**?
- Multiply the flaw. **What pattern is useful?**
- Can this aesthetic incorporation perform a useful function?
- Boost this function

### Perform Accurately



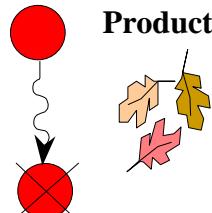
- Is the anti-function or a useful variant of the harmful function achieved by performing the modification **very accurately**?
- Boost the accuracy to the extreme.

### Non-existent Tool



- The Tool no longer Exists
- Eliminate the Source
- Eliminate the Path

### Non-Existent Product

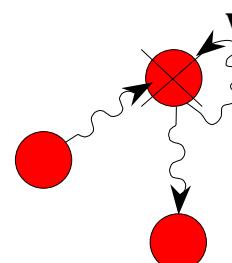


- The product no longer exists
- Use if the product is considered **harmful or waste**.

### Elimination



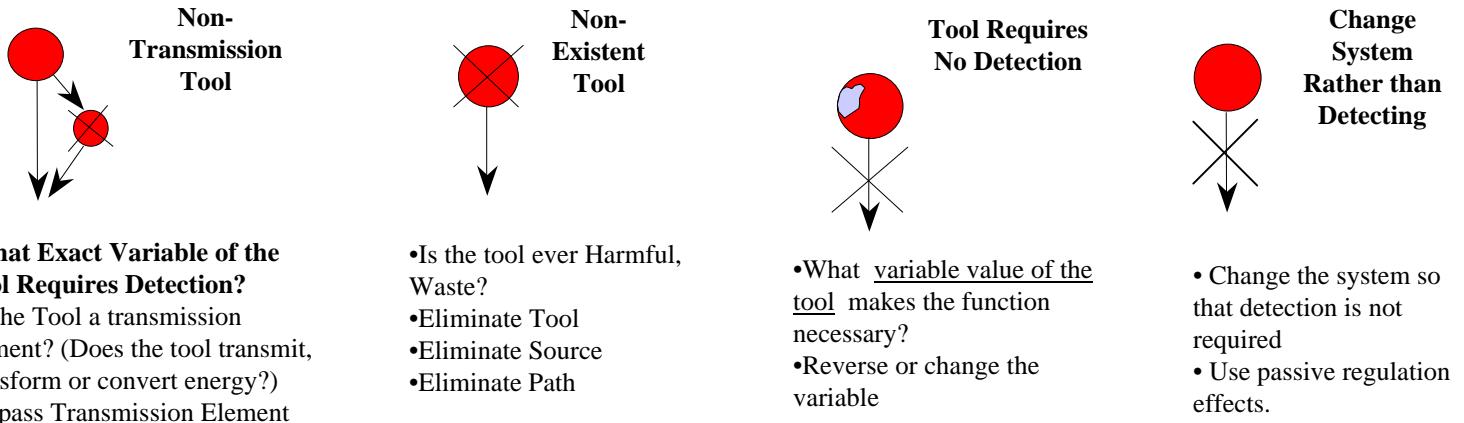
### Working with Harmful Effects to Eliminate



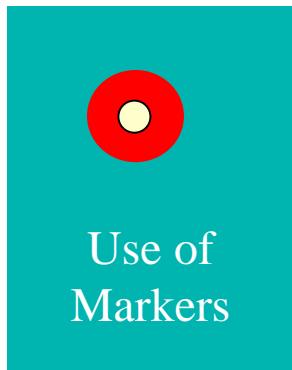
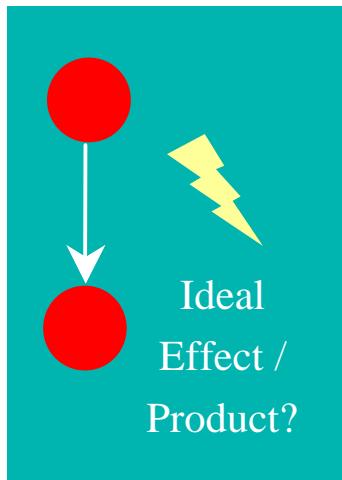
- Boost existing harmful functions on the tool to eliminate it.

# Eliminate or Replace Function Parts? Informing Functions

## Ideal Tool to be Measured?

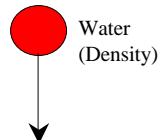


## Roundabout Variables



Use of  
Markers

### Table of Effects



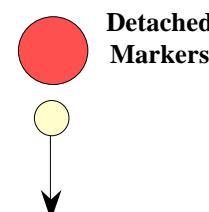
- Determine the variable or property to be measured
- Find Effect in *Table of Effects* under *Measurement*
- Determine a suitable product to receive the effect



- Add an internal substance with a paired field



- Attach a substance with a paired field



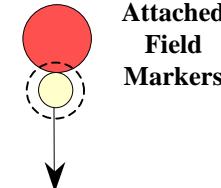
- Add a substance into the native environment with a paired field



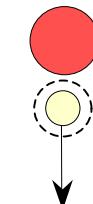
- Add an internal field



- Add an external field



- Add a field to an attached substance



- Add a field to a substance in the native environment.

## Additives

Especially Active  
Concentrated  
Temporary  
Copies

Chemical Decomposition

Decomposing Native Media

Self-Elimination of Depleted Substances

# Improve Functions to Extreme

# Improve to Extreme



Modification  
Improvement  
 $= f(\text{ temperature (hot)}  
\\ \text{humidity(50\%)}  
\\ \text{color (red)\dots})$

## Identify Improvement (Dependant Variable)

### Enduring Outcome



- What feature of the function would you like to **improve**? Improving this feature could lead to removing the primary system disadvantage or other undesirable flaws of the function.
- State the improvement as a dependent variable
- What value would you like to change this dependent variable to. What would be an IDEAL or ENDURING Goal?

### Or Flaw Remains

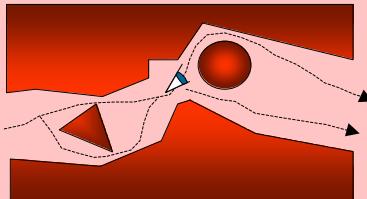


- The flaw is **not improved**, but no harm or weakness occurs....
- Leads to automatic contradiction

## Identify Controlling (Independent) Variables

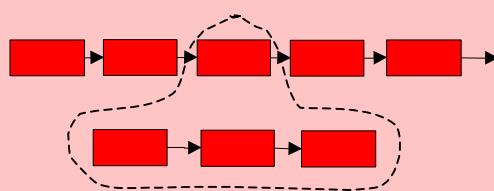
- Intuition
- Equations
- Models
- Experiments

### Empathy



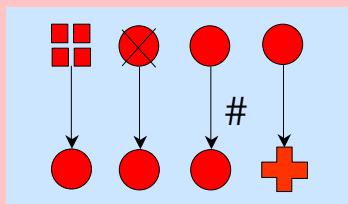
- Put yourself in the place of the objects that you are investigating
- Use Miniature Intelligent People (MIP)

### Flow of Goods & Information

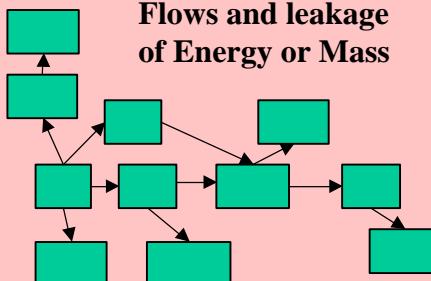


• Break down maps into progressively smaller steps

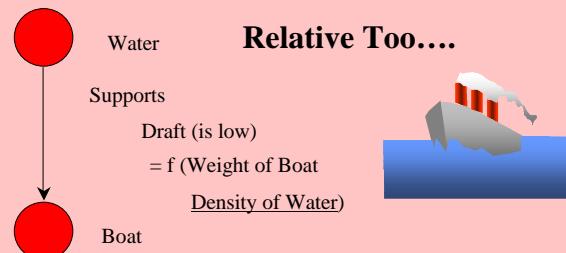
### Table of Controlling Variables



### Flows and leakage of Energy or Mass



• Break down maps into progressively smaller steps



### Relative Too....

Water  
Supports  
Draft (is low)  
 $= f(\text{Weight of Boat})$   
Density of Water

• Every Controlling Variable is measured relative to something. Consider changing that something

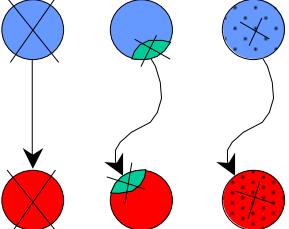
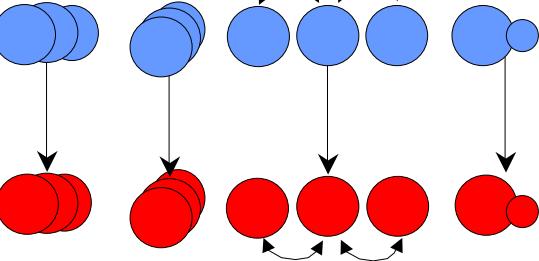
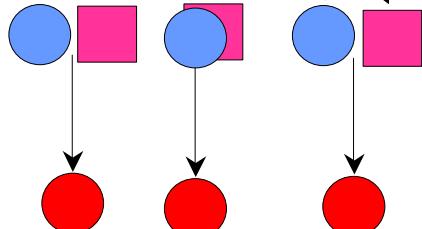
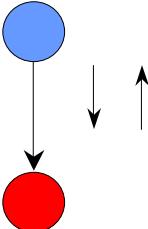
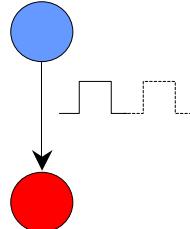
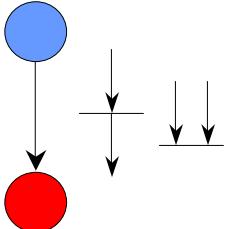
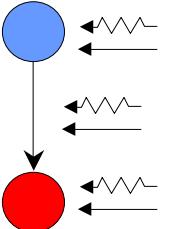
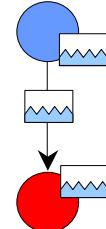
## Drive Values to the Extreme

### Setting



Drive the Value of the Controlling Variables to Hit the Enduring Goal without regard for other things that become worse

# Table of Controlling Variables

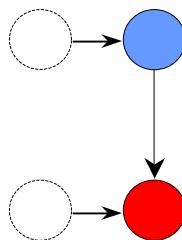
	Change Existence	Multiply Like Elements	Multiply Diverse Tools		
Existence	 <ul style="list-style-type: none"> <li>• Eliminate the <b>tool</b>, its <b>source</b> or its <b>path</b></li> <li>• Eliminate the <b>product</b>, its <b>source</b> or its <b>path</b></li> <li>• Identify and eliminate only the interaction site on the tool or product.</li> <li>• Remove only the <b>micro-constituents</b> that interact.</li> <li>• Contradiction often solved by transparency</li> </ul>	 <ul style="list-style-type: none"> <li>• Multiply the product</li> <li>• Multiply the tool</li> <li>• Combine multiple elements in different orientations. New capabilities should emerge.</li> <li>• Make the multiplied elements modify each other. New capabilities should emerge.</li> <li>• Nest or stack the elements</li> <li>• Bias some of the elements to handle different operating conditions</li> </ul>	 <ul style="list-style-type: none"> <li>• Identify another effect/tool which performs the same function.</li> <li>• What is the variable value of the new tool which would extend the capability of the two together?</li> <li>• Identify the cheap tool which should deliver most of the function.</li> <li>• Transfer the whole new tool or just the variable and its value.</li> <li>• Merge the tools. A new capability should emerge.</li> <li>• Make the tools modify each other. A new capability should emerge.</li> </ul>		
Change Timing	Coming & Going	Different Time	Partial Modification	Uncouple Other Functions	Storage of Action or Field
	 <ul style="list-style-type: none"> <li>• Does the Tool Follow a Path?</li> <li>• Can the Tool perform the function on the entire path?</li> </ul>	 <ul style="list-style-type: none"> <li>• Process Map the changing conditions over time.</li> <li>• Does the requirement for the function vary over time?</li> <li>• Could other tools help out at another time?</li> <li>• If the modification is performed as a step in a process, can the sequence be changed to a more favorable time?</li> </ul>	 <ul style="list-style-type: none"> <li>• Can the modification be broken into two (or more) <b>stages</b>?</li> <li>• Can the operation be broken into <b>parallel</b> stages</li> <li>• Can setup be performed at same time as operation?</li> <li>• Implies use of a <b>previously placed tool</b>.</li> </ul>	 <ul style="list-style-type: none"> <li>• Identify other functions performed on the tool, product and field.</li> <li>• Does uncoupling these other functions improve the function?</li> </ul>	 <ul style="list-style-type: none"> <li>• Identify the main fields of the function.</li> <li>• Consult the next page for ways to store this field</li> <li>• Is this field stored, even for an instant in the tool, product or in space? (is there a lag between field generation and application?)</li> <li>• Is there energy storage in oscillations?</li> <li>• Does storage improve the function?</li> <li>• Can storage be a mediator between the tool and product?</li> </ul>

Elastic Force Internal & External <b>Springs</b> <b>Elastic Media</b>	Gravity <b>Height of Objects</b> <b>Weight or Density</b>	Friction	Adhesive
Centrifugal Force <b>Momentum</b>	Inertia of Bodies (Note Direction) <b>Momentum</b>	Coriolis Force <b>Momentum</b>	
Buoyant force <b>Average Density of Buoyant Object</b>	Hydrostatic Pressure <b>Pressure Vessel</b>	Jet Pressure <b>Fluid Momentum</b>	Surface Tension <b>Surface Tension Area</b>
Odor & Taste <b>Container</b>	Diffusion <b>Pressure Vessel</b>	Osmosis <b>Container</b>	Chemical Fields <b>Explosives</b> <b>Chemical Potential</b>
Sound <b>Oscillation Chamber--Distance of Travel--Resonance of Objects</b>	Vibrations & Oscillations <b>Oscillation Chamber--Distance of Travel--Resonance of Objects</b>	Ultrasound <b>Oscillation Chamber--Distance of Travel--Resonance of Objects</b>	Waves <b>Oscillation Chamber--Distance of Travel--Resonance of Objects</b>
Corona Discharge <b>Low Field Vacuum</b>	Current Inductance Super-conducting media	Eddie Currents (internal and skin) Inductance Super-conducting media	Particle Beams <b>Low Field Vacuum</b>
Thermal Heating or Freezing  <b>Thermal Mass</b>		Thermal Shocks <b>Thermal Mass of Two Objects</b>	Nuclear Forces <b>Radio-active Materials</b>
Electrostatic Field <b>Capacitance--Piezo</b> Electric Materials  Electromagnetic (Voltage)  <b>Separation Space</b>		Magnetic Field <b>Permanent Magnet</b>	Information <b>Data Fields</b>
Radio Waves  <b>Separation Space</b> <b>Oscillating Circuits</b>	Micro-waves  <b>Separation Space</b> <b>Oscillating Circuits</b>	Infrared  <b>Separation Space</b> <b>Hot Objects</b>	Visible Light  <b>Separation Space</b> <b>Hot Objects</b> Fluorescence
Ultra-violet  <b>Separation Space</b> <b>Hot Objects</b> Fluorescence	X-Ray  <b>Separation Space</b> <b>Radio-active Material</b>		

# Storage of Fields

## Change Location or Movement

### Change Location



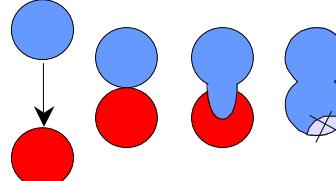
- Define the entire location Envelope for the tool and product (What space can the tool and product be located in?)
- Move the tool about in higher dimensions. Are the fields affected?
- Move the product about in higher dimensions. Are the fields Affected?

### Change Zone Location



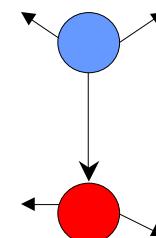
- Locate the **exact zone** of the modification on the tool and product.
- Does changing the location affect the fields of the function?

### Change Distance Contact or Combining



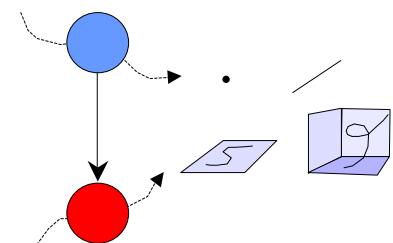
- Does changing the **distance** change the fields?
- Does **contact or separation** change the fields or introduce new fields?
- Try different locations for contact.
- **Nestle** one into the other
- **Combine** the tool and product. Consolidate. Look for new capabilities
- **Combine with super-system.** Look for much consolidation, new capabilities and room for growth.

### Change Velocity Acceleration Or Jerk



- Does changing the velocity or relative velocity improve the function?
- Try **stopping** the tool or product
- Does changing the **acceleration** improve the function?
- Does changing the rate of change of the acceleration (**jerk**) improve the function?

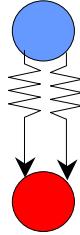
### Change the Path



- Does changing the path or relative path change the function?
- Try different paths in different dimensions.
- Useful functions **increase** path dimensions. Harmful functions **decrease** path dimensions.

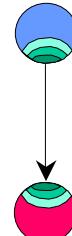
## Change Scale

### Change Intensity or Scope



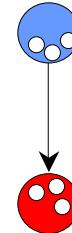
- Is the modification sometimes weak, at least in one direction?
- Does grossly increasing the intensity help in any way?
- If you were an **artist**, how would you work the defect into the picture?
- How would you extend the defect?
- Imagine the **defect multiplied**, what pattern would you multiply it to yield a useful function?
- **Excessively perform** the function and then remove the excess.

### Change Size of Interaction Zone



- Does volume or surface area of the interaction site affect the function?
- Does the interaction zone cross a **critical boundary**?
- Try changing the size of the interaction zone.
- Try increasing the **dimension** of the zone. Increase for useful. Decrease for harmful.

### Change the Number of Interaction Sites



- How many interaction sites are there now on the tool and product?
- Try changing the **number** and locations of the sites.

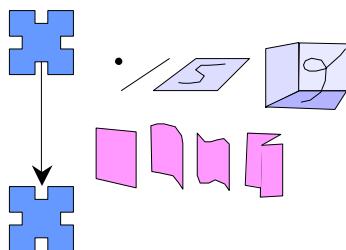
### Change to Micro-Sites



- Imagine the function at smaller and smaller scales at multiple small interaction sites.
- Are the sites on the surface or in the volume?
- Can the tool be multiplied to make this happen?
- Does the function **already exist**, to **any degree**, at the bulk material level? Boost this function.

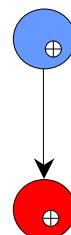
## Change Object Structure

### Change the Shape



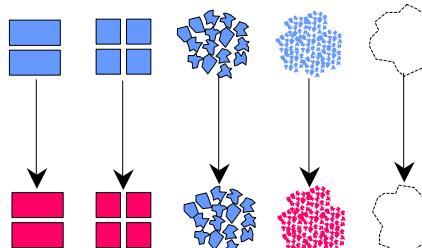
- Identify **poorly used space** around the tool and product
- Identify the dimensional construction of the interaction zone.
- If you were looking at a dimensioned drawing of the tool and product, what would be the **critical dimensions** for the function?
- Play like the tool and product are made from expandable clay. Form the tool and product into the ideal **shape, size** and **aspect ratio**.

### Change Symmetry



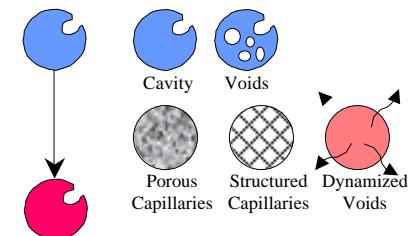
- Are the variables critical to the function symmetrically located?
- Change symmetry to **another axis**
- Make the tool or product **unsymmetrical**
- Make **symmetrical**

### Segmentation



- Would increasing the number of **interaction sites** improve the function?
- Make the sites **independent**
- Visualize dividing into **multiple copies** of the original elements.
- Change to a **powder or aerosol**
- Does the **shape** of the particles matter?
- Decompose:** Grains--Dust--Molecules--Atoms--Ions--Sub Atomic Particles
- Combine:** Sub Atomic Particles--Ions--Atoms--Molecules--Dust--Grains
- Solidify a liquid** or its constituents into particles

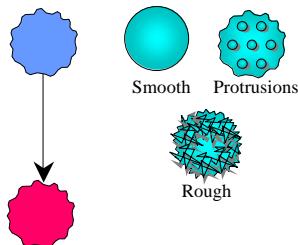
### Voids and Capillary Structures



- Place a specially shaped cavity in the tool or product.
- Place **specially shaped** voids in the tool or product (honeycomb, spherical, random)
- Use open or closed celled **porous** materials
  - Sintered powders
  - Dried or fired clays
  - porcelain
  - Sand
  - Loose Powders
  - Pumice
- Make the tool or product from **structured capillary** materials such as:
  - Fabrics
  - Fiber batting
  - Fiber bundles (thread, string, rope...)
  - Screen or layers of screens
  - Capillary tubes or tube bundles
- Fill the porous material with special **fluids** or allow fluids to move through the porous material

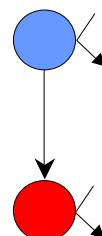
## Change Surface Properties

### Change Surface Shape



- Make the surface **smooth** if it is not already
- Make ridges **protrusions** in the surface of the tool or product (Random or structured)
- Make the surface of the tool or product **rough** (random or structured)
- Use a finer and finer surface roughness

### Change Surface Properties

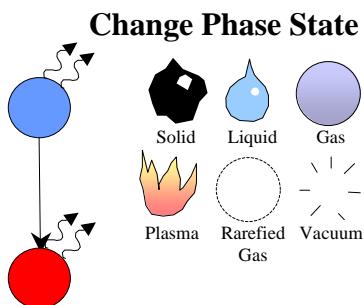


- Identify the fields which deliver the modification.
- Consult the **Table of Surface Properties** to see which ones modify the fields of the function

Elastic Force Internal & External Creep Coefficient--Strength-- Elasticity--Toughness--Ductility	Gravity	Friction Protrusions--Roughness--Phase Friction Couple--Slipperiness	Adhesive Adhesiveness--Phase Cohesiveness
Centrifugal Force	Inertia of Bodies (Note Direction)	Coriolis Force	
Buoyant force	Hydrostatic Pressure <b>Surface Phase</b>	Jet Pressure	Surface Tension <b>Bulk Properties--Phase</b> <b>Wetted Circumference--Temperature</b>
Odor & Taste <b>Chemical Composition</b> Surface Phase	Diffusion <b>Surface Porosity</b> <b>Surface Phase</b>	Osmosis <b>Surface Molecular Structure</b> <b>Surface Phase</b>	Chemical Fields <b>Chemical Reactivity</b> Surface Phase
Sound	Vibrations & Oscillations	Ultrasound <b>Surface Phase</b>	Waves
Corona Discharge <b>Surface Protrusions</b> Roughness--Surface Phase	Current <b>Continuity--Surface Phase</b> Conductivity	Eddie Currents (Internal and Skin) <b>Continuity--Surface Phase</b> Conductivity	Particle Beams <b>Phase--Chemical Reactivity</b> Surface Molecular Weight
	Thermal Heating or Freezing <b>Surface Protrusions</b> or Roughness--Surface Phase	Thermal Shocks <b>Surface Protrusions</b> or Roughness--Surface Phase	Nuclear Forces <b>Nuclear</b> <b>Particle Type</b>
Radio Waves Reflectivity--Phase Absorbtivity Emissivity	Electrostatic Field <b>Protrusions</b> <b>Roughness</b> Electromagnetic (Voltage) <b>Continuity</b> <b>Conductivity</b>	Magnetic Field	Information
Micro-waves Reflectivity--Phase Absorbtivity Emissivity	Infrared Reflectivity--Phase Absorbtivity Emissivity	Visible Light Reflectivity--Phase Absorbtivity Emissivity	Ultra-violet Reflectivity--Absorbtivity Emissivity--Phase Fluorescence
			X-Ray Atomic Weight

# Surface Properties

## Change Bulk Properties



- Change the Phase of the tool
- Change the Phase of the Product
- Change the Phase of the Environment
- Try each phase separately
- Note that **state of phase controls most fields**

## Change of Substance

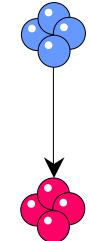


Cheap Substances

- Grocery store products
- Powders
- Foam
- Void
- Loose Bodies
- Waste or transformed waste
- Garbage
- Water, Steam or Hydrates
- Air and its components

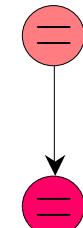
- Identify the fields of the function
- Look in the **Table of Bulk Properties** for controlling fields
- Identify different materials which have these properties
- Can the bulk properties be changed by chemically transforming, decomposing, combining existing materials or by heat treatment?
- Can the material be further enhanced by adding a field?

## Change to Foam



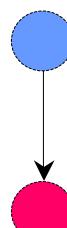
- If the tool or product were made of foam, would the function be improved?

## Match Tool & Product values



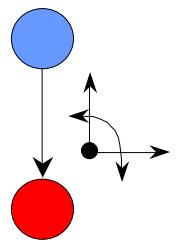
- Match or mismatch tool and product properties, especially if they are in contact or must move or expand together

## Inert Substances



- Change the tool or product to an inert substance

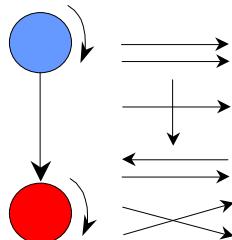
## Changing Direction



- Identify the Field Gradients
- Identify current direction of Action or fields
- Change or reverse the direction of the action or fields.

## Change Direction of Action or Fields

## Rotate or Change Orientation



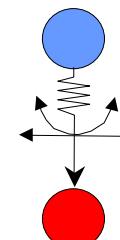
- Try different rotational orientations, relative to each other.
- Change from linear to rotary motion.

## Reverse the Action



- What constitutes the reverse of the current action?
- What is the action performed relative to? Change that instead.
- Drive the reverse action to the extreme.

## Avoid Field Gradients



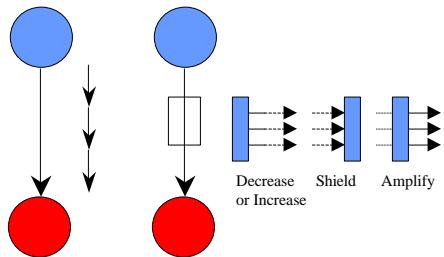
- **Draw the field lines** and the equipotential lines
- Does either element move or rotate through a field gradient?
- Make elements move **along** equipotential lines
- If either element already moves along equipotential lines, **changing the field slightly** can make the function adjustable. How can the fields be changed?

Elastic Force Internal & External Creep Coeff...Strength--Elasticity-- Toughness--Ductility--Physical Phase	Gravity Density--Phase	Friction Temperature--Viscosity Phase	Adhesive Temperature State of Phase
Centrifugal Force Density	Inertia of Bodies (Note Direction) <b>Density--Phase--Elasticity Coeff.. of Restitution</b>	Coriolis Force Density	
Buoyant force Density--Phase	Hydrostatic Pressure <b>Gas Constant--Phase Gamma--Temperature</b>	Jet Pressure Density--Phase	Surface Tension <b>Cohesiveness Phase</b>
Odor & Taste Chemical Composition Phase	Diffusion <b>Molecular Weight--Phase</b>	Osmosis <b>Molecular Size Ionization Potential--Phase</b>	Chemical Fields <b>Chemical Composition Phase</b>
Sound Coeff.. of Restitution Viscosity--Density--Phase	Vibrations & Oscillations <b>Coeff.. of Restitution Viscosity--Density--Phase</b>	Ultrasound <b>Coeff.. of Restitution Viscosity--Density--Phase</b>	Waves <b>Coeff.. of Restitution Viscosity--Density--Phase</b>
Corona Discharge Ease of Ionization Rarefaction--Phase	Current <b>Conductivity--Phase Trans-conductance</b>	Eddie Currents (internal and skin) <b>Conductivity--Phase Trans-conductance</b>	Particle Beams <b>Molecular Weight</b>
Thermal Heating or Freezing <b>Thermal Conductivity Coeff.. Thermal Expansion Thermal Capacity--Phase</b>		Thermal Shocks <b>Thermal Conductivity Coeff.. Thermal Expansion Thermal Capacity--Phase</b>	Nuclear Forces <b>Atomic Weight--Density Temperature</b>
Electrostatic Field <b>Dielectric Constant</b> Electromagnetic (Voltage) <b>Permeability--Conductivity Dielectric Constant</b>		Magnetic Field <b>Magnetic Permeability Magnetic Hysteresis--Curie Point</b>	Information
Radio Waves Transparency--Phase Image Splitting Refractive index	Infrared Transparency--Phase Image Splitting Refractive index	Light (Coherent & light Pressure) Transparency--Phase Image Splitting Refractive index	Ultra-violet Transparency--Phase Image Splitting Refractive index
Micro-waves Transparency--Phase Image Splitting Refractive index			X-Ray Molecular Weight

# Bulk Properties

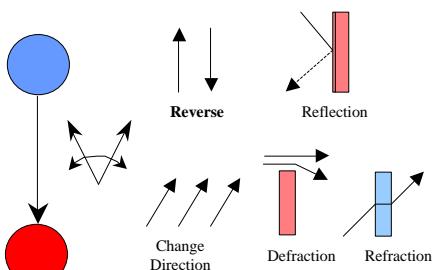
## Structure Fields in Space

### Change Field Intensity or Conductance



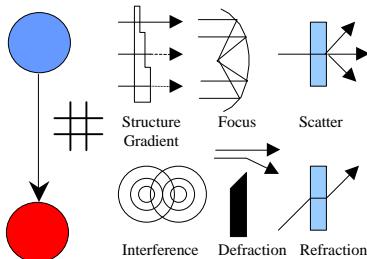
- Draw Field Potential Lines and Gradients
- Increase or Decrease the field intensity from the Tool
- Use an intermediate substance to shield, amplify or decrease the field
- Change the Conductivity of the Mediator

### Change Field Direction



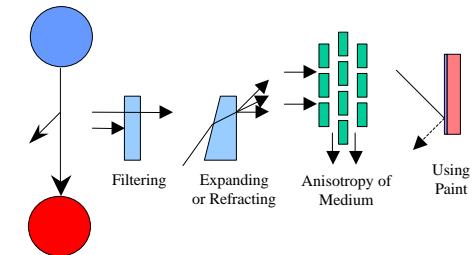
- Identify the field gradients and potential lines
- Is the field **direction** ideal? Change to the ideal field direction.
- What would happen if the fields were **reversed**?

### Change Field Gradient or Concentration



- Draw the field gradients and field potential lines as they currently exist
- Change the **gradient** to the ideal
- Move to higher dimensions
- Change the dimension of the affected area of the product
- Use heat to change the refractive index
- Sharply change the field gradient to eliminate harmful functions
- Make the Field **Coherent**

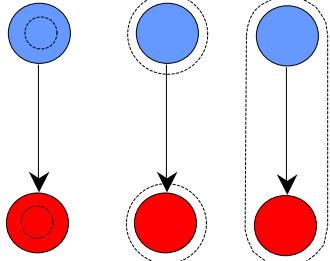
### Separate Field Components



- Can the field be broken into various components?
  - Direction
  - Frequency
  - Variety of Fundamental Fields
- Identify the **truly useful components**
- Use a different Color: Filter field or reflect only certain frequencies
- Change the receptivity of the product to certain field components
- Search the **Table of Effects** for ways to separate field components
- Can Changing to a higher dimension help the filter?

## Adding or Superimposing Fields

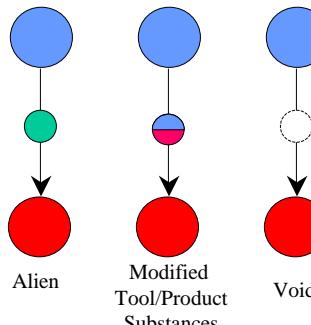
### Adding or Superimposing Fields



- Draw existing field lines and gradients
- Identify substances and constructions which react strongly to the existing fields
- Identify fields which would react strongly to the existing substances
- Identify other existing fields in the environment
- What field constructions, new or existing could be **superimposed** on the existing field construction?
- Consider adding a **counter field**
- Superimpose a new **Field Receptivity** on the product
- Superimpose a new field type
- Pre-stress the parts
- Consult the table of **Storage of Fields** for consideration of residual fields

## Mediators

### Mediators

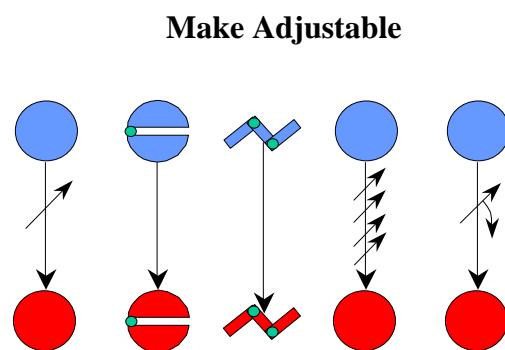


- Is direct contact required?
- Identify the field and gradient
- Make a good guess at an **alien mediator**
- Use a **modification** of the tool substance
- Use a **modification** of the product substance
- Try **mixtures** of the tool and product
- Try **multiplied versions** of the tool or product
- Place a **void** or rarified gas between the tool and product
- Would **enclosing** both the tool and the product in the mediator help?
- Break down into **two functions** and then go back through and idealize both functions.

### Possible Modifications to Substances

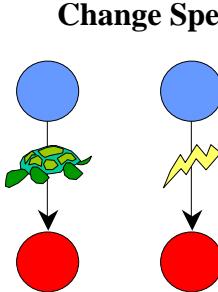
- Phase
- Chemically altered
- Heat treatment
- Electrification
- Heated
- Foam
- Decomposed
- Mobilized
- Internal additives
- Ionized
- Recombined
- Dilution of constituents
- Concentration of constituents
- Change of Bulk Properties
- Form structures at micro level

## Make Adjustable



- Which of the controlling variables of the tool, product or field can be made adjustable? (Include relative controlling variables).
- Place **Joints** in the tool or product
- Increase the **number of joints**
- If a variable is already adjustable, **increase** the degrees of freedom.
- Make **several** controlling variables adjustable
- Make an existing or new variable **continuously adjustable**.

## Vary in Time



- What would happen if the function were slowed way down (hours, days, weeks, months, years)
- How are the fields changed by performing the modification more slowly?
- Is the function improved if the modification is performed very rapidly? (Days, hours, minutes, seconds...)
- If the modification were performed more rapidly, would other harmful functions be precluded?

## Make Adjustable

## Make Flexible



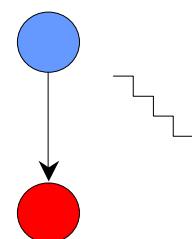
- **Everything** is flexible. Look at the system as a collection of springs, masses and dampers.
- Change the flexibility of the **tool**.
- Change the flexibility of the **product**.
- Change the **direction** of flexibility.
- Make very flexible by transforming to a **liquid or gas**.

## Operate Near or Far from Critical Point



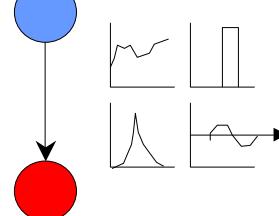
- Does the controlling variable have a **natural critical condition** or threshold, such as boiling point or curie temperature?
- Can a critical condition or threshold **be created** for a variable which does not normally have one, such as a bi-stable condition?
- If the function is useful, **operate near the critical condition** so that small inputs can trigger large results.
- If the function is harmful, **operate far away** from the critical point.

## Discrete Steps



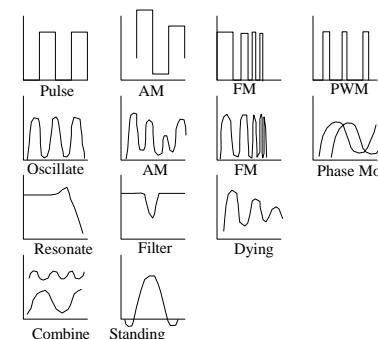
- **Multiply or segment** the tool into separate pieces.
- Each piece moves into action in discrete steps or into fixed positions or amplitudes.

## Vary in Time or Pulse



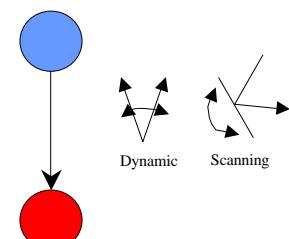
- If you could continuously vary the action in time, what would be the **perfect shape** of the curve?
- Square pulse the action.
- Shape the pulse.
- Make the pulse travel.

## Pulsate or Oscillate



- Pulsate or oscillate the tool
- Pulsate or oscillate the product
- Pulsate or oscillate the field
- Pulsate or oscillate the product receptivity
- Resonate the tool, product or field
- Create standing waves
- Cancel oscillations in the tool, product or field
- Mismatch the product natural frequency with the tool driving frequency

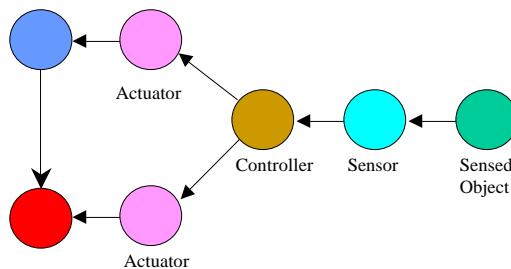
## Vary Field Direction



- Identify the field gradient and potential
- Does varying the field direction improve the function?

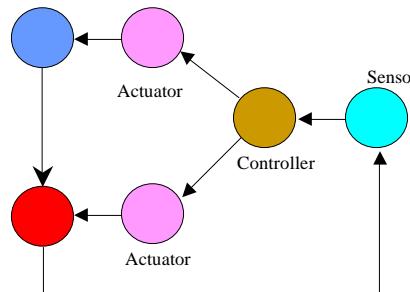
## Control

### Add Control Elements



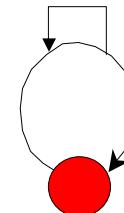
- Does the modification need to be more precise?
- Is the tool or product already adjustable?
  - Discrete positions=bang-bang
  - Continuously adjustable?
- Are means provided to sense changing conditions
- **Add Actuator** to tool or product
- **Add Controller**
- **Add Sensors**

### Closed Loop Control



- Does the modification need to be yet more precise?
- Sense the important modified variable
- Increase the number of variables sensed
- Increase the order of the variable sensed (first derivative, second derivative...)

### Passive Control



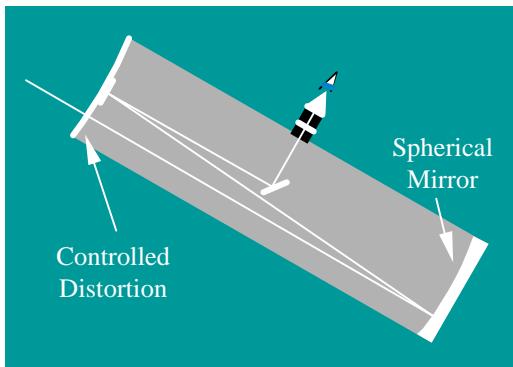
- **HIGHEST FORM OF CONTROL**
- Does the system ideally use one field for operation and control?
- Provide for self-service operation (Ideal Tool / Effect)
- Identify the **critical point** at which small changes in input cause large changes in output
- Move the critical point to the desired control point.

# Resolve Contradictions

# Removing the Problems of Improving to the Extreme

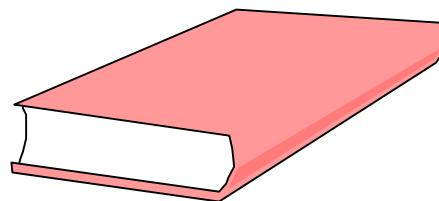
## Alternative Approaches

### Fix the New Offending Function



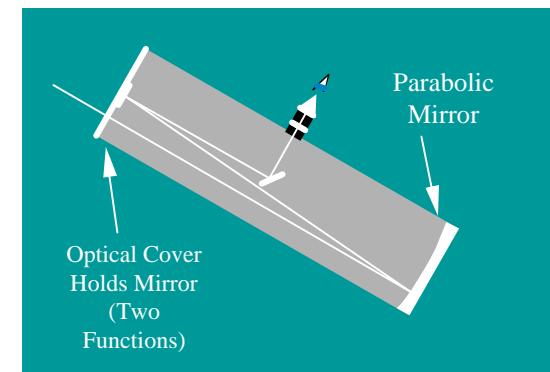
- Identify functions which become worse or harmful due to the extreme change.
- Go back and identify this as the function which must be improved.

### Table of Contradictions



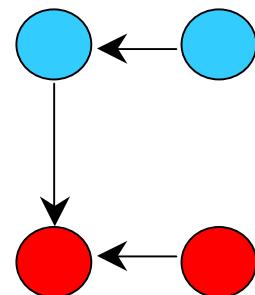
- Consider this alternative first as it generally creates the most ideal solutions

### Reduce the Cost Penalty



If new elements are costly, increase the number of functions performed by the new costly element.

### Introduction of New Functions



- Sometimes there are no objections to a change, yet the change requires the introduction of a new function and there are no elements which perform this new function.
- Go back to Redefining Useful Functions and consider appropriate ways to add the new function
- This is usually done as a last resort as the addition of elements is less ideal

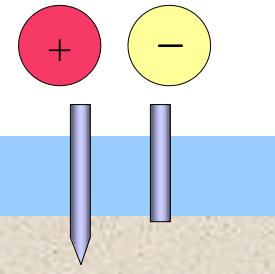
# Table of Contradictions

## Separate in Space

Sharp

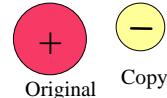
Blunt

### Complete Separation



- Which element must have conflicting values? Begin with that element and its duplicate
- Modify the duplicate element so that it has the anti-value

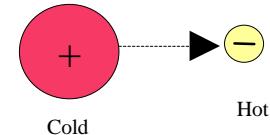
### Copy



Photographs  
Movies  
Paint Coverings  
Molds  
Time lapse photos  
Impressions  
Silhouettes  
Casting  
Resists  
Projections

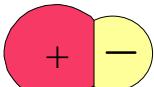
- Make a *copy* of the element that requires conflicting values. The Original has the required value. The copy has the anti-value

### Take Away



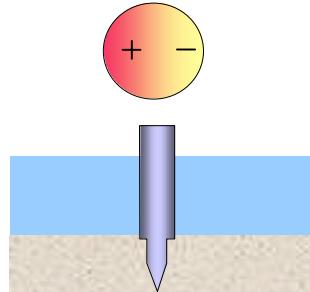
- Does the contradiction exist because one of the elements is at risk or causes a dangerous situation?
- Separate out the part of the element which is dangerous or at risk and make it as small as possible. (Both parts still interact).
- One has the anti-value of the other

### Carrier



Inert Carriers  
Dual States-same material  
Dual Phase Substances  
Thin Films  
Paint

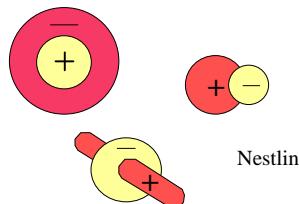
### Non-uniform



Transformers(electric, levers, etc.)  
Standing Waves  
Concentrated Additives  
Especially active Additives

- One element has the desired value. It is attached to another element, (the carrier), having the anti-value

### Nesting

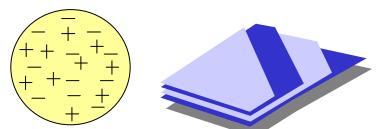


Nestling  
Through

Dual Phases-Change of State  
Foams  
Porous materials  
Paint  
Inert Environments

- **One element** has both conflicting values
- Part of an object has the anti-value
- Consider a smooth transition between values

### Mixture



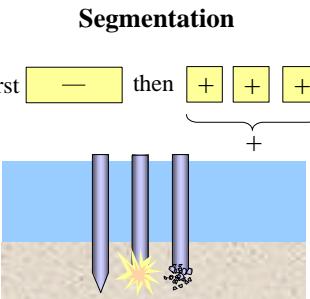
Fabrics and Matrix  
Multi Fiber Fabrics  
Multi Property Laminates  
Mixtures of Different Molecules  
Gels (Liquids + Solids)  
Pastes (Liquids + Solids)  
Foams (solid or liquid)  
Capillary Structures (Solid + Liquid)  
Components of Solids or Liquid

- The element becomes a composite structure which is a mixture of both values
- Could existing bulk constituents be modified to have the anti-value?
- Consider finer and finer scales down to sub-atomic particles

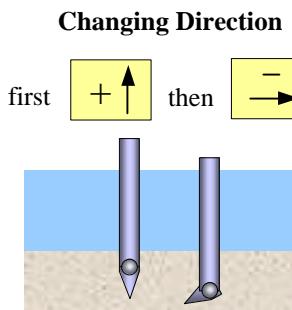
## Separate in Time

First Sharp then Blunt

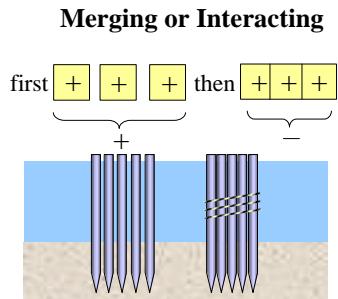
(Usually Requires Addition of Function)



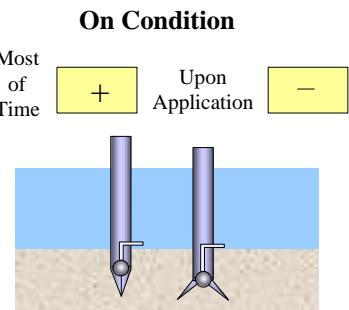
The values of the system are changed when the object is segmented.  
• Consider performing this at the micro-level. Dissolving, etc.



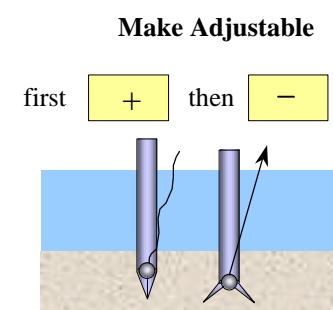
• Can variable be oriented in direction?  
Change orientation in time.



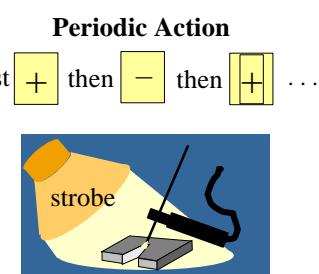
• Begin separated and then merge the pieces, or vice versa.  
• Begin separate and then make individual pieces interact.



- What changing conditions drive the need for the conflicting values?
- Can these changing conditions, themselves, drive the change?

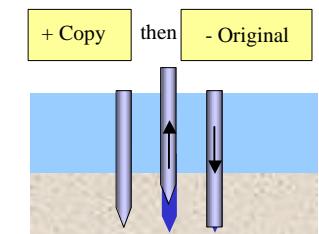


- Is the Variable Currently Adjustable?
- CHANGE OF STATE: Solution, phase, breakable, phase accompanying effects, heat effect, chemical stage, etc.
- TEMPORARY ADDITIVES
- VIBRATION EFFECTS: First vibration Effect #1 then Effect #2

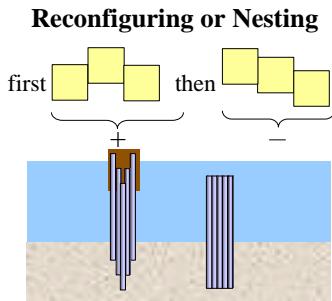


- First the value, then the anti-value, then the value, etc.
- Bright to see puddle, dark to see arc...

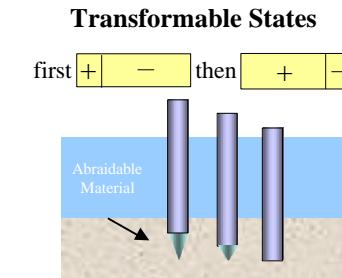
### Copy



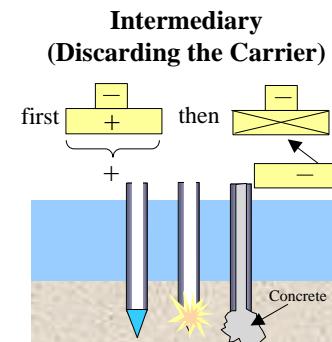
- Can the **essential part** of one of the opposing values be **copied** into another object?



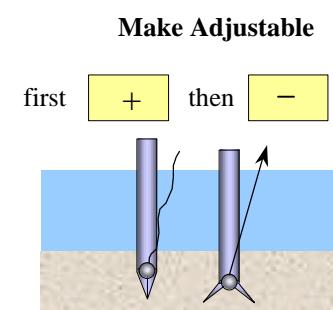
- Multiply elements and form them for merging and moving about.
- Consider Nesting



- Solid to Liquid
- Solid to gas
- Gas to liquid
- Combustible materials
- Soluble or dissolvable materials
- Fissable
- Glue
- Settable liquids--(increase of volume)
- Easily breakable or abradable
- Explosive
- Exo-Endothermic
- Polymerizing or de-polymerizing
- Mixture decomposition --Electrolysis
- Disassociation- recombination
- Shape Memory Materials
- Magnetic materials using Curie Effect

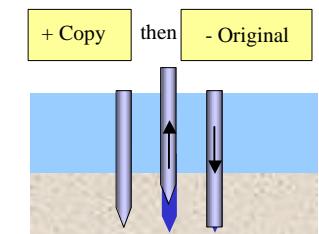


- **Discard** or disengage **the carrier** after use
- Consider **Replacing** with an object having the anti-value



- First the value, then the anti-value, then the value, etc.
- Bright to see puddle, dark to see arc...

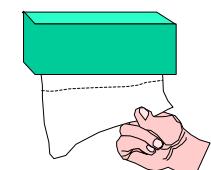
### Copy



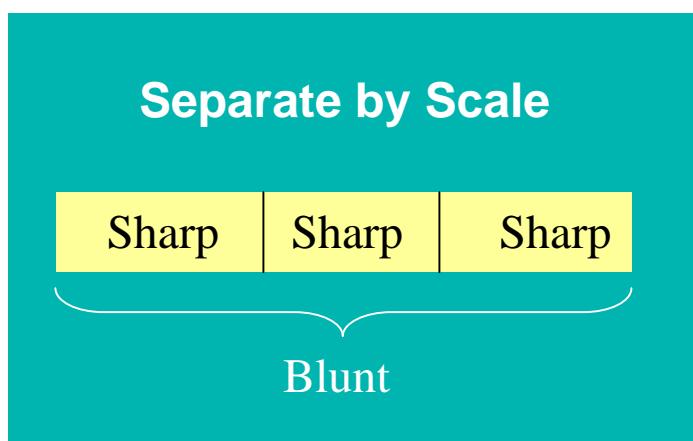
- Can the **essential part** of one of the opposing values be **copied** into another object?

### Preliminary Action

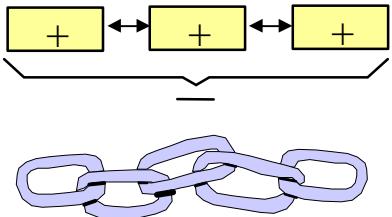
+ way(partially) then - way(fully)



- Are the opposing variable values **the way** that the modification is performed?
- Can the modification be performed one way **partially** and then finished the opposite way? (Cut slowly and rapidly)
- Can **part of a tool** be preinstalled to perform the modification partially?
- Can the modification be **excessively** performed and then remove the excess later?
- If the **reliability** of the modification is the variable with opposing values, can another element be placed to take over in the event of a failure? (Previously Placed Cushion).

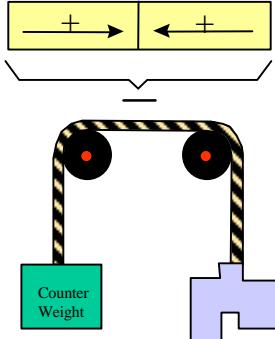


### Interact



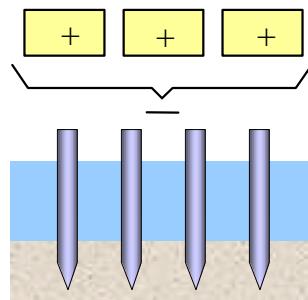
- **Multiply or Segment** the main object
- The parts have the anti-value of the whole
- Make the parts interact
  - Parts Adhere
  - Parts Nestle into each other
  - Parts Shaped to Inter-link
  - Parts linked by transmission elements
  - Parts interact by field (Consult table)
- **BLESSING IN DISGUISE** multiply a harmful variable and then arrange and interact to make useful

### Counter-Variables



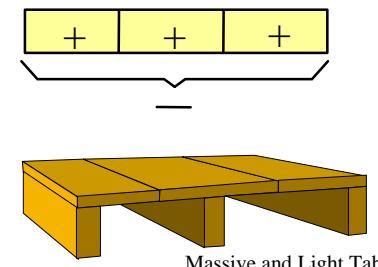
- Does the variable have direction or can it be changed in some way to have direction?
- Draw the field gradients or vectors. Can **same, biased, or different** elements be oriented such that the fields overlap, counter or otherwise nullify each other? (COUNTER WEIGHT) Can the elements **Butt or Tension** each other?  
(Consider a **transmission** between elements).
- NEGATIVE + POSITIVE SPRING RATE
- NEGATIVE RATE CHANGE OF LEVER ARM

### Segmented and Separate



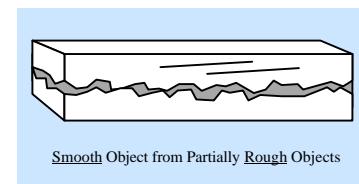
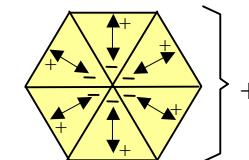
- **Multiply or Segment** the object and separate in space
- The parts have the anti-value of the whole

### Merging



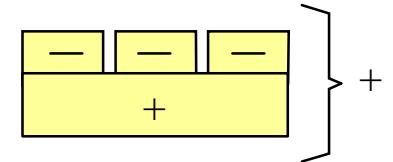
- **Multiply or Segment** the object and merge
- The merged whole has the anti-value of the individual parts
- **POROUS MATERIALS** (Many Small volumes = large volume)
- **SPHEROIDALITY** (Many curved thin sections = thick section)
- **MACRO-MICRO VIEW** (3 colors on micro level = 1 color at the macro level such as stamps, color TV)
- **EXCESSIVE ACTION** (Uncontrolled + Uncontrolled = Controlled)
- **BLESSING IN DISGUISE** multiply a harmful variable and then arrange and merge to make useful

### Hidden variables



- Does any part of the object have the **desired macro variable**, even in the slightest degree?
- Merge **same, biased, or different** elements and orient them in such a way that the undesirable anti-value is **hidden**, (at least functionally).

### Carrier

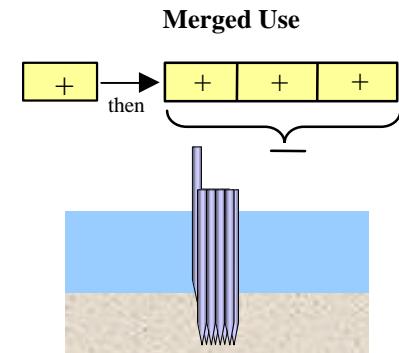
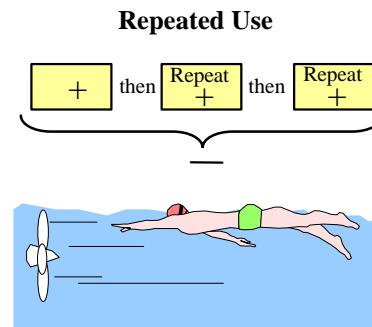
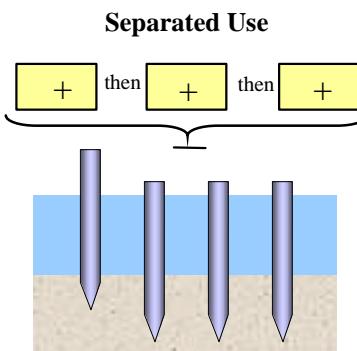


- Multiply objects with one value and attach them to a second object with the anti-value.
- **COMPOSITE MATERIALS**
- **USING PAINT:** The field reacts with the paint with (+) value and with the painted object with (-) value.

## Separate by Scale in Time

Sharp | Sharp | Sharp | Sharp

Blunt



The variable or action comes into use, one at a time. Over the course of time the values add up to the anti-value

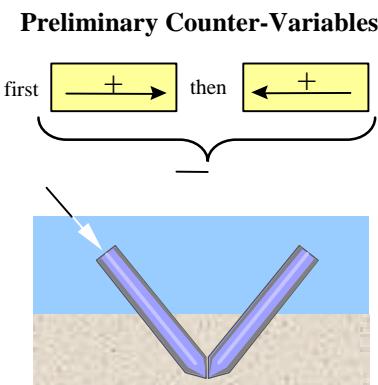
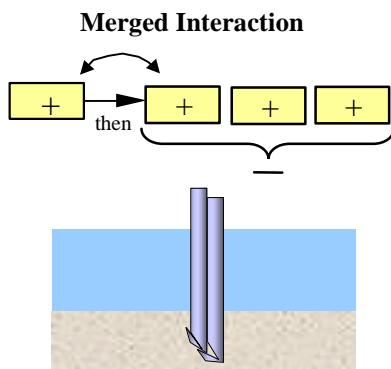
- CHEAP SHORT LIFE: Un-durable + Un-durable = Durable
- SEGMENTATION: Part + Part + Part = Whole
- PARTIAL ACTION: Partial action + Partial action = whole action
- PREVIOUSLY PLACED CUSHION: Unreliable + Unreliable = Reliable

A variable is used repeatedly, perhaps after being recovered. **Usually involves a repeated or circular process.**

- SPHEROIDALITY: repeated circular path = long path
- REUSE: Little + Same Little + Same Little = Lots
- UNINTERRUPTED EFFECT: One + Same + Same = Multiple
- REGENERATION: Little + Regenerated little + Regenerated little = Lots

**Multiply or Segment** the object and merge one at a time. The merged whole has the anti-value of the individual parts

- SEGMENTATION AND REMERGING: Part + Part + Part = Reunited whole
- STORAGE: Little Stored + Little Stored = Lot
- MERGE AT MICRO LEVEL

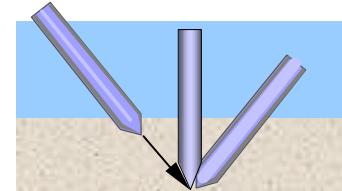
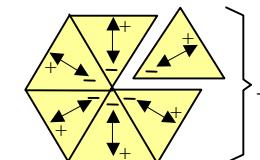


- How can the added part modify the parts already in place to cause them to have the anti-value? (At least a little with each addition until the whole has the anti-value).

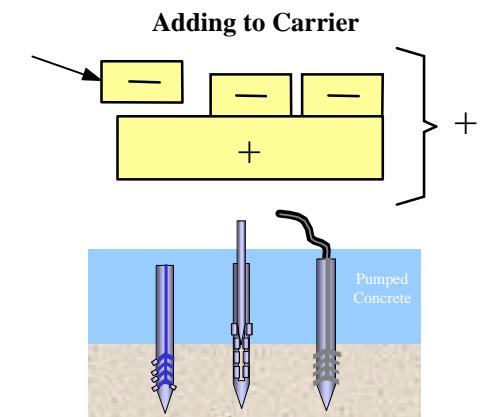
- Interact:
  - Parts Adhere
  - Parts Nestle into each other
  - Parts Shaped to Inter-link
  - Parts linked by transmission elements
  - Parts interact by field (Consult table)
  - Parts reshape the existing parts

- Does the variable have direction or can it be changed in some way to have direction?
- Gradually orient **same, biased, or different** elements to nullify each other. If different, implies previous placement of a tool.
- **Butt or Tension** the directions
- Consider using a **transmission** between elements
- Consider performing at micro level
- **COUNTER WEIGHT**
- **VIBRATION CANCELLATION**
- **NEGATIVE + POSITIVE SPRING RATE**
- **NEGATIVE RATE CHANGE OF LEVER ARM**

### Slowly Hidden

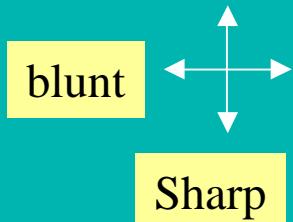


- Does any part of the object have the desired **macro variable**, even in the slightest degree?
- Gradually merge **same, biased, or different** elements and orient them in such a way that the undesirable anti-value is hidden, (at least functionally).

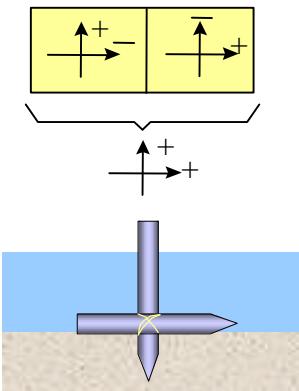


- Multiply objects with one value and gradually attach them to a second object with the anti-value.
- **COMPOSITE MATERIALS**
- **USING PAINT:** The field reacts with the paint with (+) value and with the painted object with (-) value.

## Separate by Direction, Path or Plane

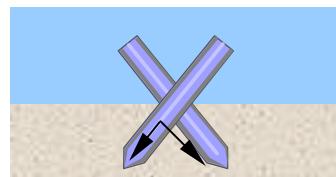
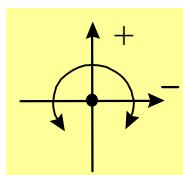


### Complimentary Variables



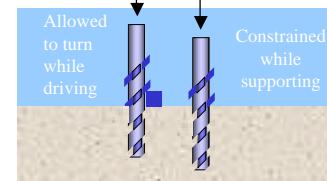
- Can the variable be oriented in a direction, such as force or velocity?
- Do all other directions have the anti -value?
- Combine **same**, **biased**, or **different** elements which are oriented in complimentary directions, the whole now has the required value in both directions. A seat belt constrains in one direction. A side impact bag constrains in another. They compliment each other.

### Direction



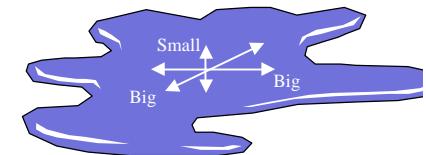
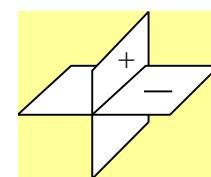
- Does the object have the value in one direction and not in the other? Can it be made to?
- Identify the two functions that it must perform.
- The object performs one function in one direction and the other in the other direction
- EQUIPOTENTIALITY: In a potential field, limit position changes against the potential gradient. For example, eliminate the need to raise or lower objects against gravity. Moves (+) rotationally but No Movement (-) up or down.
- SPHEROIDALITY: Joints or shafts allow rotating but prohibit translating.

### Path



- Can the object operate along a path with two end points?
- Can the object be envisioned as a path with two end points?
- Consider paths in other dimensions
- SPHEROIDALITY: A path may be long (+) around a section of a circle and short (-) around another section of a circle

### Plane



- Does the object have the value in one plane c surface and the anti-value in another?
- Can the object be formed to be this way?
- For example, a city is large in only one plane

## Change Relative Measurement Standard

**Sharp**

Compared to old standard

**Blunt**

Compared to new standard

### By Comparison



Compared to Old Standard

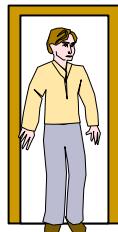


Compared to New Standard

Tall  
Compared  
to Old  
Door

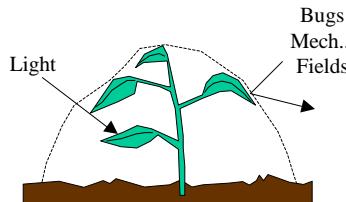
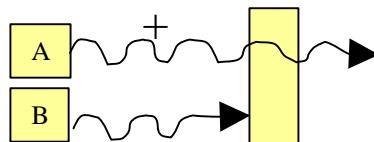


Short  
Compared  
to New  
Door

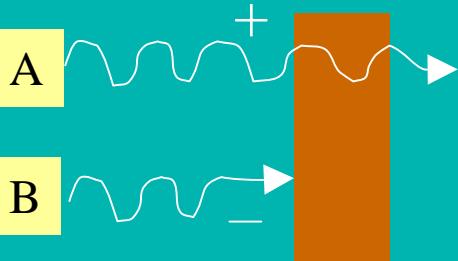


- What is the variable compared to? Change that object instead. (Change the standard by which it is measured)
- STRONG ACIDIFIERS: Strong (+) compared to small objects and Weak (-) compared to large objects
- Easy (+) for you and Hard (-) for me
- It is \_\_\_\_\_ in my eyes and \_\_\_\_\_ in someone else's eyes

### Transparency

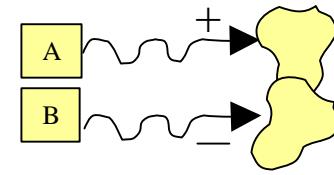


## Field Susceptibility

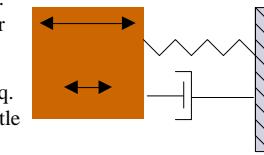


- The system is transparent (+) to Field A and opaque (-) to Field B
- Consult list of fields.
- INERT ENVIRONMENTS: Opaque to oxidizing environments
- PAINT: Passes certain types of radiation.
- FILTERS, SIEVES, FABRICS, FILAMENT WRAPS, MOLECULAR SEIVES: Passes liquids and gasses.
- FOAM: Passes solids in motion.
- FLUIDS: Passes solids in motion.
- FABRICS: Passes solids in motion

### Two Field (or Field Component) Effects



Low freq.  
moves far



High freq.  
moves little

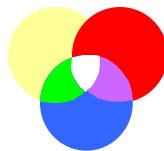
- PAINT: Field A reacts with the paint with the (+) effect and the painted article with the (-) effect
- INERT ENVIRONMENT: Field A reacts with the inert environment with the (+) effect and with an object in the inert environment with the (-) effect.

- Nitrogen
- Nobel gasses
- Oxidized materials
- Non-reactive chemicals
- Foams
- Water

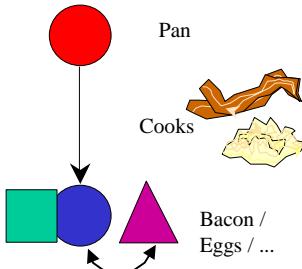
Expand  
&  
Consolidate

## Expand the Solution

### Combine Solutions

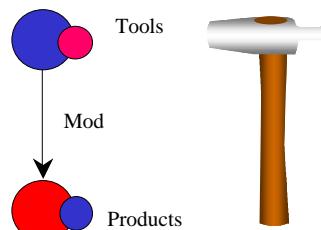


### Diversify the Product



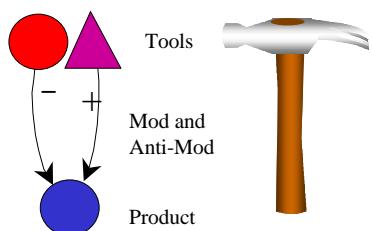
- What other Products in the immediate environment can the tool operate on?
- What modification to the tool would be required to operate on these products?
- Combine the products and see if new capabilities emerge.
- In what useful ways can the products modify each other?

### Merge Biased Elements



- Can two or more tools with biased properties be merged to operate on slightly different products?

### Merge Anti-Tools

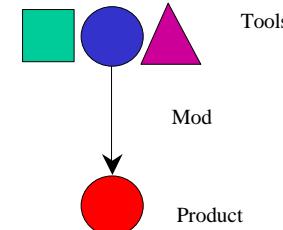


- Identify the Anti-function?
- What effect/tool exists in the environment or could be used to perform the anti-function
- Can this anti-tool be merged with the system?

### Permute the Elements

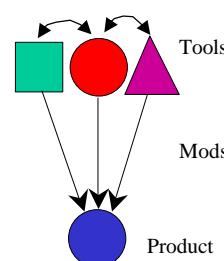
ABC  
ACB  
BAC  
BCA  
CAB  
CBA

### Diversify the Tool



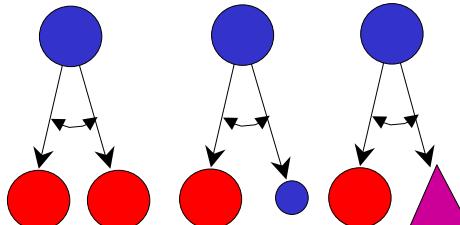
- What other effects/tools perform the **same** function? Consider again combining solutions where alternate tools have been used
- Can several different effects/tools be used to broaden the range of modification?

### Make Different Tools Interact



- What other tools in the environment operate on the product?
- Can these tools interact with each other to create an **unexpected capability**?

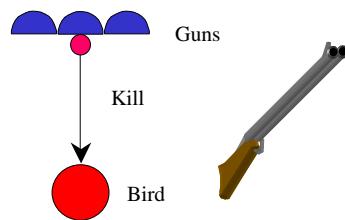
### Switching Back and Forth



- Are all parts of the system at full load?
- Have dummy runs and downtimes been eliminated?
- What else in the system requires the same modification?
- Can biased products be modified?
- Can diverse products be modified?

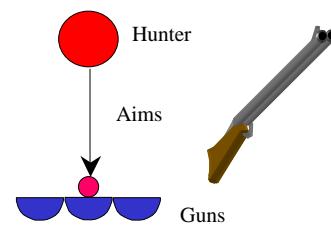
## Consolidate Elements

### Consolidate Multiple Tool Elements



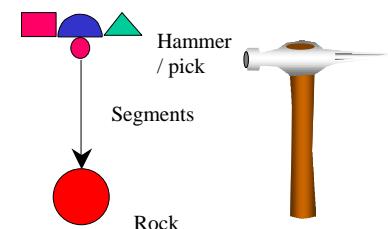
- What part of the tool elements could be made to serve all of the elements?

### Consolidate Multiple Product Elements



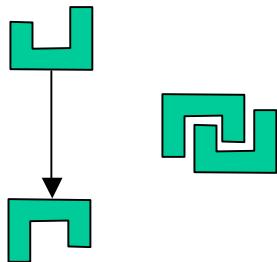
- What part of the product elements could be consolidated?

### Consolidate Unlike Elements



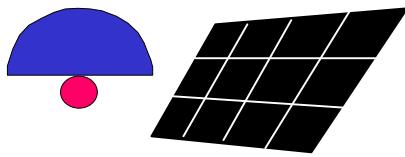
- What part of the tool elements could be made to serve all of the elements?

## Folding Elements



- Consider how the tool and product may be folded **into themselves**.
- Consider different orientations of the tool and product which allow them to be folded **into one another**?

### Merge with Super System and Consolidate



Solar panels merge with home and become tiles

- What elements of the system have functional duplicates in the super system?
- Combine with the super system and then consolidate the parts which are functional duplicates? **Look for unexpected capabilities to emerge**